Worldwide trends in population-based survival for children, adolescents, and young adults diagnosed with leukaemia, by subtype, during 2000–14 (CONCORD-3): analysis of individual data from 258 cancer registries in 61 countries

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Summary

Background Leukaemias comprise a heterogenous group of haematological malignancies. In CONCORD-3, we analysed data for children (aged 0–14 years) and adults (aged 15–99 years) diagnosed with a haematological malignancy during 2000–14 in 61 countries. Here, we aimed to examine worldwide trends in survival from leukaemia, by age and morphology, in young patients (aged 0–24 years).

Methods We analysed data from 258 population-based cancer registries in 61 countries participating in CONCORD-3 that submitted data on patients diagnosed with leukaemia. We grouped patients by age as children (0–14 years), adolescents (15–19 years), and young adults (20–24 years). We categorised leukaemia subtypes according to the International Classification of Childhood Cancer (ICCC-3), updated with International Classification of Diseases for Oncology, third edition (ICD-O-3) codes. We estimated 5-year net survival by age and morphology, with 95% CIs, using the non-parametric Pohar-Perme estimator. To control for background mortality, we used life tables by country or region, single year of age, single calendar year and sex, and, where possible, by race or ethnicity. All-age survival estimates were standardised to the marginal distribution of young people with leukaemia included in the analysis.

Findings 164 563 young people were included in this analysis: 121 328 (73·7%) children, 22 963 (14·0%) adolescents, and 20 272 (12·3%) young adults. In 2010–14, the most common subtypes were lymphoid leukaemia (28 205 [68·2%] patients) and acute myeloid leukaemia (7863 [19·0%] patients). Age-standardised 5-year net survival in children, adolescents, and young adults for all leukaemias combined during 2010–14 varied widely, ranging from 46% in Mexico to more than 85% in Canada, Cyprus, Belgium, Denmark, Finland, and Australia. Individuals with lymphoid leukaemia had better age-standardised survival (from 43% in Ecuador to ≥80% in parts of Europe, North America, Oceania, and Asia) than those with acute myeloid leukaemia (from 32% in Peru to ≥70% in most high-income countries in Europe, North America, and Oceania). Throughout 2000–14, survival from all leukaemias combined remained consistently higher for children than adolescents and young adults, and minimal improvement was seen for adolescents and young adults in most countries.

Interpretation This study offers the first worldwide picture of population-based survival from leukaemia in children, adolescents, and young adults. Adolescents and young adults diagnosed with leukaemia continue to have lower survival than children. Trends in survival from leukaemia for adolescents and young adults are important indicators of the quality of cancer management in this age group.

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Introduction

Leukaemias comprise a heterogenous group of haematological malignancies, mostly with unknown causes.[1] The estimated world-standardised incidence rate during 2001–10 was 46·4 per million person-years in children (aged 0–14 years), compared to 28·5 per million person-years in adolescents (aged 15–19 years).[2] Leukaemias represented 36·1% of all cancers in very young children (aged 0–4 years), compared with 15·4% of all cancers in adolescents.

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Research in context

Evidence before this study

Cancer in young people (aged 0–24 years) is rare and the extent of its burden in this population is often unknown, especially in low-income and middle-income countries. Predominantly seen in childhood, acute lymphoblastic leukaemia has a more favourable prognosis in children than in adolescents and young adults. Individuals diagnosed with acute myeloid leukaemia have poorer survival than those with acute lymphoblastic leukaemia; survival is often lower in adolescents and young adults than in children. Advances in treatment and supportive care for children diagnosed with leukaemia have greatly improved survival, especially in high-income countries.
We searched PubMed for English-language research articles using a combination of the following keywords: "("children" AND "adolescents" OR "teenager" AND "young adults") AND ("leukaemia", "lymphoma", OR "haematological malignancy" OR "cancer" AND "survival" OR "population-based/cancer registry")". We found few studies reporting international comparisons of survival from leukaemia for patients aged 0–24 years: studies published so far have focused on specific geographical regions. In 2018, CONCORD-3 identified huge worldwide variation in age-standardised 5-year net survival for children (aged 0–14 years) diagnosed with acute lymphoblastic leukaemia: from 50% in Ecuador to more than 90% in most high-income countries. Survival improved for adolescents and young adults from the late 1970s to the early 2000s, but the gains have been less notable than in children.

Added value of this study

This study extends the results from CONCORD-3 to cover a wider age range (0–24 years), and examines survival trends for the main subtypes of leukaemia, grouped according to the third edition of the International Classification of Childhood Cancer. We included high-quality data for more than 160 000 patients diagnosed with leukaemia aged 0–24 years during 2000–14, provided by 258 population-based cancer registries in 61 countries. Acute lymphoblastic leukaemia and acute myeloid leukaemia were more common in children than in adolescents and young adults. 5-year net survival increased substantially worldwide, but the trends were generally more favourable in North America, Europe, and Oceania than in other regions. During 2000–14, the gains in survival for children, adolescents, and young adults combined were largely driven by improvements in children. Individuals with acute lymphoblastic leukaemia and chronic myeloproliferative diseases had higher survival, and survival for all types of leukaemia combined was mostly driven by increases in survival for these two subtypes. Survival for patients with acute myeloid leukaemia was generally poorer than for other subtypes. For children with leukaemia, the gap in survival between high-income countries and low-income and middle-income countries persists. Additionally, adolescents and young adults continue to have lower survival than children worldwide, and this disparity is even more marked in low-income and middle-income countries. Global disparities in survival from acute lymphoblastic leukaemia have narrowed over time, especially in children, but patients with acute myeloid leukaemia continue to have poorer outcomes.

Implications of all the available evidence

Endeavours to improve outcomes for children with cancer have led to higher survival, particularly in high-income countries, where most children with leukaemia have been enrolled in long-running series of clinical trials for many years. Despite such improvements, disparities in survival still exist for children living in low-income and middle-income countries. The improvements observed for adolescents and young adults still lag behind those of children. The results of this study offer the first worldwide and most-up-to-date comparisons of population-based survival between children, adolescents, and young adults diagnosed with leukaemia. Lasting progress in survival will require long-term international investment to improve worldwide access to appropriate cancer care.

Cancer in young people is rare, but it is often the leading cause of non-accidental death in children, adolescents, and young adults (aged 0–24 years) living in high-income countries.[3,4] However, the full extent of the cancer burden is unknown, especially in low-income and middle-income countries, where the disease is probably under-registered.[2] The few international comparisons of survival from leukaemia in this age group published to date have focused on specific geographical regions. Survival from leukaemia varied widely between 19 European countries during 1978–97: 5-year observed survival was also much lower in adolescents than in children (44% *vs* 73%).[5] In the USA, 20-year survival for children diagnosed during 1975–88 was highest among those younger than 10 years at diagnosis.[6]

Acute lymphoblastic leukaemia is the most common malignancy in children, accounting for nearly a third of all childhood cancers, compared with 10% of cancers among adolescents (aged 15–19 years) in Europe.[7] 5-year relative survival was much higher among adolescents than among young adults (aged 20–24 years) diagnosed with acute lymphoblastic leukaemia during 2000–07 (62% *vs* 46%), but survival from acute myeloid leukaemia was similar in both age groups (52% *vs* 55%).[8] In the UK, 5-year relative survival for children (aged 0–12 years) with acute lymphoblastic leukaemia was 90% versus 66% in adolescents and young adults (aged 13–24 years), and 5-year relative survival from acute myeloid leukaemia was higher in children than in adolescents and young adults (66% *vs* 58%).[4]

In 2018, the third cycle of the CONCORD programme (CONCORD-3) updated worldwide trends in cancer survival with data for 37·5 million patients diagnosed

during 2000–14 in the areas covered by 322 population-based cancer registries from 71 countries, including 123 058 children (aged 0–14 years) and 4 162 280 adults (aged 15–99 years) with a haematological malignancy.[9] International variation in age-standardised 5-year net survival from acute lymphoblastic leukaemia in children was very wide, ranging from 50% to more than 90%. Among adults, survival from lymphoid malignancies ranged from 40% to 70%, and survival from myeloid malignancies ranged from 30% to 50%.

