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Nationwide statistical analysis of myeloid malignancies in Korea: incidence and survival rate from 1999 to 2012

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Background
Large-scale epidemiologic analysis for hematologic malignancies will be helpful to understand the trends in incidence and survival.

Methods
The Korea Central Cancer Registry (KCCR) updated the nationwide analysis on the incidence and survival of myeloid malignancies, from the Korean National Cancer Incidence Database between 1999 and 2012. Myeloid malignancies were classified based on the International Classification of Diseases for Oncology 3rd edition (ICD-O-3).

Results
Overall 3,771 cases of myeloid diseases, which was 1.7% of all cancers, were identified in 2012. The highest incidence of myeloid malignancies was observed in age 70s and male predominance was noted (1.3:1). Acute myeloid leukemia (AML) was the most frequent subtype, followed by myeloproliferative neoplasms (MPN), myelodysplastic syndrome (MDS) and MDS/MPN: age-standardized incidence rates (ASR) in 2012 for each disease were 2.02, 1.95, 1.13, and 0.12 per 100,000 persons, respectively. The ASR for all myeloid malignancies was increased from 3.31 in 1999 to 5.70 in 2012 with the annual percentage change (APC) of 5.4 %. Five-year relative survival rate (RS) for myeloid malignancies has gradually improved for decades. RS changed from 26.3% to 34.8% in AML, specifically from 51.6% to 69.6% in acute promyelocytic leukemia (APL) and from 23.8% to 29.9% in non-APL AML, between 1996–2000 and 2008–2012. RS also increased from 81.8% to 87.1% in MPN, with a significant improvement in CML (from 74.5% to 85.5%), and from 27.3% to 31.7% in MDS/MPN between 2001–2005 and 2008–2012. However, there was no survival improvement in MDS during the study period (45.6% in 2001–2005 to 44.4% in 2008–2012).

Conclusion
This report updated the nationwide statistical analysis on myeloid malignancies since 2008, showing increasing incidence and improving trends in survival.

Key Words Myeloid malignancy, Incidence, Survival, Korea

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INTRODUCTION

Hematologic malignancies are classified on the basis of the morphology, immunophenotype, cytogenetics, and clinical characteristics. The most recent classification suggested by the World Health Organization (WHO) have grouped myeloid malignancies into five categories: acute myeloid leukemia (AML), myelodysplastic syndromes (MDS), myeloproliferative neoplasms (MPN), myelodysplastic and myeloproliferative (MDS/MPN) neoplasms, and other rare diseases associated with eosinophilia and abnormalities of growth factor receptors derived from platelets or fibroblasts [1, 2]. The classification of these diseases has been modified to

include recent advances in cytogenetics and molecular genetics for hematologic malignancies.

In cancer registries, the International Classification of Diseases for Oncology (ICD-O) has been widely used since 1976, for coding the tumor site and histology. The most recent publication of ICD-O is the third edition (ICD-O-3), published in 2000 and revised in 2013 [3]. This updated version of ICD-O-3 includes the new terms and code changes suggested by the updated WHO classification on tumors of hematopoietic and lymphoid tissues in 2008. Recent cancer registry reports adopted this ICD-O-3 classification, as it was considered to better reflect our current understanding of diseases [4-6].

In Korea, the Ministry of Health and Welfare started the Korea Central Cancer Registry (KCCR), a nationwide hospital-based cancer registry in 1980. The KCCR expanded to include the entire population under the population-based cancer registry program since 1999 [7]. ICD-O-3 was applied to all incident cases for neoplastic diseases since the year 2003.

The KCCR and the Korean Society of Hematology (KSH) reported the first nationwide statistics of hematologic malignancies 4 years ago, covering the incident cases from 1999 to 2008 [8]. In the previous analysis, disease entities were defined based on the International Classification of Diseases 10th edition (ICD-10) and calculated incidence and survival according to broad disease groups such as non-Hodgkin lymphoma (C82–C85, C96), myeloid leukemia (C92–C94), and lymphoid leukemia (C91).

The main objective of the current study is to update the statistical data on hematologic malignancies, focusing on myeloid malignancies, with the most recent database of KCCR in 2012. Incidence and survival estimates were analyzed according to more detailed disease groups compared

Table 1. Incident cases of myeloid malignancies and trend in crude incidence rates and age-standardized incidence rates in Korea from 1999 to 2012.

		Year														APC
		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	
AML	Cases	880	833	936	1,033	1,034	1,070	1,073	1,104	1,113	1,224	1,292	1,246	1,311	1,257	
	CR	1.87	1.75	1.96	2.15	2.14	2.21	2.20	2.26	2.27	2.48	2.60	2.50	2.62	2.50	
	ASR	1.88	1.75	1.94	2.10	2.06	2.09	2.06	2.07	2.03	2.17	2.22	2.09	2.20	2.02	1.0[b]
Non-APL AML	Cases	796	749	867	941	956	980	943	996	991	1,091	1,135	1,082	1,150	1,104	
	CR	1.69	1.58	1.81	1.96	1.98	2.02	1.94	2.04	2.02	2.21	2.29	2.17	2.29	2.19	
	ASR	1.70	1.58	1.79	1.91	1.90	1.91	1.80	1.85	1.79	1.92	1.94	1.79	1.91	1.76	0.6
APL	Cases	84	84	69	92	78	90	130	108	122	133	157	164	161	153	
	CR	0.18	0.18	0.14	0.19	0.16	0.19	0.27	0.22	0.25	0.27	0.32	0.33	0.32	0.30	
	ASR	0.18	0.18	0.14	0.19	0.16	0.18	0.26	0.21	0.24	0.25	0.28	0.30	0.29	0.27	5.2[b]
MPN[a]	Cases	-	-	-	-	681	746	851	867	985	1,070	1,138	1,215	1,301	1,274	
	CR	-	-	-	-	1.41	1.54	1.75	1.77	2.00	2.17	2.29	2.44	2.60	2.53	
	ASR	-	-	-	-	1.34	1.42	1.58	1.56	1.73	1.82	1.86	1.96	2.03	1.95	4.7[b]
CML	Cases	-	-	-	-	322	383	345	371	364	399	377	448	478	458	
	CR	-	-	-	-	0.67	0.79	0.71	0.76	0.74	0.81	0.76	0.90	0.95	0.91	
	ASR	-	-	-	-	0.64	0.75	0.66	0.69	0.68	0.72	0.66	0.78	0.80	0.76	1.7[b]
Non-CML MPN	Cases	-	-	-	-	359	363	506	496	621	671	761	767	823	816	
	CR	-	-	-	-	0.74	0.75	1.04	1.01	1.26	1.36	1.53	1.54	1.64	1.62	
	ASR	-	-	-	-	0.69	0.67	0.92	0.87	1.05	1.10	1.19	1.18	1.23	1.19	7.1[b]
MDS[a]	Cases	-	-	-	-	393	414	467	482	555	635	713	763	855	813	
	CR	-	-	-	-	0.81	0.85	0.96	0.99	1.13	1.29	1.44	1.53	1.71	1.61	
	ASR	-	-	-	-	0.76	0.77	0.85	0.84	0.93	1.03	1.11	1.13	1.25	1.13	5.8[b]
MDS/MPN[a]	Cases	-	-	-	-	32	36	2	25	37	42	48	60	77	86	
	CR	-	-	-	-	0.07	0.07	0.05	0.05	0.08	0.09	0.10	0.12	0.15	0.17	
	ASR	-	-	-	-	0.06	0.07	0.05	0.04	0.06	0.07	0.08	0.09	0.11	0.12	9.3[b]
Unknown myeloid neoplasms	Cases	375	357	348	377	335	343	341	341	351	310	326	345	341	341	
	CR	0.80	0.75	0.73	0.78	0.69	0.71	0.70	0.70	0.71	0.63	0.66	0.69	0.68	0.68	
	ASR	0.81	0.75	0.71	0.75	0.65	0.64	0.62	0.61	0.60	0.52	0.51	0.53	0.51	0.48	−3.8[b]
All myeloid malignancies	Cases	1,255	1,190	1,284	1,410	2,475	2,609	2,758	2,819	3,041	3,281	3,517	3,629	3,885	3,771	
	CR	2.66	2.50	2.68	2.93	5.12	5.38	5.67	5.77	6.19	6.64	7.08	7.28	7.75	7.49	
	ASR	2.70	2.50	2.65	2.85	4.86	5.00	5.16	5.13	5.35	5.61	5.78	5.80	6.10	5.70	7.4[b]

[a]Official registration employing ICD-O-3 began in 2003 at KCCR. [b]The annual percent change is statistically significantly different from zero ($P < 0.05$).