Although extensive research has been done over many years to understand cancer survival in children, adolescents and young adults have been the focus of only a few studies.[4–6,10,11] Population-based survival estimates by morphological subtype can provide insight into the effectiveness of patient management and outcomes, and international comparisons enable health-care planners to identify opportunities for improving care. Internationally comparable survival estimates for this transitional age band between childhood and adulthood are scarce. We aimed to examine worldwide trends in survival from leukaemia, by age and morphology, in patients aged 0–24 years who were diagnosed during 2000–14.

Methods

Study design and data sources

We analysed data from 258 population-based cancer registries in 61 countries participating in CONCORD-3 that submitted data on patients diagnosed with leukaemia. We examined data for young people (aged 0–24 years) diagnosed during 2000–14 and followed up until Dec 31, 2014. Four registries (in Québec, Canada; Thiruvananthapuram, India; Maryland, USA; and Barretos, Brazil) submitted data after publication of the CONCORD-3 study in 2018, and they are included in this analysis. Registries submitted data separately for children (aged 0–14 years) and adults (aged 15–99 years).[9] When we received data from a national registry of childhood cancers, we excluded data for children submitted by other registries in that country, to avoid double counting. Some national childhood cancer registries also capture data on adolescents (aged 15–19 years), and we applied the same rationale for these registries. Argentina, Mexico, France, and Switzerland submitted data with national coverage for childhood cancers but with subnational coverage for adolescents and young adults aged 15–24 years. Belarus and Greece provided data only for children (aged 0–14 years).

The Cancer Survival Group maintains approval for processing sensitive personal data for the CONCORD programme from the UK's statutory Health Research Authority (reference ECC 3-04(i)/2011; last update Oct 2, 2021), the UK National Health Service Research Ethics Service (11/LO/0331; Oct 6, 2021), and the Ethics Committee of the London School of Hygiene & Tropical Medicine, London, UK (12171; Oct 6, 2021).

Procedures

Topography and morphology were coded to the International Classification of Diseases for Oncology, third edition (ICD-O-3),[12] including its first revision.[13] Leukaemias were defined by morphology (ICD-O-3 codes 9800–9992) and behaviour (malignant, code 3). Full details of data acquisition, ethical approval, and data quality control procedures in the CONCORD programme have been described elsewhere.[9] No standardised classification for children, adolescents, and young adults is available, so we extended the International Classification of Childhood Cancer, 3rd edition (ICCC-3)[14] from the childhood age range (0–14 years) to group the leukaemia subtypes for patients aged 15–24 years.

We extended the classification by including new entities for leukaemia introduced in the first revision of ICD-O-3,[13] published in 2013, that were not included in ICCC-3 (2005).[14] Among the lymphoid leukaemias, codes were included if the anatomical site was blood, bone marrow, reticulo-endothelial, haematopoietic system not otherwise specified (C42.0–42.1, C42.3–42.4), or unknown primary site (C80.9).[9]

We therefore grouped morphology as follows, according to the ICCC-3 and ICD-O-3 codes: lymphoid leukaemia (Ia), acute myeloid leukaemia (Ib), chronic myeloproliferative diseases (Ic), myelodysplastic syndrome and other myeloproliferative diseases (Id), and unspecified leukaemias (Ie; appendix pp 1–3).

See Online for appendix

Statistical analysis

We estimated 5-year net survival with 95% CIs using the Pohar-Perme estimator.[15] Net survival is the cumulative probability of surviving up to a given time since diagnosis (eg, 5 years), after correcting for other causes of death (background mortality).[9] To control for background mortality, we produced 6210 life tables of all-cause mortality rates by sex, single year of age, and single calendar year in the general population of each contributing country or jurisdiction during 2000–14 and, where possible, by race or ethnicity (Israel, Singapore, USA, the Northern Territory in Australia, and New Zealand).[9,16] The method of life table construction depended on whether we received raw data (numbers of deaths and populations) or mortality rates, and on whether the raw data or the mortality rates were by single year of age (complete) or by 5-year age group (abridged). Each set of life tables was accompanied by a standardised statistical summary on the earliest and latest year of available data, showing the data source and the method of construction and smoothing.[16] We estimated survival by calendar period of diagnosis (2000–04, 2005–09, and 2010–14), morphology subtype, and age group.

We used the cohort approach to estimate survival for patients diagnosed during 2000–04 and 2005–09 because in most datasets all patients had been followed up for at least 5 years. The cohort approach provides a survival

	Number of patients	Lymphoid leukaemias (%)	Acute myeloid leukaemias (%)	Chronic myeloproliferative disease (%)	Myelodysplastic syndrome and other myeloproliferative diseases (%)	Unspecified and other specified leukaemias (%)
Africa						
Algeria (two registries)						
0–14 years	12	7 (58·3%)	3 (25·0%)	..	..	2 (16·7%)
15–19 years	12	..	..	9 (75·0%)	..	3 (25·0%)
20–24 years	10	1 (10·0%)	..	7 (70·0%)	..	2 (20·0%)
Nigeria (Ibadan)						
0–14 years	16	7 (43·8%)	6 (37·5%)	..	..	3 (18·8%)
15–19 years	6	2 (33·3%)	2 (33·3%)	1 (16·7%)	..	1 (16·7%)
20–24 years	4	..	1 (25·0%)	1 (25·0%)	..	2 (50·0%)
South Africa (Eastern Cape)						
0–14 years	8	2 (25·0%)	..	..	..	6 (75·0%)
15–19 years	..	..	..	..	..	..
20–24 years	1	..	..	..	..	1 (100·0%)
America (central and south)						
Argentina* (four registries)						
0–14 years	1482	1199 (80·9%)	249 (16·8%)	12 (0·8%)	15 (1·0%)	7 (0·5%)
15–19 years	23	11 (47·8%)	5 (21·7%)	3 (13·0%)	..	4 (17·4%)
20–24 years	16	3 (18·8%)	8 (50·0%)	3 (18·8%)	1 (6·3%)	1 (6·3%)
Brazil (four registries)						
0–14 years	59	40 (67·8%)	13 (22·0%)	1 (1·7%)	1 (1·7%)	4 (6·8%)
15–19 years	8	7 (87·5%)	..	1 (12·5%)	..	..
20–24 years	18	4 (22·2%)	7 (38·9%)	5 (27·8%)	..	2 (11·1%)
Chile (four registries)						
0–14 years	19	15 (78·9%)	2 (10·5%)	1 (5·3%)	1 (5·3%)	..
15–19 years	6	4 (66·7%)	2 (33·3%)	..	..	..
20–24 years	1	..	..	..	1 (100·0%)	..
Colombia (three registries)						
0–14 years	17	14 (82·4%)	1 (5·9%)	1 (5·9%)	..	1 (5·9%)
15–19 years	40	31 (77·5%)	6 (15·0%)	2 (5·0%)	..	1 (2·5%)
20–24 years	19	10 (52·6%)	2 (10·5%)	7 (36·8%)	..	..
Costa Rica†						
0–14 years	248	207 (83·5%)	33 (13·3%)	3 (1·2%)	..	5 (2·0%)
15–19 years	33	19 (57·6%)	3 (9·1%)	..	..	11 (33·3%)
20–24 years	29	12 (41·4%)	8 (27·6%)	2 (6·9%)	..	7 (24·1%)
Ecuador (five registries)						
0–14 years	320	252 (78·8%)	48 (15·0%)	4 (1·3%)	1 (0·3%)	15 (4·7%)
15–19 years	75	47 (62·7%)	16 (21·3%)	7 (9·3%)	1 (1·3%)	4 (5·3%)
20–24 years	40	18 (45·0%)	13 (32·5%)	5 (12·5%)	..	4 (10·0%)
Guadeloupe†						
0–14 years	6	2 (33·3%)	3 (50·0%)	1 (16·7%)	..	..
15–19 years	..	..	..	..	..	..
20–24 years	3	1 (33·3%)	..	1 (33·3%)	1 (33·3%)	..
Martinique†						
0–14 years	8	7 (87·5%)	1 (12·5%)	..	..	..
15–19 years	1	..	..	..	1 (100·0%)	..
20–24 years	1	..	..	1 (100·0%)	..	..
Mexico Childhood*						
0–14 years	3945	3395 (86·1%)	537 (13·6%)	..	..	13 (0·3%)
15–19 years	439	337 (76·8%)	100 (22·8%)	..	..	2 (0·5%)
20–24 years	1	..	1 (100·0%)	..	..	..

(Table 1 continues on next page)

	Number of patients	Lymphoid leukaemias (%)	Acute myeloid leukaemias (%)	Chronic myeloproliferative disease (%)	Myelodysplastic syndrome and other myeloproliferative diseases (%)	Unspecified and other specified leukaemias (%)
(Continued from previous page)						
Peru (Lima)						
0–14 years	262	187 (71·4%)	28 (10·7%)	14 (5·3%)	7 (2·7%)	26 (9·9%)
15–19 years	69	49 (71·0%)	10 (14·5%)	5 (7·2%)	1 (1·4%)	4 (5·8%)
20–24 years	54	25 (46·3%)	10 (18·5%)	9 (16·7%)	5 (9·3%)	5 (9·3%)
Puerto Rico†						
0–14 years	36	22 (61·1%)	8 (22·2%)	1 (2·8%)	2 (5·6%)	3 (8·3%)
15–19 years	7	4 (57·1%)	1 (14·3%)	2 (28·6%)	..	..
20–24 years	4	..	1 (25·0%)	2 (50·0%)	1 (25·0%)	..
America (north)						
Canada (ten registries)						
0–14 years	1171	886 (75·7%)	153 (13·1%)	63 (5·4%)	34 (2·9%)	35 (3·0%)
15–19 years	214	97 (45·3%)	62 (29·0%)	33 (15·4%)	12 (5·6%)	10 (4·7%)
20–24 years	213	62 (29·1%)	68 (31·9%)	59 (27·7%)	14 (6·6%)	10 (4·7%)
USA (49 registries)						
0–14 years	8005	6213 (77·6%)	1139 (14·2%)	253 (3·2%)	224 (2·8%)	176 (2·2%)
15–19 years	1802	932 (51·7%)	500 (27·7%)	241 (13·4%)	67 (3·7%)	62 (3·4%)
20–24 years	1748	590 (33·8%)	551 (31·5%)	450 (25·7%)	83 (4·7%)	74 (4·2%)
Asia						
China (21 registries)						
0–14 years	404	215 (53·2%)	62 (15·3%)	8 (2·0%)	14 (3·5%)	105 (26·0%)
15–19 years	122	27 (22·1%)	44 (36·1%)	11 (9·0%)	1 (0·8%)	39 (32·0%)
20–24 years	148	33 (22·3%)	33 (22·3%)	21 (14·2%)	7 (4·7%)	54 (36·5%)
Cyprus†						
0–14 years	19	17 (89·5%)	2 (10·5%)	..	..	..
15–19 years	12	8 (66·7%)	3 (25·0%)	1 (8·3%)	..	..
20–24 years	6	1 (16·7%)	2 (33·3%)	2 (33·3%)	..	1 (16·7%)
India (two registries)						
0–14 years	24	13 (54·2%)	8 (33·3%)	..	..	3 (12·5%)
15–19 years	7	4 (57·1%)	..	2 (28·6%)	..	1 (14·3%)
20–24 years	4	2 (50·0%)	2 (50·0%)	..	..	..
Israel†						
0–14 years	241	171 (71·0%)	42 (17·4%)	4 (1·7%)	5 (2·1%)	19 (7·9%)
15–19 years	52	29 (55·8%)	12 (23·1%)	4 (7·7%)	..	7 (13·5%)
20–24 years	48	15 (31·3%)	16 (33·3%)	12 (25·0%)	3 (6·3%)	2 (4·2%)
Japan (16 registries)						
0–14 years	506	339 (67·0%)	98 (19·4%)	16 (3·2%)	43 (8·5%)	10 (2·0%)
15–19 years	138	58 (42·0%)	43 (31·2%)	14 (10·1%)	13 (9·4%)	10 (7·2%)
20–24 years	147	41 (27·9%)	55 (37·4%)	38 (25·9%)	12 (8·2%)	1 (0·7%)
Jordan†						
0–14 years	267	197 (73·8%)	45 (16·9%)	4 (1·5%)	7 (2·6%)	14 (5·2%)
15–19 years	58	37 (63·8%)	13 (22·4%)	2 (3·4%)	..	6 (10·3%)
20–24 years	51	18 (35·3%)	17 (33·3%)	11 (21·6%)	2 (3·9%)	3 (5·9%)
South Korea†						
0–14 years	1410	872 (61·8%)	315 (22·3%)	75 (5·3%)	87 (6·2%)	61 (4·3%)
15–19 years	467	135 (28·9%)	173 (37%)	108 (23·1%)	41 (8·8%)	10 (2·1%)
20–24 years	415	92 (22·2%)	144 (34·7%)	122 (29·4%)	41 (9·9%)	16 (3·9%)
Kuwait†						
0–14 years	70	58 (82·9%)	9 (12·9%)	1 (1·4%)	1 (1·4%)	1 (1·4%)
15–19 years	18	6 (33·3%)	7 (38·9%)	2 (11·1%)	..	3 (16·7%)
20–24 years	3	2 (66·7%)	1 (33·3%)	..	..	..

(Table 1 continues on next page)