Abbreviations: CR, crude incidence rate; ASR, age-standardized incidence rate; APC, annual percentage change; APL, acute promyelocytic leukemia; AML, acute myeloid leukemia; CML, chronic myelogenous leukemia; MPN, myeloproliferative neoplasia; MDS, myelodysplastic syndrome.

to the previous report, using the ICD-O-3 codes. We also investigated recent epidemiologic changes of myeloid malignancies for decades in Korea with database from 1999 to 2012.

MATERIALS AND METHODS

Incident cases of myeloid malignancies between 1999 and 2012 were obtained from the Korean National Cancer Incidence Database (KNCIDB) [9]. Myeloid malignancies were defined according to the revised version of ICD-O-3 (2013) and each code was categorized as shown in Supplementary Table 1, taking into account the clinical relevance. Myeloid malignancies were grouped into five categories: AML, MPN, MDS, MDS/MPN, and unknown myeloid neoplasms. AML and MPN were further divided into two subgroups as shown in Table 1, in consideration with acute promyelocytic leukemia (APL) and chronic myelogenous leukemia (CML), those have unique characteristics, treatments, and clinical outcomes separated from non-APL AML and non-CML MPN. For MPN, MDS, and MDS/MPN, incident cases between 1999 and 2002 were not included in this analysis because official registration by KCCR employing ICD-O-3 began in 2003. Codes for these categories by ICD-O-3 had significantly changed, but it could not be converted from old data.

Crude incidence rates (CRs) and age-specific incidence rates of each myeloid malignancy were calculated. The CRs per 100,000, an incidence rate based on the frequency of cancer in the entire population, were calculated by dividing the total number of events (N) by the total number of person-year of observation (P) and multiplying the result by 100,000. The age-specific incidence rates per 100,000 within age group i, were calculated by dividing the number of incidence observed in the age group (N_i) by the number of corresponding person-year of observation (P_i) and multiplying the result by 100,000. Age-standardized incidence rates (ASRs), weighted average of crude age-specific rates, were determined by using the mid-year population in Korea in 2000 as the standard population. Both age-specific incidence rates and ASRs were calculated according to age group: <14, 15–34, 35–49, 50–64, 65–79, and ≥80 years. Changes in the annual ASRs were examined by calculating the annual percentage change (APC) over a time period as (exp(b)-1)×100, where b is the slope of the regression of log(ASR) on a calendar year using the following linear regression equation [10]:

$$E(\log(ASR)|year) = a + b\,year$$

For the survival analysis, five-year relative survival rates were calculated. To find any changes for recent decades, KNCIDB data from 1996 to 2012 were included. The survival status of these patients was followed until December 31, 2013. Five-year relative survival (RS) rates for AML, and unknown myeloid neoplasms were calculated according to four periods of diagnosis: 1996–2000, 2001–2005, 2006–2010, and 2008–2012. RS for MPN, MDS, and MDS/MPN were calculated according to three periods of diagnosis (2001–2005, 2006–2010, and 2008–2012) since data before 2003 for these entities were not reliable. RS rates were developed by comparing the observed survival in the cancer patient group with the expected survival of the general population [11]. Five- year RS rates using the Ederer II method were based on an algorithm written by Paul Dickman in SAS [12, 13]. All analyses were performed using SAS version 9.2.

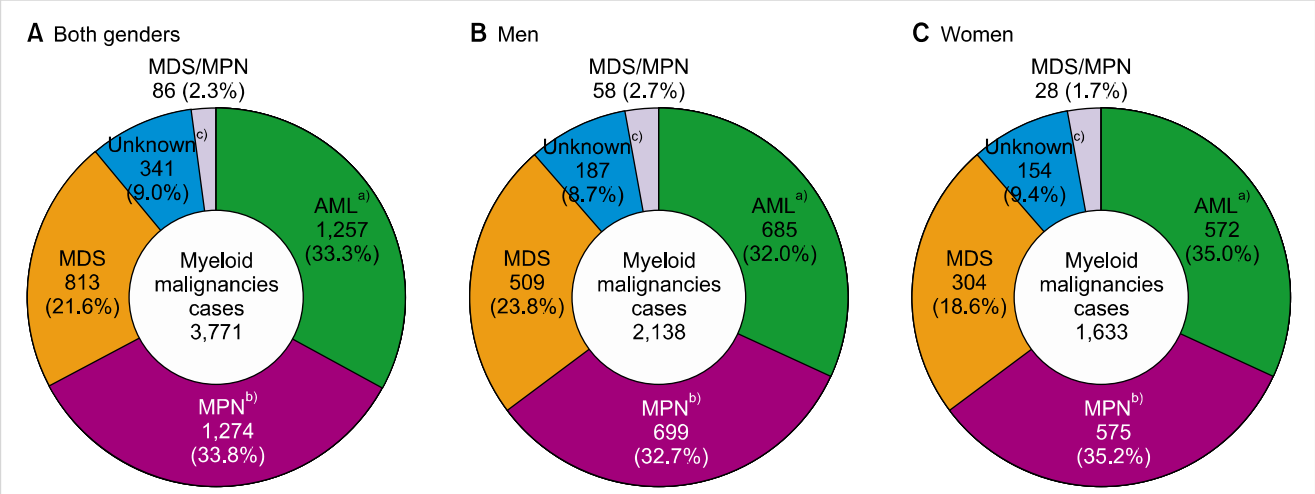


Fig. 1. Incident cases of myeloid malignancies in men **(B)** and women **(C)** in Korea, 2012. [a]AML cases include 153 cases of APL in both genders (77 cases in men, and 76 cases in women); [b]MPN cases include 458 cases of CML in both genders (288 cases in men, and 170 cases in women); [c]Unknown cases include 15 cases of acute leukemia, ambiguous lineage in both genders (7 cases in men, 8 cases in women).
Abbreviations: AML, acute myeloid leukemia; MPN, myeloproliferative neoplasms; MDS, myelodysplastic syndrome; MDS/MPN, myelodysplastic/myeloproliferative neoplasms.

RESULTS

Incidence

The overall number of incident cases for all neoplastic diseases in 2012 was 224,177. Myeloid malignancies occurred in 3,771 patients, which was 1.7% of all cancers (Fig. 1). It occurred in 2,138 men and 1,633 women, with a ratio of 1.3:1. Among all myeloid malignancies, AML (33.3%) was the most frequent, followed by MPN (33.8%), and MDS (21.6%). There was no significant difference between men and women.