	Number of patients	Lymphoid leukaemias (%)	Acute myeloid leukaemias (%)	Chronic myeloproliferative disease (%)	Myelodysplastic syndrome and other myeloproliferative diseases (%)	Unspecified and other specified leukaemias (%)
(Continued from previous page)						
Malaysia (Penang)						
0–14 years	52	28 (53·8%)	11 (21·2%)	..	..	13 (25·0%)
15–19 years	13	3 (23·1%)	8 (61·5%)	..	..	2 (15·4%)
20–24 years	12	2 (16·7%)	9 (75·0%)	1 (8·3%)	..	..
Qatar†						
0–14 years	33	27 (81·8%)	4 (12·1%)	..	1 (3·0%)	1 (3·0%)
15–19 years	3	1 (33·3%)	2 (66·7%)	..	..	..
20–24 years	27	10 (37·0%)	8 (29·6%)	4 (14·8%)	1 (3·7%)	4 (14·8%)
Singapore†						
0–14 years	124	90 (72·6%)	22 (17·7%)	6 (4·8%)	6 (4·8%)	..
15–19 years	28	13 (46·4%)	7 (25·0%)	6 (21·4%)	..	2 (7·1%)
20–24 years	26	9 (34·6%)	4 (15·4%)	7 (26·9%)	1 (3·8%)	5 (19·2%)
Taiwan†						
0–14 years	624	465 (74·5%)	120 (19·2%)	12 (1·9%)	13 (2·1%)	14 (2·2%)
15–19 years	214	96 (44·9%)	80 (37·4%)	28 (13·1%)	3 (1·4%)	7 (3·3%)
20–24 years	187	58 (31·0%)	70 (37·4%)	44 (23·5%)	9 (4·8%)	6 (3·2%)
Thailand (six registries)						
0–14 years	243	146 (60·1%)	47 (19·3%)	13 (5·3%)	2 (0·8%)	35 (14·4%)
15–19 years	78	25 (32·1%)	22 (28·2%)	14 (17·9%)	2 (2·6%)	15 (19·2%)
20–24 years	52	11 (21·2%)	15 (28·8%)	18 (34·6%)	1 (1·9%)	7 (13·5%)
Turkey (eight registries)						
0–14 years	587	421 (71·7%)	104 (17·7%)	13 (2·2%)	16 (2·7%)	33 (5·6%)
15–19 years	130	69 (53·1%)	29 (22·3%)	25 (19·2%)	3 (2·3%)	4 (3·1%)
20–24 years	123	39 (31·7%)	40 (32·5%)	35 (28·5%)	3 (2·4%)	6 (4·9%)
Europe						
Austria†						
0–14 years	497	392 (78·9%)	89 (17·9%)	6 (1·2%)	2 (0·4%)	8 (1·6%)
15–19 years	48	30 (62·5%)	11 (22·9%)	6 (12·5%)	..	1 (2·1%)
20–24 years	51	17 (33·3%)	24 (47·1%)	9 (17·6%)	..	1 (2·0%)
Belarus Childhood*						
0–14 years	291	236 (81·1%)	34 (11·7%)	5 (1·7%)	13 (4·5%)	3 (1·0%)
15–19 years	..	..	..	..	..	..
20–24 years	..	..	..	..	..	..
Belgium†						
0–14 years	378	281 (74·3%)	47 (12·4%)	17 (4·5%)	26 (6·9%)	7 (1·9%)
15–19 years	65	31 (47·7%)	20 (30·8%)	9 (13·8%)	5 (7·7%)	..
20–24 years	93	27 (29·0%)	27 (29·0%)	23 (24·7%)	14 (15·1%)	2 (2·2%)
Bulgaria†						
0–14 years	155	127 (81·9%)	17 (11·0%)	1 (0·6%)	7 (4·5%)	3 (1·9%)
15–19 years	31	17 (54·8%)	5 (16·1%)	2 (6·5%)	5 (16·1%)	2 (6·5%)
20–24 years	34	7 (20·6%)	11 (32·4%)	14 (41·2%)	..	2 (5·9%)
Croatia†						
0–14 years	130	106 (81·5%)	19 (14·6%)	2 (1·5%)	1 (0·8%)	2 (1·5%)
15–19 years	21	8 (38·1%)	8 (38·1%)	2 (9·5%)	..	3 (14·3%)
20–24 years	12	2 (16·7%)	7 (58·3%)	1 (8·3%)	2 (16·7%)	..
Czech Republic†						
0–14 years	129	113 (87·6%)	10 (7·8%)	3 (2·3%)	..	3 (2·3%)
15–19 years	26	13 (50·0%)	7 (26·9%)	3 (11·5%)	2 (7·7%)	1 (3·8%)
20–24 years	40	12 (30·0%)	12 (30·0%)	10 (25·0%)	4 (10·0%)	2 (5·0%)

(Table 1 continues on next page)

	Number of patients	Lymphoid leukaemias (%)	Acute myeloid leukaemias (%)	Chronic myeloproliferative disease (%)	Myelodysplastic syndrome and other myeloproliferative diseases (%)	Unspecified and other specified leukaemias (%)
(Continued from previous page)						
Denmark†						
0–14 years	215	156 (72·6%)	25 (11·6%)	8 (3·7%)	18 (8·4%)	8 (3·7%)
15–19 years	34	22 (64·7%)	6 (17·6%)	2 (5·9%)	3 (8·8%)	1 (2·9%)
20–24 years	36	10 (27·8%)	13 (36·1%)	7 (19·4%)	5 (13·9%)	1 (2·8%)
Estonia†						
0–14 years	17	15 (88·2%)	1 (5·9%)	..	1 (5·9%)	..
15–19 years	2	1 (50·0%)	1 (50·0%)	..	..	..
20–24 years	4	2 (50·0%)	2 (50·0%)	..	..	..
Finland†						
0–14 years	192	139 (72·4%)	28 (14·6%)	7 (3·6%)	4 (2·1%)	14 (7·3%)
15–19 years	32	21 (65·6%)	7 (21·9%)	2 (6·3%)	1 (3·1%)	1 (3·1%)
20–24 years	31	11 (35·5%)	9 (29·0%)	6 (19·4%)	..	5 (16·1%)
France* (15 registries)						
0–14 years	1020	823 (80·7%)	134 (13·1%)	17 (1·7%)	33 (3·2%)	13 (1·3%)
15–19 years	..	..	..	..	..	..
20–24 years	..	..	..	..	..	..
Germany (ten registries)						
0–14 years	357	279 (78·2%)	47 (13·2%)	3 (0·8%)	23 (6·4%)	5 (1·4%)
15–19 years	112	61 (54·5%)	26 (23·2%)	11 (9·8%)	13 (11·6%)	1 (0·9%)
20–24 years	133	52 (39·1%)	46 (34·6%)	26 (19·5%)	6 (4·5%)	3 (2·3%)
Greek National Paediatric*						
0–14 years	382	328 (85·9%)	40 (10·5%)	4 (1·0%)	2 (0·5%)	8 (2·1%)
15–19 years	..	..	..	..	..	..
20–24 years	..	..	..	..	..	..
Iceland†						
0–14 years	10	10 (100·0%)	..	..	..	..
15–19 years	4	..	..	3 (75·0%)	1 (25·0%)	..
20–24 years	2	..	1 (50·0%)	1 (50·0%)	..	..
Ireland†						
0–14 years	137	115 (83·9%)	17 (12·4%)	2 (1·5%)	3 (2·2%)	..
15–19 years	20	10 (50·0%)	5 (25·0%)	2 (10·0%)	2 (10·0%)	1 (5·0%)
20–24 years	18	4 (22·2%)	8 (44·4%)	5 (27·8%)	1 (5·6%)	..
Italy (44 registries)						
0–14 years	290	221 (76·2%)	47 (16·2%)	15 (5·2%)	6 (2·1%)	1 (0·3%)
15–19 years	46	25 (54·3%)	14 (30·4%)	4 (8·7%)	2 (4·3%)	1 (2·2%)
20–24 years	56	21 (37·5%)	15 (26·8%)	14 (25·0%)	4 (7·1%)	2 (3·6%)
Latvia†						
0–14 years	49	41 (83·7%)	3 (6·1%)	2 (4·1%)	..	3 (6·1%)
15–19 years	11	7 (63·6%)	3 (27·3%)	..	..	1 (9·1%)
20–24 years	7	4 (57·1%)	..	3 (42·9%)	..	..
Lithuania†						
0–14 years	49	38 (77·6%)	7 (14·3%)	..	3 (6·1%)	1 (2·0%)
15–19 years	17	7 (41·2%)	4 (23·5%)	6 (35·3%)	..	..
20–24 years	14	7 (50·0%)	2 (14·3%)	3 (21·4%)	2 (14·3%)	..
Malta†						
0–14 years	7	3 (42·9%)	2 (28·6%)	1 (14·3%)	1 (14·3%)	..
15–19 years	2	1 (50·0%)	..	..	1 (50·0%)	..
20–24 years	1	1 (100·0%)	..	..	..	..