Crude rates and age-specific incidence of myeloid malignancies by age group in 2012 were shown in Fig. 2 and 3, respectively. Patients with ages between 70 and 79 showed the highest CR of myeloid malignancies followed by ages 60 to 69, and ages 50 to 59. AML was most prevalent in patients who were less than 49 years old and those aged 60 to 69, while MPN and MDS were most prevalent in patients 50 to 59 years old and older than 70 years, respectively (Fig. 2). For age-specific incidence rates in 2012, AML was the most common myeloid disease in men patients younger than 50 years old. However, MDS surpassed AML in elderly patients with an age of 65 or more. In women, AML showed the highest incidence rate in patients up to 34 years old, and MPN substituted AML in ages above 35

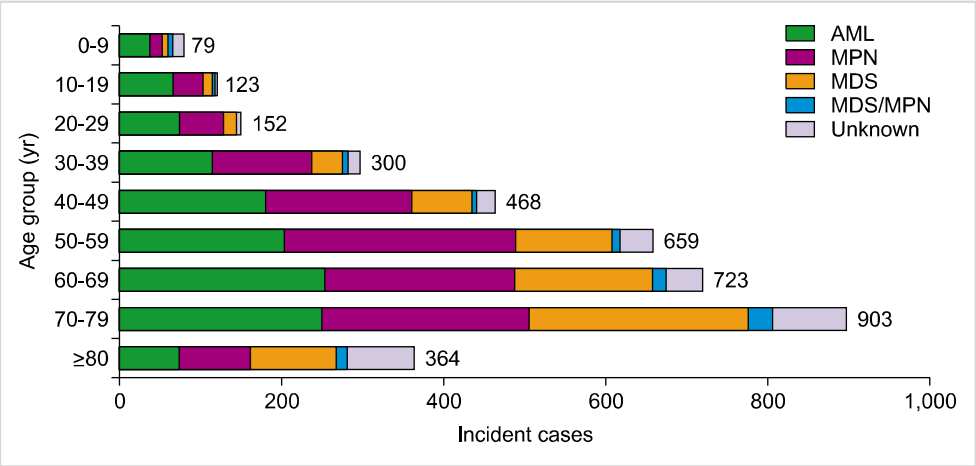
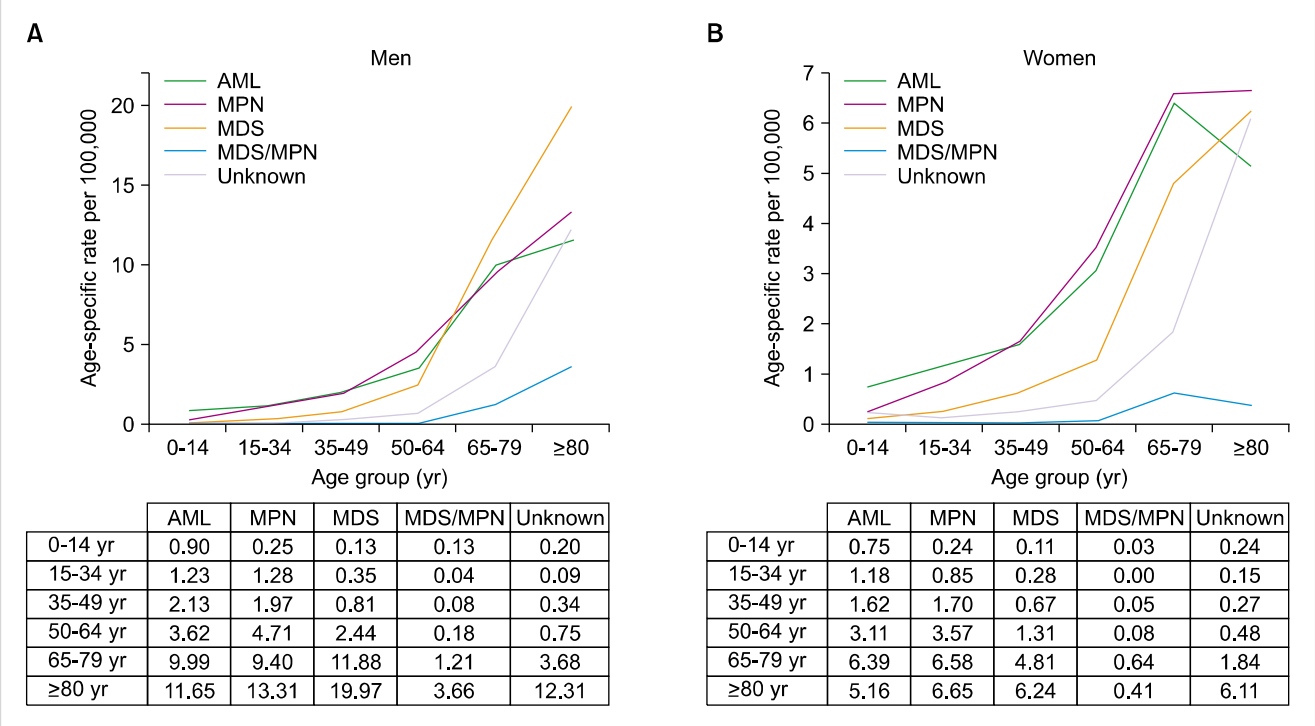


Fig. 2. Incident cases of myeloid malignancies by age group in Korea, 2012.
Abbreviations: same as in Fig. 1.



	AML	MPN	MDS	MDS/MPN	Unknown
0-14 yr	0.90	0.25	0.13	0.13	0.20
15-34 yr	1.23	1.28	0.35	0.04	0.09
35-49 yr	2.13	1.97	0.81	0.08	0.34
50-64 yr	3.62	4.71	2.44	0.18	0.75
65-79 yr	9.99	9.40	11.88	1.21	3.68
≥80 yr	11.65	13.31	19.97	3.66	12.31

	AML	MPN	MDS	MDS/MPN	Unknown
0-14 yr	0.75	0.24	0.11	0.03	0.24
15-34 yr	1.18	0.85	0.28	0.00	0.15
35-49 yr	1.62	1.70	0.67	0.05	0.27
50-64 yr	3.11	3.57	1.31	0.08	0.48
65-79 yr	6.39	6.58	4.81	0.64	1.84
≥80 yr	5.16	6.65	6.24	0.41	6.11

Fig. 3. Age-specific incidence rates of myeloid malignancies in men (A) and in women (B) in Korea, 2012.
Abbreviations: same as in Fig. 1.

Table 2. Five-year relative survival rates of myeloid malignancies by age group in Korea.