(Table 1 continues on next page)

	Number of patients	Lymphoid leukaemias (%)	Acute myeloid leukaemias (%)	Chronic myeloproliferative disease (%)	Myelodysplastic syndrome and other myeloproliferative diseases (%)	Unspecified and other specified leukaemias (%)
(Continued from previous page)						
Netherlands†						
0–14 years	471	355 (75·4%)	84 (17·8%)	10 (2·1%)	18 (3·8%)	4 (0·8%)
15–19 years	118	74 (62·7%)	27 (22·9%)	8 (6·8%)	6 (5·1%)	3 (2·5%)
20–24 years	89	29 (32·6%)	28 (31·5%)	25 (28·1%)	3 (3·4%)	4 (4·5%)
Norway†						
0–14 years	176	136 (77·3%)	31 (17·6%)	2 (1·1%)	6 (3·4%)	1 (0·6%)
15–19 years	43	23 (53·5%)	7 (16·3%)	8 (18·6%)	3 (7·0%)	2 (4·7%)
20–24 years	45	15 (33·3%)	15 (33·3%)	13 (28·9%)	2 (4·4%)	..
Poland (16 registries)†						
0–14 years	882	703 (79·7%)	133 (15·1%)	14 (1·6%)	5 (0·6%)	27 (3·1%)
15–19 years	187	99 (52·9%)	71 (38·0%)	12 (6·4%)	..	5 (2·7%)
20–24 years	156	62 (39·7%)	56 (35·9%)	25 (16·0%)	..	13 (8·3%)
Portugal (four registries)†						
0–14 years	121	98 (81·0%)	15 (12·4%)	2 (1·7%)	3 (2·5%)	3 (2·5%)
15–19 years	21	11 (52·4%)	7 (33·3%)	1 (4·8%)	1 (4·8%)	1 (4·8%)
20–24 years	19	5 (26·3%)	8 (42·1%)	4 (21·1%)	1 (5·3%)	1 (5·3%)
Romania (Cluj)						
0–14 years	15	10 (66·7%)	3 (20·0%)	..	1 (6·7%)	1 (6·7%)
15–19 years	2	..	1 (50·0%)	..	1 (50·0%)	..
20–24 years	1	..	1 (100·0%)	..	..	..
Russia (three registries)						
0–14 years	146	105 (71·9%)	33 (22·6%)	3 (2·1%)	..	5 (3·4%)
15–19 years	17	7 (41·2%)	8 (47·1%)	1 (5·9%)	1 (5·9%)	..
20–24 years	30	7 (23·3%)	18 (60·0%)	2 (6·7%)	1 (3·3%)	2 (6·7%)
Slovakia†						
0–14 years	37	26 (70·2%)	8 (21·6%)	3 (8·2%)	..	..
15–19 years	..	..	..	..	..	..
20–24 years	..	..	..	..	..	..
Slovenia†						
0–14 years	47	36 (76·6%)	8 (17·0%)	1 (2·1%)	2 (4·3%)	..
15–19 years	9	5 (55·6%)	1 (11·1%)	2 (22·2%)	..	1 (11·1%)
20–24 years	12	3 (25·0%)	4 (33·3%)	3 (25·0%)	2 (16·7%)	..
Spain (11 registries)						
0–14 years	516	417 (80·8%)	80 (15·5%)	6 (1·2%)	7 (1·4%)	6 (1·2%)
15–19 years	29	17 (58·6%)	9 (31·0%)	3 (10·3%)	..	..
20–24 years	22	4 (18·2%)	10 (45·5%)	7 (31·8%)	..	1 (4·5%)
Sweden†						
0–14 years	326	261 (80·1%)	41 (12·6%)	4 (1·2%)	11 (3·4%)	9 (2·8%)
15–19 years	47	21 (44·7%)	15 (31·9%)	8 (17·0%)	1 (2·1%)	2 (4·3%)
20–24 years	70	26 (37·1%)	25 (35·7%)	17 (24·3%)	1 (1·4%)	1 (1·4%)
Switzerland* (ten registries)						
0–14 years	301	237 (78·7%)	35 (11·6%)	5 (1·7%)	23 (7·6%)	1 (0·3%)
15–19 years	19	7 (36·8%)	5 (26·3%)	5 (26·3%)	2 (10·5%)	..
20–24 years	17	1 (5·9%)	7 (41·2%)	8 (47·1%)	1 (5·9%)	..
UK (four registries)†						
0–14 years	2158	1675 (77·6%)	327 (15·2%)	62 (2·9%)	53 (2·5%)	41 (1·9%)
15–19 years	405	206 (50·9%)	110 (27·2%)	62 (15·3%)	14 (3·5%)	13 (3·2%)
20–24 years	423	131 (31·0%)	161 (38·1%)	98 (23·2%)	19 (4·5%)	14 (3·3%)

(Table 1 continues on next page)

	Number of patients	Lymphoid leukaemias (%)	Acute myeloid leukaemias (%)	Chronic myeloproliferative disease (%)	Myelodysplastic syndrome and other myeloproliferative diseases (%)	Unspecified and other specified leukaemias (%)
(Continued from previous page)						
Oceania						
Australia (eight registries)†						
0–14 years	855	677 (79·2%)	107 (12·5%)	31 (3·6%)	32 (3·7%)	8 (0·9%)
15–19 years	148	77 (52·0%)	43 (29·1%)	18 (12·2%)	8 (5·4%)	2 (1·4%)
20–24 years	173	48 (27·7%)	59 (34·1%)	53 (30·6%)	11 (6·4%)	2 (1·2%)
New Zealand†						
0–14 years	168	118 (70·2%)	34 (20·2%)	3 (1·8%)	9 (5·4%)	4 (2·4%)
15–19 years	31	10 (32·3%)	16 (51·6%)	3 (9·7%)	2 (6·5%)	..
20–24 years	31	11 (35·5%)	10 (32·3%)	8 (25·8%)	..	2 (6·5%)
Total						
0–24 years	41 358	28 205 (68·2%)	7863 (19·0%)	2698 (6·5%)	1277 (3·1%)	1315 (3·2%)

Data are n (%), unless otherwise specified. *Data with 100% coverage of the national population for childhood malignancies only; data for 15–24 years, if available, were provided from registries with subnational coverage. †Data with 100% coverage of the national population.

Table 1: **Number of patients diagnosed with leukaemia during 2010–14, by age and morphology**

estimate for a group of patients who were diagnosed during the same year or period, are likely to have been treated in a similar manner, and who have all been followed up for at least the duration of survival required, in this case 5 years.[17] We used the period approach for patients diagnosed during 2010–14, because 5 years of follow-up data were not available for all patients.[18]

We grouped patients in three age ranges: children (aged 0–14 years), adolescents (aged 15–19 years), and young adults (aged 20–24 years). Survival estimates for all ages combined (0–24 years) were standardised by age to maximise comparability between countries and over time. Age standardisation of cancer survival for children has traditionally been done as a simple average of the estimates for children aged 0–4, 5–9, and 10–14 years,[19] but no standard set of age weights is available for young people in the age range 0–24 years. We therefore derived the following weights from the marginal age distribution of all patients included in these analyses: 0·739 for children, 0·136 for adolescents, and 0·125 for young adults.

We did not estimate survival if data from fewer than ten patients were available for analysis for a given combination of age, morphology subgroup, and calendar period. If data from 10–49 patients were available, we only estimated survival for all ages combined. If data from 50 or more patients were available, we attempted to obtain age-standardised estimates. If a single age-specific estimate could not be obtained, we merged the data for adjacent age groups and assigned the combined estimate to both age groups before standardisation for age. If two or more age-specific estimates could not be obtained, we presented only the unstandardised estimate for all ages combined. We did not merge data between consecutive calendar periods.

Survival estimates from registries where 15% or more patients were lost to follow-up, or registered from a death certificate or at autopsy, or registered with incomplete dates, were considered less reliable for international comparisons, but merit inclusion in such a publication because of the paucity of data on survival estimates for that malignancy or from that country or region. The pooled estimates for countries with more than one registry do not include data from registries for which survival estimates were less reliable. If the reported survival estimates were the only available information from a given country or territory, this has been highlighted as such in the figures and tables. Where relevant, we provided only reliable, age-standardised survival estimates.

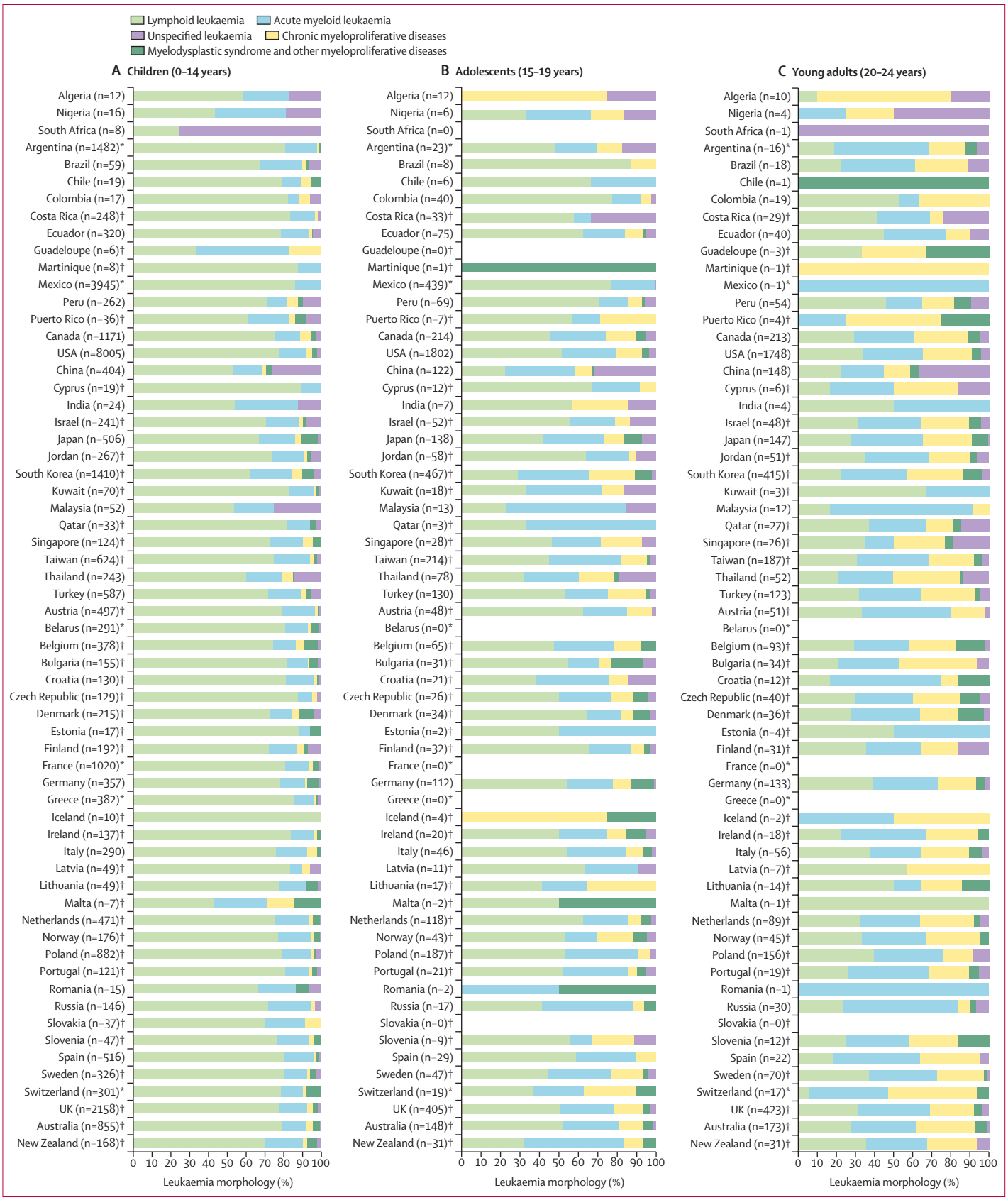
Role of the funding source

The funding sources played no part in study design, data collection, quality control, data analysis, interpretation of the findings, writing of the manuscript or the decision to submit the manuscript for publication.

Results

We examined 166 883 records of patients aged 0–24 years diagnosed with leukaemia, of whom 834 (0·5%) were excluded because of incomplete dates and 162 (0·1%) were excluded for other reasons. Of the 165 887 patients otherwise eligible for inclusion, we excluded 817 (0·5%) because their survival time was unknown or the leukaemia was registered only from a death certificate or discovered at autopsy. 507 (0·3%) records were excluded for other reasons (appendix pp 4–6).

We therefore included 164 563 young people in the analyses: 121 328 (73·7%) children, 22 963 (14·0%) adolescents, and 20 272 (12·3%) young adults. 164 069 (99·7%) patients received histological confirmation of their diagnosis (appendix pp 4–6). Of these, 4608 (2·8%) patients were censored within 5 years of diagnosis, and 3127 (1·9%) were lost to follow-up.