	Age (yr)	Year							
		1996–2000		2001–2005		2006–2010		2008–2012	
		Cases	Relative survival	Cases	Relative survival	Cases	Relative survival	Cases	Relative survival
AML	Total	3,816	26.3	4,897	30.7	5,577	34.3	5,802	34.8
	0–14	516	41.8	499	51.0	431	59.5	410	62.4
	15–34	910	38.2	958	46.2	856	55.1	832	58.7
	35–49	941	29.7	1,211	39.7	1,241	48.4	1,221	48.3
	50–64	888	14.2	1,180	20.2	1,413	31.0	1,508	33.5
	65–79	514	5.0	944	7.2	1,423	8.7	1,564	9.4
	≥80	47	3.8	105	6.8	213	0.8	267	0.0
Non-APL AML	Total	3,476	23.8	4,454	27.1	4,934	29.3	5,089	29.9
	0–14	480	39.9	464	50.1	391	56.3	366	59.8
	15–34	815	35.4	827	40.9	701	50.1	682	54.1
	35–49	825	26.6	1,044	35.7	1,028	42.7	984	42.1
	50–64	821	11.9	1,101	17.2	1,244	25.8	1,317	29.1
	65–79	491	4.7	913	6.5	1,359	7.0	1,477	7.7
	≥80	44	4.0	105	6.8	211	0.8	263	0.0
APL	Total	340	51.6	443	66.0	643	72.2	713	69.6
	0–14	36	66.8	35	62.9	40	90.1	44	86.2
	15–34	95	62.3	131	79.6	155	77.8	150	79.6
	35–49	116	52.4	167	64.7	213	75.8	237	74.9
	50–64	67	42.2	79	61.7	169	69.2	191	64.0
	65–79	23	10.4	31	28.5	64	44.8	87	41.1
	≥80	3	0	0	-	2	0	4	0
MPN[a]	Total	-	-	2,120	81.8	5,000	86.4	5,660	87.1
	0–14	-	-	41	73.2	85	89.5	86	93.3
	15–34	-	-	308	87.0	639	93.5	693	94.4
	35–49	-	-	567	90.0	1,180	94.4	1,215	94.7
	50–64	-	-	645	84.1	1,425	90.3	1,690	91.1
	65–79	-	-	501	67.8	1,447	77.0	1,681	78.4
	≥80	-	-	58	60.8	224	47.7	295	53.0
CML	Total	-	-	980	74.5	1,844	83.7	2,016	85.5
	0–14	-	-	34	67.7	49	83.8	41	91.4
	15–34	-	-	228	82.7	395	92.0	421	93.1
	35–49	-	-	297	85.2	539	91.5	551	91.4
	50–64	-	-	246	72.8	469	85.3	546	87.5
	65–79	-	-	160	50.5	334	67.2	391	71.5
	≥80	-	-	15	0.0	58	16.8	66	20.3
Non-CML MPN	Total	-	-	1,140	88.1	3,156	88.0	3,644	88.1
	0–14	-	-	7	100.2	36	97.4	45	95.8
	15–34	-	-	80	99.1	244	95.8	272	96.5
	35–49	-	-	270	95.3	641	96.8	664	97.6
	50–64	-	-	399	91.0	956	92.7	1,144	92.8
	65–79	-	-	341	75.9	1,113	79.9	1,290	80.4
	≥80	-	-	43	80.8	166	58.2	229	60.1
MDS[a]	Total	-	-	1,029	45.6	2,863	42.2	3,435	44.0
	0–14	-	-	52	65.5	52	82.8	54	78.4
	15–34	-	-	125	73.0	223	75.7	231	77.5
	35–49	-	-	174	59.9	456	63.5	512	66.4
	50–64	-	-	289	45.1	731	47.2	846	50.3
	65–79	-	-	336	28.8	1,230	24.6	1,497	27.5
	≥80	-	-	53	6.6	171	16.8	295	22.9
MDS/MPN[a]	Total	-	-	88	27.3	197	29.6	290	31.7
	0–14	-	-	16	50.2	33	63.8	41	70.0
	15–34	-	-	4	25.1	3	33.4	3	0
	35–49	-	-	13	31.3	21	48.0	28	53.6
	50–64	-	-	18	23.2	37	24.1	47	27.4
	65–79	-	-	34	18.3	84	18.5	133	17.4
	≥80	-	-	3	0	19	0	38	0
Unknown myeloid neoplasms	Total	1,180	22.9	1,381	29.6	1,359	39.5	1,357	41.1
	0–14	133	44.4	121	56.3	111	67.2	91	75.6
	15–34	186	29.2	163	36.3	144	51.9	124	55.6
	35–49	161	29.1	171	43.8	177	59.3	173	58.4
	50–64	291	21.0	285	33.4	257	49.0	243	55.1
	65–79	351	10.7	505	18.5	472	25.8	500	28.8
	≥80	58	12.8	136	8.9	198	12.4	226	11.1
All myeloid malignancies	Total	4,996	25.5	9,515	43.5	14,996	53.6	16,544	55.1
	0–14	649	42.3	729	54.1	712	66.1	682	69.6
	15–34	1,096	36.7	1,558	55.3	1,865	70.4	1,883	73.7
	35–49	1,102	29.6	2,136	55.0	3,075	68.9	3,149	69.8
	50–64	1,179	15.9	2,417	41.8	3,863	57.1	4,334	60.2
	65–79	865	7.3	2,320	26.1	4,656	36.2	5,375	38.4
	≥80	105	8.7	355	16.3	825	19.3	1,121	21.6

[a]Official registration employing ICD-O-3 began in 2003 at KCCR.
Abbreviations: same as in Table 1.

years (Fig. 3).

The incident cases of myeloid malignancies and trend in CR and ASR between 1999 and 2012 was shown briefly in Table 1 (for detailed data, see Supplementary Table 2). During the study period, 36,924 cases of myeloid malignancies occurred. The overall ASR of all myeloid malignancies increased from 2.7 in 1999 to 5.7 in 2012. The APC was 7.4% between 1999 and 2012, which was higher than the APC of 3.5% for all cancers, and it was statistically significant. The ASRs increased from 1.88 to 2.02 in AML (APC=1.0%, $P<0.05$), from 1.70 to 1.76 in non-APL AML (APC=0.6%, not significant), from 0.18 to 0.27 in APL (APC=5.2%, $P<0.05$) from 1999 to 2012. The ASRs in MPN also increased from 1.34 to 1.95 (APC=4.7%, $P<0.05$), from

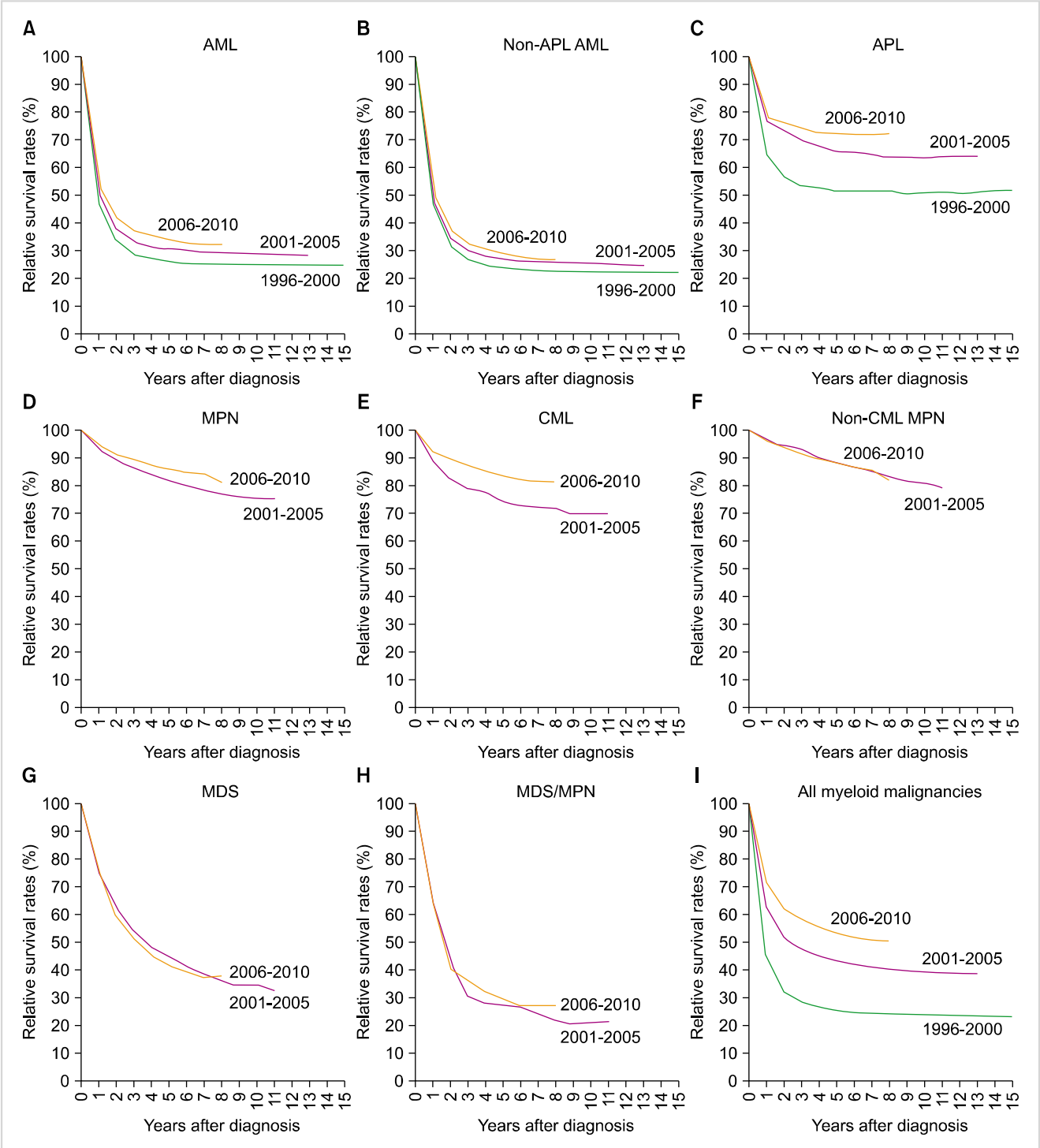


Fig. 4. Trend in relative survival rate of myeloid malignances between 1996 and 2010 in Korea.
Abbreviations: same as in Fig. 1.

0.64 to 0.76 in CML (APC=1.7%, $P<0.05$), from 0.69 to 1.19 in non-CML MPN (APC=7.1%, $P<0.05$), from 2003 to 2012. Similar increasing trends were observed both in MDS and MDS/MPN, from 0.76 to 1.13 in MDS (APC=5.8%, $P<0.05$) and from 0.06 to 0.12 in MDS/MPN (APC=9.3%, $P<0.05$) between 2003 and 2012, respectively. The number of unknown myeloid neoplasms had decreased, but still counted up to 341 cases in 2012.

Survival rates

Five-year RS rates for patients with myeloid malignancies for four intervals (1996–2000, 2001–2005, 2006–2010, and 2008–2012) stratified by years and age are described in Table 2. RS varied between the disease entities: being 34.8% for AML (29.9 % for non-APL AML and 69.6% for APL), 87.1% for MPN (85.5% for CML and 88.1% for non-CML MPN), 44% for MDS, and 31.7% for MDS/MPN in 2008–2012.

More detailed survival data for subcategories are described in Supplementary Table 3. Polycythemia vera showed the most favorable outcome with a 5-year relative survival rate of 99.7%, followed by essential thrombocythemia with a rate of 90.3%. Poor survival in some disease entities, such as AML with multilineage dysplasia or transformed AML from MDS (17.8%), acute panmyelosis with fibrosis (13.9%), MDS-refractory anemia with excess blasts (24.3%), and chronic myelomonocytic leukemia (23.2%), was noted. In most cases, the RS of the patients with myeloid malignancies decreased as their age increased.

Five-year RS for all myeloid malignancies has gradually improved recently, from 25.5% in 1996–2000 to 55.1% in 2008–2012, with an increase of 29.6%. For last few decades, survival rates for most myeloid malignancies improved except for non-CML MPN, and MDS. Specifically, 5-year RS rates changed from 26.3% to 34.8% in AML from 1996–2000 to 2008–2012 (from 23.8% to 29.9% in non-APL AML, and 51.6% to 69.6% in APL). The 5-year RS rates increased from 81.8% to 87.1% in MPN, with significant improvement in CML (from 74.5% to 85.5%), from 2001–2005 to 2008–2012. Survival in MDS/MPN also increased from 27.3% to 31.7% from 2001–2005 to 2008–2012. However, there was no improvement of relative survival in MDS during the study period (45.6% in 2001–2005 to 44.4% in 2008–2012). Changes in survival curves for myeloid diseases are shown in Fig. 4.

DISCUSSION

We showed the epidemiologic data for myeloid malignancies in Korea between 1996 and 2012, updating the previous report [8], which had focused on analyzing the basic characteristics and past survival rates of domestic hematologic malignancies roughly classified according to ICD-10 code [14]. In this study, we adopted the latest ICD-O-3 codes [3] and the WHO classifications [1] to distinguish many different subcategories based on the cell lineage, histologic/genetic characteristics, and clinical prognosis, to avoid grouping clinically different diseases together as a single vague entity such as 'myeloid leukemia'. Analysis with subcategories enriched this study with data closely related to real-life practice, although it caused some artifacts in survival estimates owing to the small number of rare diseases.

Calculating population-based relative survival can measure survival improvement in each myeloid malignancy, which can be more easy compared to conventional cohort approaches or clinical trials. In Korea, the KNCIDB includes entire annual population diagnosed with malignant diseases, which is enough to truly represent the nationwide status.

Consistent with the first report by KCCR [8], we found an increasing incidence of most myeloid malignancies by age and year at diagnosis. Furthermore, increasing incidences in MDS, MPN, MDS/MPN were also detected, which could not be calculated in the previous report. Age and environmental factors [15-17] can be considered a potential cause of inflated incidence. A similar change was observed in the European HAEMACARE project [18], but Korean ASRs of MDS and MPN are much lower than that of European, probably because of ethnic or regional differences. The increased number of cancer survivors owing to the improvements in overall cancer survival [19] also needs to be considered because the risk of myeloid malignancies increases after chemo- or radiotherapy [20], although the exact effect would be difficult to validate.

The relative survival for most myeloid malignancies was comparable to other country. Five-year survival of patients with AML (non-APL AML) was 29.9% in 2008–2012 and this is better than or comparable to European data (15% in 2006–2008) [21] and US data (25.9% in 2005–2011) [6]. Because the conventional chemotherapy with anthracycline and cytarabine has been widely applied for AML without significant change for years, prolonged survival may be due to the improvement in transplantation and supportive care such as anti-infective agents and immunosuppressive agents [22-24]. Best supportive care might influence on reduced early mortality in APL, with an introduction of arsenic trioxide for relapsed disease or frail patients to anthracycline.

For MDS, relative survival was significantly different between the subtypes, ranging from 24.3% for refractory anemia with excess blasts to 68.1% for MDS with 5q deletion. This is the first time that survival analysis according to the subtypes of MDS was performed.

Poor survival of patients with AML and high-risk MDS was more apparent in patients over 65 years old. It is well known that elderly AML or MDS patients are associated with unfavorable tumor biology compared to younger patients, but they also tend to be too frail to undergo intensive treatments, including hematopoietic stem cell transplantation required to induce the potential cure [25, 26]. Survival improvements in elderly AML and MDS were not apparent compared to younger patients so far. In Korea, hypomethylating agents were approved for elderly patients with AML [27]. We should find the effect of this noble treatment in the future analysis

In the presented data, relative survival of CML strikingly

increased in the 2000s, and became more apparent in the late 2000s. The main cause of such improvement is attributed to the introduction of tyrosine kinase inhibitors, as expected. In Korea, imatinib, the first tyrosine kinase inhibitor, was introduced in 2001 as a phase III clinical trial for approval. After its formal approval in 2006, this effective treatment has been prescribed widely. Five-year relative survival for patients with CML in our data (69.4% in 2001–2005 and 83.7% in 2006–2010) seems to be higher than in data from western countries (SEER database: 63.2% in 2005–2011 and EUROCARE data: 46% in 2003–2005) [6, 21], although direct comparison between the databases has many limitations.