Lymphoid leukaemia
Acute myeloid leukaemia
Unspecified leukaemia
Chronic myeloproliferative diseases
Myelodysplastic syndrome and other myeloproliferative diseases
A Children (0–14 years)
B Adolescents (15–19 years)
C Young adults (20–24 years)
Algeria (n=12)
Nigeria (n=16)
South Africa (n=8)
Argentina (n=1482)*
Brazil (n=59)
Chile (n=19)
Colombia (n=17)
Costa Rica (n=248)†
Ecuador (n=320)
Guadeloupe (n=6)†
Martinique (n=8)†
Mexico (n=3945)*
Peru (n=262)
Puerto Rico (n=36)†
Canada (n=1171)
USA (n=8005)
China (n=404)
Cyprus (n=19)†
India (n=24)
Israel (n=241)†
Japan (n=506)
Jordan (n=267)†
South Korea (n=1410)†
Kuwait (n=70)†
Malaysia (n=52)
Qatar (n=33)†
Singapore (n=124)†
Taiwan (n=624)†
Thailand (n=243)
Turkey (n=587)
Austria (n=497)†
Belarus (n=291)*
Belgium (n=378)†
Bulgaria (n=155)†
Croatia (n=130)†
Czech Republic (n=129)†
Denmark (n=215)†
Estonia (n=17)†
Finland (n=192)†
France (n=1020)*
Germany (n=357)
Greece (n=382)*
Iceland (n=10)†
Ireland (n=137)†
Italy (n=290)
Latvia (n=49)†
Lithuania (n=49)†
Malta (n=7)†
Netherlands (n=471)†
Norway (n=176)†
Poland (n=882)†
Portugal (n=121)†
Romania (n=15)
Russia (n=146)
Slovakia (n=37)†
Slovenia (n=47)†
Spain (n=516)
Sweden (n=326)†
Switzerland (n=301)*
UK (n=2158)†
Australia (n=855)†
New Zealand (n=168)†
Algeria (n=12)
Nigeria (n=6)
South Africa (n=0)
Argentina (n=23)*
Brazil (n=8)
Chile (n=6)
Colombia (n=40)
Costa Rica (n=33)†
Ecuador (n=75)
Guadeloupe (n=0)†
Martinique (n=1)†
Mexico (n=439)*
Peru (n=69)
Puerto Rico (n=7)†
Canada (n=214)
USA (n=1802)
China (n=122)
Cyprus (n=12)†
India (n=7)
Israel (n=52)†
Japan (n=138)
Jordan (n=58)†
South Korea (n=467)†
Kuwait (n=18)†
Malaysia (n=13)
Qatar (n=3)†
Singapore (n=28)†
Taiwan (n=214)†
Thailand (n=78)
Turkey (n=130)
Austria (n=48)†
Belarus (n=0)*
Belgium (n=65)†
Bulgaria (n=31)†
Croatia (n=21)†
Czech Republic (n=26)†
Denmark (n=34)†
Estonia (n=2)†
Finland (n=32)†
France (n=0)*
Germany (n=112)
Greece (n=0)*
Iceland (n=4)†
Ireland (n=20)†
Italy (n=46)
Latvia (n=11)†
Lithuania (n=17)†
Malta (n=2)†
Netherlands (n=118)†
Norway (n=43)†
Poland (n=187)†
Portugal (n=21)†
Romania (n=2)
Russia (n=17)
Slovakia (n=0)†
Slovenia (n=9)†
Spain (n=29)
Sweden (n=47)†
Switzerland (n=19)*
UK (n=405)†
Australia (n=148)†
New Zealand (n=31)†
Algeria (n=10)
Nigeria (n=4)
South Africa (n=1)
Argentina (n=16)*
Brazil (n=18)
Chile (n=1)
Colombia (n=19)
Costa Rica (n=29)†
Ecuador (n=40)
Guadeloupe (n=3)†
Martinique (n=1)†
Mexico (n=1)*
Peru (n=54)
Puerto Rico (n=4)†
Canada (n=213)
USA (n=1748)
China (n=148)
Cyprus (n=6)†
India (n=4)
Israel (n=48)†
Japan (n=147)
Jordan (n=51)†
South Korea (n=415)†
Kuwait (n=3)†
Malaysia (n=12)
Qatar (n=27)†
Singapore (n=26)†
Taiwan (n=187)†
Thailand (n=52)
Turkey (n=123)
Austria (n=51)†
Belarus (n=0)*
Belgium (n=93)†
Bulgaria (n=34)†
Croatia (n=12)†
Czech Republic (n=40)†
Denmark (n=36)†
Estonia (n=4)†
Finland (n=31)†
France (n=0)*
Germany (n=133)
Greece (n=0)*
Iceland (n=2)†
Ireland (n=18)†
Italy (n=56)
Latvia (n=7)†
Lithuania (n=14)†
Malta (n=1)†
Netherlands (n=89)†
Norway (n=45)†
Poland (n=156)†
Portugal (n=19)†
Romania (n=1)
Russia (n=30)
Slovakia (n=0)†
Slovenia (n=12)†
Spain (n=22)
Sweden (n=70)†
Switzerland (n=17)*
UK (n=423)†
Australia (n=173)†
New Zealand (n=31)†
0 10 20 30 40 50 60 70 80 90 100
Leukaemia morphology (%)

In 2010–14, 28 205 (68·2%) patients were diagnosed with lymphoid leukaemia and 7863 (19·0%) with acute myeloid leukaemia (table 1). Other subtypes of leukaemia were much less common, ranging from 3·1% to 6·5%. Lymphoid leukaemias were the most common in children, with the proportion of diagnoses decreasing with age. In adolescents and young adults, other leukaemia subtypes (acute myeloid leukaemia, chronic myeloproliferative diseases, myelodysplastic syndrome and other myeloproliferative diseases, and unspecified leukaemias) were more common: this pattern was broadly consistent throughout 2000–14 (appendix pp 7–20, 42–45). Countries where a higher proportion (≥25%) of registrations were for unspecified and other leukaemias were mainly in Africa (Algeria and South Africa) and Asia (China and Thailand; table 1, figure 1); this pattern was also observed in the preceding years of diagnosis (appendix pp 7–20, 42–45).

For patients aged 0–24 years who were diagnosed during 2010–14, 5-year age-standardised net survival for all leukaemias combined varied from 46% (95% CI 43–48) in Mexico to more than 85% in eight countries: Canada, Cyprus, five European countries (Belgium, Denmark, Finland, Iceland, and Switzerland), and Australia (table 2, figure 2). Most countries in Europe, Asia, and parts of central and south America reported 5-year survival of 70% or higher. Survival was lower than 65% in Chile and Peru; China and India; and Russia.

During 2010–14, survival from all leukaemias combined was higher in children than in adolescents or young adults (appendix pp 35–41, 60–61). In children (aged 0–14 years), survival ranged from 48% (95% CI 26–70) in India to 91% (95% CI 84–98) in Puerto Rico; in adolescents (aged 15–19 years), survival ranged from 24% (95% CI 11–38) in Colombia to 85% (95% CI 75–95) in Denmark; and in young adults (20–24 years), survival ranged from 20% (95% CI 27–52) in Ecuador to 86% (95% CI 73–99) in Ireland. Survival estimates for adolescents and young adults were wide-ranging and less precise than those for children, with wider confidence intervals because the estimates were based on small numbers of patients.

Age-standardised 5-year net survival varied widely around the world for each of the leukaemia subtypes. During 2010–14, 5-year survival for lymphoid leukaemia was 80% or higher in parts of Europe, North America, Oceania, and three Asian countries: Israel, Japan, and Singapore (table 2). Survival was lower than 60% in China and Peru, and as low as 42% in Ecuador. 5-year survival from acute myeloid leukaemia was 70% or higher in ten countries (Costa Rica; Kuwait, Japan, Singapore; Denmark, France, Ireland, the Netherlands, and Norway; and Australia) and as low as 32% in Peru. In most high-income countries in Europe, North America, and Oceania, survival for acute myeloid leukaemia was modest compared to that for lymphoid leukaemia (table 2; appendix pp 50–53).

Survival from chronic myeloproliferative diseases was generally high. In 2010–14, survival ranged between 70% and 100% in several countries in Europe, North America, Oceania, and Asia (table 2; appendix pp 54–55). The numbers of patients diagnosed with myelodysplastic syndrome and other myeloproliferative diseases and unspecified leukaemias were much smaller than those diagnosed with lymphoid leukaemia, acute myeloid leukaemia, and chronic myeloproliferative diseases (tables 1, 2; appendix pp 56–59). For patients diagnosed with myelodysplastic syndrome and other myeloproliferative disease, survival varied widely and was generally modest, but higher than 75% in seven countries: Canada; Japan and South Korea; Belgium, Germany, and the UK; and Australia. In 2010–14, survival for individuals with unspecified leukaemias varied from 35% in China to 87% in Australia.

Most high-income countries in Europe, North America, and Oceania saw increases in 5-year survival for all leukaemias combined of about 5% between 2000–04 and 2010–14 (table 2, figure 2; appendix pp 48–49). Substantial increases of 10% or higher were seen in 11 countries and territories: Puerto Rico, six Asian countries (China, Japan, Korea, Singapore, Taiwan, and Turkey), and four European countries (Bulgaria, Estonia, Ireland, and Lithuania).

The gap in survival between high-income countries and low-income and middle-income countries for all leukaemias combined persisted throughout the 15-year period (figure 3). 5-year survival for all leukaemias combined increased to more than 80% in children in Europe, North America, and Oceania (appendix pp 21–41, 60–61). Survival increased to 70% and higher in most parts of Europe, North America, and Oceania; however, this increase was not uniform in individuals aged 15–24 years. The largest increases in 5-year survival were seen for lymphoid leukaemia, reaching 90% or higher for children diagnosed during 2010–14 (appendix pp 21–41, 62–63). Improvements in 5-year survival from acute myeloid leukaemia during 2000–14 were generally much less marked than for lymphoid leukaemia, especially for young adults (aged 20–24 years), reaching 70% by 2010–14 (appendix pp 21–26, 64–65).