In terms of unknown myeloid malignancies, acute leukemia with ambiguous lineage and other vague entities (leukemia, acute leukemia, and myeloid leukemia) that cannot be classified to any categories of the WHO classification. The proportion of cases reported with vague terms among all myeloid malignancies has decreased from 24.2% in 1999 to 8.6% in 2012. To reduce this proportion further, we should make an effort to diagnose the disease using exact terms and codes. Annual education and update of recent changes in classification of hematologic diseases should be provided for medical record administrators.

In summary, we found an increasing incidence according to age and year at diagnosis for most myeloid malignancies. Patient survival was also improved over the study periods, mainly because of a notable increase in survival of patients with APL and CML owing to the widespread use of more effective and less toxic treatments and supportive care. Serial reports of population-based cancer registry data enable us to monitor the improvements in survival associated with recent advances in diagnosis and treatment for hematologic malignancies. To perform this essential task, maintaining the quality of cancer registries through comprehensive data collection and monitoring, adequate education programs, and recruiting stable investment for resources are prerequisites. A qualified registry would provide more amount of informative evidence as to whether the recent changes in treatment do lead to improved survival.

Authors' Disclosures of Potential Conflicts of Interest

No potential conflicts of interest relevant to this article were reported.

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Supplementary Table 1. Classification of myeloid malignancies (ICD-O-3).

Site	ICD-O-3 code	Description
Acute myeloid leukemia		
Non-APL AML	9840	Acute erythroid leukemia
	9861	AML, NOS
	9867	Acute myelomonocytic leukemia
	9870	Acute basophilic leukemia
	9872	AML, minimal differentiation
	9873	AML without maturation
	9874	AML with maturation
	9891	Acute monocytic leukemia
	9910	Acute megakaryoblastic leukemia
	9930	Myeloid sarcoma
	9871	AML with abnormal marrow eosinophils
	9896	AML, t(8,21) (q22,q22)
	9897	AML, 11q23 abnormalities
	9895	AML, with multilineage dysplasia
	9984	Refractory anemia with excess blasts in transformation (obsolete)
	9931	Acute panmyelosis with myelofibrosis
	9920	Therapy-related myeloid neoplasms
Acute promyelocytic leukemia	9866	Acute promyelocytic leukemia t(15; 17) (q22;q11-12)
Myeloproliferative neoplsms		
Chronic myelogenous leukemia	9863	CML, NOS
	9875	Chronic myelogenous leukemia, BCR/ABL positive
Non-CML MPN	9950	Polycythemia vera
	9961	Myelosclerosis with myeloid metaplasia
	9962	Essential thrombocythemia
	9963	Chronic neutrophilic leukemia
	9964	Hypereosinophilic syndrome
	9960	Chronic myeloproliferative disease, NOS
	9740	Mast cell sarcoma
	9741	Malignant mastocytosis
	9742	Mast cell leukemia
Myelodysplastic syndrome	9980	Refractory anemia
	9982	Refractory anemia with sideroblasts
	9983	Refractory anemia with excess blasts
	9985	Refractory cytopenia with multilineage dysplasia
	9986	Myelodysplastic syndrome 5q deletion
	9987	Therapy-related myelodysplastic syndrome, NOS
	9989	Myelodysplastic syndrome, NOS
Myelodysplastic/myeloproliferative neoplasms	9945	Chronic myelomonocytic leukemia
	9876	Atypical CML, BCR/ABL-1 negative
	9946	Juvenile myelomonocytic leukemia
	9975	Myelodysplastic/myeloproliferative neoplasm, unclassifiable
Unknown myeloid neoplasms	9800	Leukemia, NOS
	9801	Acute leukemia, NOS
	9860	Myeloid leukemia, NOS
	9805	Acute leukemia, ambiguous lineage

Abbreviation: NOS, not otherwise specified.

Supplementary Table 2. Incident cases of myeloid malignancies and trend in crude incidence rates and age-standardized incidence rates in Korea from 1999 to 2012 (in detail).

ICD-O-3 code	ICD-O-3 description		Year														APC
			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	
Acute myeloid leukemia: Non-APL AML																	
9840	Acute erythroid leukemia	Cases	791	740	861	927	900	944	886	941	928	1,033	1,088	1,028	1,075	1,007	
9861	AML, NOS	CR	1.68	1.56	1.80	1.93	1.86	1.95	1.82	1.92	1.89	2.09	2.19	2.06	2.15	2.00	
9867	Acute myelomonocytic leukemia	ASR	1.69	1.56	1.78	1.88	1.78	1.84	1.69	1.75	1.68	1.82	1.87	1.71	1.80	1.61	0.1
9870	Acute basophilic leukemia		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
9872	AML, minimal differentiation		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
9873	AML without maturation		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
9874	AML with maturation		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
9891	Acute monocytic leukemia		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
9910	Acute megakaryoblastic leukemia		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
9930	Myeloid sarcoma		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
9871	AML with abnormal marrow eosinophils		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
9896	AML, t(8,21) (q22,q22)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
9897	AML, 11q23 abnormalities		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
9895	AML, with multilineage dysplasia	Cases	<5	<5	0	8	49	27	39	43	44	43	31	40	53	63	
9984	Refractory anemia with excess blasts	CR	0.00	0.00	0.00	0.02	0.10	0.06	0.08	0.09	0.09	0.09	0.06	0.08	0.11	0.13	
	in transformation (obsolete)	ASR	0.00	0.00	0.00	0.02	0.10	0.05	0.07	0.08	0.08	0.07	0.05	0.06	0.08	0.09	25.2[b]
9931	Acute panmyelosis with myelofibrosis	Cases	<5	7	6	6	7	9	15	10	18	13	10	9	19	21	
		CR	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.04	0.03	0.02	0.02	0.04	0.04	
		ASR	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.03	0.02	0.02	0.02	0.03	0.03	6.8[b]
Acute myeloid leukemia: APL																	
9866	Acute promyelocytic leukemia t(15; 17)	Cases	84	84	69	92	78	90	130	108	122	133	157	164	161	153	
	(q22;q11-12)	CR	0.18	0.18	0.14	0.19	0.16	0.19	0.27	0.22	0.25	0.27	0.32	0.33	0.32	0.30	
		ASR	0.18	0.18	0.14	0.19	0.16	0.18	0.26	0.21	0.24	0.25	0.28	0.30	0.29	0.27	5.2[b]
Myeloproliferative neoplasms: CML[a]																	
9863	CML, NOS	Cases	-	-	-	-	322	383	345	371	364	399	377	448	478	458	
9875	Chronic myelogenous leukemia,	CR	-	-	-	-	0.67	0.79	0.71	0.76	0.74	0.81	0.76	0.90	0.95	0.91	
	BCR/ABL Positive	ASR	-	-	-	-	0.64	0.75	0.66	0.69	0.68	0.72	0.66	0.78	0.80	0.76	1.7[b]
Myeloproliferative neoplasms: Non-CML MPN[a]																	
9950	Polycythemia vera	Cases	-	-	-	-	118	125	165	149	196	178	221	228	202	218	
		CR	-	-	-	-	0.24	0.26	0.34	0.30	0.40	0.36	0.45	0.46	0.40	0.43	
		ASR	-	-	-	-	0.23	0.23	0.30	0.26	0.33	0.29	0.35	0.35	0.30	0.33	4.0[b]
9961	Myelosclerosis with myeloid metaplasia	Cases	-	-	-	-	37	38	53	51	67	77	88	73	76	88	
		CR	-	-	-	-	0.08	0.08	0.11	0.10	0.14	0.16	0.18	0.15	0.15	0.17	
		ASR	-	-	-	-	0.07	0.07	0.09	0.09	0.11	0.12	0.13	0.11	0.10	0.12	5.8[b]
9962	Essential thrombocythemia	Cases	-	-	-	-	105	125	188	202	213	283	319	342	423	403	
		CR	-	-	-	-	0.22	0.26	0.39	0.41	0.43	0.57	0.64	0.69	0.84	0.80	
		ASR	-	-	-	-	0.20	0.23	0.34	0.36	0.36	0.46	0.50	0.52	0.64	0.59	12.9[b]
9963	Chronic neutrophilic leukemia	Cases	-	-	-	-	5	<5	6	<5	5	6	<5	<5	<5	<5	
		CR	-	-	-	-	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	
		ASR	-	-	-	-	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	−11.5
9964	Hypereosinophilic syndrome	Cases	-	-	-	-	34	22	27	28	56	74	74	70	53	35	
		CR	-	-	-	-	0.07	0.05	0.06	0.06	0.11	0.15	0.15	0.14	0.11	0.07	
		ASR	-	-	-	-	0.07	0.04	0.05	0.05	0.10	0.13	0.13	0.12	0.09	0.06	7.2
9960	Chronic myeloproliferative disease,	Cases	-	-	-	-	43	37	53	61	78	40	45	40	64	52	
	NOS	CR	-	-	-	-	0.09	0.08	0.11	0.12	0.16	0.08	0.09	0.08	0.13	0.10	
		ASR	-	-	-	-	0.08	0.07	0.09	0.10	0.13	0.06	0.07	0.06	0.09	0.07	−2.1
Myelodysplastic syndrome[a]																	
9980	Refractory anemia	Cases	-	-	-	-	76	56	77	73	60	84	61	55	50	59	
9982	Refractory anemia with sideroblasts	CR	-	-	-	-	0.16	0.12	0.16	0.15	0.12	0.17	0.12	0.11	0.10	0.12	
		ASR	-	-	-	-	0.15	0.11	0.14	0.13	0.10	0.14	0.10	0.08	0.08	0.08	−6.4[b]
9983	Refractory anemia with excess blasts	Cases	-	-	-	-	73	84	91	79	131	150	166	167	188	211	
		CR	-	-	-	-	0.15	0.17	0.19	0.16	0.27	0.30	0.33	0.33	0.38	0.42	
		ASR	-	-	-	-	0.14	0.16	0.17	0.14	0.22	0.24	0.25	0.24	0.27	0.29	8.9[b]
9985	Refractory cytopenia with multilineage	Cases	-	-	-	-	18	43	55	55	70	111	133	177	193	148	
	Dysplasia	CR	-	-	-	-	0.04	0.09	0.11	0.11	0.14	0.22	0.27	0.35	0.39	0.29	
		ASR	-	-	-	-	0.04	0.08	0.10	0.10	0.12	0.19	0.22	0.27	0.30	0.21	21.7[b]
9986	Myelodysplastic syndrome 5q deletion	Cases	-	-	-	-	0	<5	<5	<5	<5	<5	5	7	<5	6	
		CR	-	-	-	-	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.01	
		ASR	-	-	-	-	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.01	8.9

Supplementary Table 2. Continued.

ICD-O-3 code	ICD-O-3 description		Year														APC
			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	
Myelodysplastic/myeloproliferative neoplasms[a]																	
9945	Chronic myelomonocytic leukemia	Cases	-	-	-	-	26	27	22	21	30	25	33	45	54	60	
		CR	-	-	-	-	0.05	0.06	0.05	0.04	0.06	0.05	0.07	0.09	0.11	0.12	
		ASR	-	-	-	-	0.05	0.05	0.04	0.04	0.05	0.04	0.05	0.06	0.07	0.08	5.9[b]
9876	Atypical CML, BCR/ABL-1 negative	Cases	-	-	-	-	<5	<5	0	<5	<5	7	5	8	12	14	
		CR	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.03	
		ASR	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	30.8[b]
9946	Juvenile myelomonocytic leukemia	Cases	-	-	-	-	5	7	<5	<5	5	10	9	7	10	5	
		CR	-	-	-	-	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.01	
		ASR	-	-	-	-	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.01	8.5
9975	Myelodysplastic/myeloproliferative neoplasm, Unclassifiable	Cases	-	-	-	-	0	0	0	0	0	0	<5	0	<5	7	
		CR	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	
		ASR	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	71.6
Unknown myeloid neoplasms																	
9800	Leukemia, NOS	Cases	349	338	329	351	291	301	298	293	302	255	290	298	285	300	
9801	Acute leukemia, NOS	CR	0.74	0.71	0.69	0.73	0.60	0.62	0.61	0.60	0.61	0.52	0.58	0.60	0.57	0.60	
		ASR	0.76	0.71	0.67	0.69	0.56	0.55	0.53	0.51	0.51	0.41	0.44	0.45	0.41	0.42	−4.8[b]
9860	Myeloid leukemia, NOS	Cases	25	17	18	8	12	14	17	12	20	13	10	31	27	26	
		CR	0.053	0.036	0.038	0.017	0.025	0.029	0.035	0.025	0.041	0.026	0.02	0.062	0.054	0.052	
		ASR	0.054	0.036	0.037	0.016	0.023	0.026	0.033	0.022	0.033	0.022	0.015	0.047	0.041	0.036	−0.4
9805	Acute leukemia, ambiguous lineage	Cases	<5	<5	<5	18	32	28	26	36	29	42	26	16	29	15	
		CR	0.00	0.00	0.00	0.04	0.07	0.06	0.05	0.07	0.06	0.09	0.05	0.03	0.06	0.03	
		ASR	0.00	0.00	0.00	0.04	0.07	0.06	0.05	0.07	0.06	0.09	0.06	0.03	0.06	0.03	21.9[b]
All myeloid malignancies[C]		Cases	1,255	1,190	1,284	1,410	2,475	2,609	2,758	2,819	3,041	3,281	3,517	3,629	3,885	3,771	
		CR	2.66	2.50	2.68	2.93	5.12	5.38	5.67	5.77	6.19	6.64	7.08	7.28	7.75	7.49	
		ASR	2.70	2.50	2.65	2.85	4.86	5.00	5.16	5.13	5.35	5.61	5.78	5.80	6.10	5.70	7.4[b]

[a]Official registration employing ICD-O-3 began in 2003 at KCCR, [b]The annual percent change is statistically significantly different from zero ($P<0.05$), [C]ICD-O-3 codes 9920, 9740, 9741, 9742, 9987, and 9989 were included in all myeloid malignancies.
Abbreviations: CR, crude incidence rate; ASR, age-standardized incidence rate; APC, annual percentage change; APL, acute promyelocytic leukemia; AML, acute myeloid leukemia; CML, chronic myelogenous leukemia; MPN, myeloproliferative neoplasms; NOS, not otherwise specified.

Supplementary Table 3. Five-year relative survival rates of myeloid malignancies by age group in Korea (in detail).

ICD-O-3 code	ICD-O-3 description	Age (yr)	Year							
			1996–2000		2001–2005		2006–2010		2008–2012	
			Cases	Relative survival	Cases	Relative survival	Cases	Relative survival	Cases	Relative survival
Acute myeloid leukemia: Non-APL AML										
9840	Acute erythroid leukemia	Total	3,452	23.7	4,297	27.4	4,686	29.8	4,810	30.5
9861	AML, NOS	0–14	479	40.0	452	50.3	382	57.3	362	60.3
9867	Acute myelomonocytic leukemia	15–34	811	35.3	808	41.1	676	50.5	667	54.8
9870	Acute basophilic leukemia	35–49	823	26.5	1,010	35.8	978	43.3	931	42.4
9872	AML, minimal differentiation	50–64	812	11.7	1,046	17.3	1,158	26.7	1,218	30.4
9873	AML without maturation	65–79	485	4.3	880	6.5	1,287	6.7	1,379	7.3
9874	AML with maturation	≥80	42	0.0	101	7.1	205	0.8	253	0.0
9891	Acute monocytic leukemia	-	-	-	-	-	-	-	-	-
9910	Acute megakaryoblastic leukemia	-	-	-	-	-	-	-	-	-
9930	Myeloid sarcoma	-	-	-	-	-	-	-	-	-
9871	AML with abnormal marrow eosinophils	-	-	-	-	-	-	-	-	-
9896	AML, t(8,21) (q22,q22)	-	-	-	-	-	-	-	-	-
9897	AML, 11q23 abnormalities	-	-	-	-	-	-	-	-	-
9895	AML, with multilineage dysplasia	Total	9	37.1	118	20.1	189	20.1	211	17.8
9984	Refractory anemia with excess blasts in transformation (obsolete)	0–14	1	0.0	9	55.6	4	50.0	1	0.0
		15–34	4	50.3	15	20.1	19	40.7	11	0.0
		35–49	1	102.5	32	28.5	43	31.9	45	37.3
		50–64	1	0.0	39	13.4	69	17.9	76	14.1
		65–79	1	0.0	21	5.6	49	4.0	69	9.4
		≥80	1	0.0	2	0.0	5	0.0	9	0.0
9931	Acute panmyelosis with myelofibrosis	Total	15	46.2	38	24.9	57	20.4	66	13.9
		0–14	0	-	3	0.0	5	0.0	3	0.0
		15–34	0	-	4	75.4	6	33.4	4	50.1
		35–49	1	0.0	2	101.0	7	29.0	8	0.0
		50–64	8	39.8	15	20.7	15	0.0	21	0.0
		65–79	5	47.4	12	9.5	23	34.1	29	13.3
		≥80	1	162.7	2	0.0	1	0.0	1	0.0
Acute myeloid leukemia: APL										
9866	Acute promyelocytic leukemia t(15; 17) (q22;q11–12)	Total	340	51.6	443	66.0	643	72.2	713	69.6
		0–14	36	66.8	35	62.9	40	90.1	44	86.2
		15–34	95	62.3	131	79.6	155	77.8	150	79.6
		35–49	116	52.4	167	64.7	213	75.8	237	74.9
		50–64	67	42.2	79	61.7	169	69.2	191	64.0
		65–79	23	10.4	31	28.5	64	44.8	87	41.1
		≥80	3	0.0	0	-	2	0.0	4	0.0
Myeloproliferative neoplasms: CML[a)]										
9863	CML, NOS	Total	-	-	980	74.5	1,844	83.7	2,016	85.5
9875	Chronic myelogenous leukemia, BCR/ABL positive	0–14	-	-	34	67.7	49	83.8	41	91.4
		15–34	-	-	228	82.7	395	92.0	421	93.1
		35–49	-	-	297	85.2	539	91.5	551	91.4
		50–64	-	-	246	72.8	469	85.3	546	87.5
		65–79	-	-	160	50.5	334	67.2	391	71.5
		≥80	-	-	15	0	58	16.8	66	20.3
Myeloproliferative neoplasms: Non-CML MPN[a)]										
9950	Polycythemia vera	Total	-	-	396	95.5	942	98.4	1,015	99.7
9961	Myelosclerosis with myeloid metaplasia	Total	-	-	124	53.4	338	52.9	378	54.6
9962	Essential thrombocythemia	Total	-	-	409	93.9	1,321	92.3	1,708	90.3
9963	Chronic neutrophilic leukemia	Total	-	-	12	54.5	13	65.3	12	34.2
9964	Hypereosinophilic syndrome	Total	-	-	81	96.6	298	94.1	300	95.6
9960	Chronic myeloproliferative disease, NOS	Total	-	-	115	77.2	242	67.5	229	66.4

Supplementary Table 3. Continued.

ICD-O-3 code	ICD-O-3 description	Age(yr)	Year							
			1996–2000		2001–2005		2006–2010		2008–2012	
			Cases	Relative survival	Cases	Relative survival	Cases	Relative survival	Cases	Relative survival
Myelodysplastic syndrome[a]										
9980	Refractory anemia	Total	-	-	193	60.1	318	60.8	292	65.0
9982	Refractory anemia with sideroblasts	-	-	-	-	-	-	-	-	-
9983	Refractory anemia with excess blasts	Total	-	-	226	23.7	646	20.4	809	24.3
9985	Refractory cytopenia with multilineage dysplasia	Total	-	-	108	63.5	501	52.9	706	54.4
9986	Myelodysplastic syndrome 5q deletion	Total	-	-	5	82.8	15	40.7	21	68.1
Myelodysplastic/myeloproliferative neoplasms[a]										
9945	Chronic myelomonocytic leukemia	Total	-	-	69	21.3	139	23.3	195	23.2
9876	Atypical CML, BCR/ABL-1 negative	Total	-	-	3	34.9	23	14.2	45	0.0
9946	Juvenile myelomonocytic leukemia	Total	-	-	16	50.2	34	65.0	41	70.4
9975	Myelodysplastic/myeloproliferative neoplasm, unclassifiable	Total	-	-	0	-	1	0.0	9	0.0
Unknown myeloid neoplasms										
9800	Leukemia, NOS	Total	1,094	22.6	1,217	29.4	1,146	39.9	1,143	41.6
9801	Acute leukemia, NOS	0–14	119	45.5	85	55.4	61	65.7	56	73.3
		15–34	170	29.6	125	37.7	105	56.4	88	61.2
		35–49	148	27.5	141	46.0	140	66.1	132	64.8
		50–64	267	21.3	252	34.9	220	51.7	207	57.3
		65–79	332	10.2	479	19.3	433	27.3	454	30.5
		≥80	58	12.8	135	9.0	187	12.5	206	11.4
9860	Myeloid leukemia, NOS	Total	81	26.1	59	26.7	75	37.9	94	38.5
		0–14	13	30.8	3	66.8	3	100.1	4	0.0
		15–34	14	21.6	9	33.4	7	28.6	5	40.1
		35–49	12	50.7	7	57.9	14	64.9	21	66.8
		50–64	23	18.6	19	27.4	17	54.6	16	57.3
		65–79	19	19.7	20	5.7	24	14.8	31	0.0
		≥80	0	-	1	0.0	10	0.0	17	0.0
9805	Acute leukemia, ambiguous lineage	Total	5	40.3	105	34.5	138	37.8	120	40.5
All myeloid malignancies[b]		Total	4,996	25.5	9,515	43.5	14,996	53.6	16,544	55.1
		0–14	649	42.3	729	54.1	712	66.1	682	69.6
		15–34	1,096	36.7	1,558	55.3	1,865	70.4	1,883	73.7
		35–49	1,102	29.6	2,136	55.0	3,075	68.9	3,149	69.8
		50–64	1,179	15.9	2,417	41.8	3,863	57.1	4,334	60.2
		65–79	865	7.3	2,320	26.1	4,656	36.2	5,375	38.4
		≥80	105	8.7	355	16.3	825	19.3	1,121	21.6

[a]Official registration employing ICD-O-3 began in 2003 at KCCR, [b]ICD-O-3 codes 9920, 9740, 9741, 9742, 9987, and 9989 were included in all myeloid malignancies.
Abbreviations: same as in Supplementary Table 2.