Figure 1: **Worldwide distribution of leukaemia morphology in children (aged 0–14 years), adolescents (aged 15–19 years), and young adults (aged 20–24 years) diagnosed during 2010–14, grouped according to the International Classification of Childhood Cancer, 3rd edition (ICCC-3)**
*Data with 100% coverage of the national population for childhood malignancies only; data for 15–24 years, if available, were provided from registries with subnational coverage. †Data with 100% coverage of the national population.

Discussion

International comparisons of population-based survival trends between children, adolescents, and young adults with leukaemia are rare and have generally focused on specific geographical regions. To our knowledge, this is

	All leukaemias	Lymphoid leukaemia	Acute myeloid leukaemias	Chronic myeloproliferative diseases	Myelodysplastic syndrome and other myeloproliferative diseases	Unspecified and other specified leukaemias
Africa						
Algeria (two registries)						
2000–04	7·8% (0·3–15·3)‡§	5·7% (0·0–13·0)‡§	17·3% (0·0–35·7)‡§	..	..	..
2005–09	55·6% (41·8–69·4)‡§	35·8% (11·0–60·6)‡§	..	..	..	64·5% (39·2–89·9)‡§
2010–14	..	..	..	..	..	..
South Africa (Eastern Cape)						
2000–04	76·4% (39·2–100·0)§	..	..	..	..	68·5% (24·2–100·0)‡§
2005–09	80·2% (48·8–100·0)§	..	..	..	..	75·0% (38·3–100·0)‡§
2010–14	..	..	..	..	..	..
America (central and south)						
Argentina (four registries)*						
2000–04	59·9% (55·0–64·7)	66·2% (64·0–68·4)§	41·8% (37·2–46·5)§	75·2% (56·8–93·7)§	..	43·0% (25·3–60·7)§
2005–09	62·3% (59·2–65·3)	63·5% (59·0–67·9)	47·9% (42·0–53·7)	75·2% (61·9–88·6)§	65·4% (46·5–84·4)§	38·2% (23·9–52·6)§
2010–14	67·2% (63·5–70·9)‡	70·0% (63·7–76·3)‡	58·7% (47·8–69·6)‡	..	..	..
Brazil (four registries)						
2000–04	62·4% (55·5–69·3)	68·2% (60·3–76·2)	42·4% (28·2–56·6)§	..	..	..
2005–09	60·4% (54·3–66·6)	66·0% (59·2–72·8)	40·9% (27·4–54·5)§	..	..	..
2010–14	65·7% (58·0–73·4)	65·5% (56·5–74·5)	54·1% (38·2–69·9)	..	..	..
Chile (four registries)						
2000–04	59·2% (47·4–70·9)§	62·0% (47·5–76·4)	..	..	..	100·0% (73·5–100·0)§
2005–09	60·2% (53·6–66·8)	71·4% (61·1–81·7)§	43·0% (26·9–59·0)§	..	..	..
2010–14	58·7% (49·5–68·0)	..	..	..	..	..
Colombia (three registries)						
2000–04	42·3% (36·3–48·4)	43·7% (36·5–50·9)	16·8% (4·3–29·3)§	..	..	20·1% (0·0–41·6)§
2005–09	50·6% (43·9–57·3)	48·6% (41·2–56·0)	38·1% (20·6–55·7)§	56·1% (25·8–86·4)§	..	25·8% (0·0–52·3)§
2010–14	49·8% (36·7–62·9)‡	50·9% (36·1–65·7)‡	29·5% (7·2–51·7)‡§	56·2% (22·1–90·2)‡§	..	..
Costa Rica†						
2000–04	78·7% (74·3–83·0)	79·2% (74·4–83·9)	64·4% (47·0–81·8)§	..	..	..
2005–09	76·2% (72·2–80·2)	74·8% (70·1–79·5)	78·5% (70·9–86·1)	..	..	50·1% (23·4–76·7)§
2010–14	73·6% (69·3–77·9)	72·7% (67·7–77·7)	79·4% (68·3–90·5)	..	..	53·5% (31·9–75·0)§
Ecuador (five registries)						
2000–04	41·9% (36·2–47·6)‡	43·2% (36·8–49·6)‡	31·0% (17·4–44·5)‡§	..	..	31·5% (8·3–54·7)‡§
2005–09	47·2% (43·0–51·3)	49·1% (43·3–54·8)§	34·7% (21·4–48·1)	37·8% (15·2–60·4)§	..	..
2010–14	46·8% (42·6–51·1)	42·5% (36·1–48·9)	38·5% (22·3–54·6)	..	..	44·0% (17·9–70·2)§
Martinique†						
2000–04	71·0% (50·1–91·8)§	71·9% (49·4–94·5)§	..	..	..	..
2005–09	75·4% (57·0–93·8)§	81·9% (60·2–100·0)§	..	..	..	..
2010–14	..	..	..	..	..	..
Mexico Childhood*						
2000–04	..	..	..	..	..	..
2005–09	45·4% (43·1–47·7)	48·7% (46·2–51·3)	27·6% (22·5–32·6)	..	..	..
2010–14	45·5% (42·6–48·4)	47·8% (44·7–50·9)	30·3% (23·9–36·7)	..	..	61·6% (20·1–100·0)§
Peru (Lima)						
2000–04	..	..	..	..	..	..
2005–09	..	..	..	..	..	..
2010–14	52·1% (47·3–56·8)	52·2% (46·7–57·7)	31·8% (20·6–43·0)	78·9% (64·8–93·0)§	69·5% (47·6–91·5)§	42·3% (24·2–60·3)§
Puerto Rico†						
2000–04	68·4% (62·6–74·2)	74·1% (65·3–82·8)§	44·6% (30·3–58·9)§	95·9% (87·7–100·0)§	..	59·6% (45·8–73·5)§
2005–09	74·6% (68·8–80·3)	74·0% (67·7–80·3)	58·0% (43·7–72·3)§	..	..	57·9% (36·5–79·4)§
2010–14	81·8% (74·9–88·7)	79·8% (71·2–88·5)	66·0% (49·9–82·1)	..	..	..

(Table 2 continues on next page)

	All leukaemias	Lymphoid leukaemia	Acute myeloid leukaemias	Chronic myeloproliferative diseases	Myelodysplastic syndrome and other myeloproliferative diseases	Unspecified and other specified leukaemias
(Continued from previous page)						
America (north)						
Canada (ten registries)						
2000–04	81·3% (79·2–83·5)	85·0% (82·4–87·5)	62·5% (55·7–69·3)	85·6% (75·8–95·4)	64·2% (49·4–79·0)§	48·8% (33·4–64·2)§
2005–09	85·0% (83·0–86·9)	85·7% (83·1–88·2)	72·3% (66·2–78·5)	99·2% (98·0–100·0)	72·3% (57·9–86·7)§	75·1% (63·1–87·2)§
2010–14	86·0% (84·0–88·0)	87·9% (85·3–90·4)	68·8% (62·2–75·5)	99·1% (98·2–100·0)	76·2% (62·6–89·7)	75·6% (62·4–88·9)
USA (49 registries)						
2000–04	76·7% (76·1–77·3)	80·1% (79·4–80·8)	56·5% (54·7–58·2)	83·0% (80·0–86·1)	65·4% (61·2–69·6)	60·7% (56·1–65·3)
2005–09	80·8% (80·3–81·4)	83·0% (82·3–83·6)	62·5% (60·9–64·2)	92·3% (90·4–94·2)	67·7% (64·1–71·3)	69·8% (65·5–74·0)
2010–14	83·3% (82·7–83·8)	85·6% (84·9–86·2)	65·5% (63·7–67·2)	95·6% (94·1–97·1)	69·0% (65·1–72·9)	74·9% (70·5–79·2)
Asia						
China (21 registries)						
2000–04	38·1% (32·5–43·7)	43·1% (31·7–54·4)	27·8% (15·5–40·0)	..	..	18·7% (10·8–26·7)
2005–09	46·3% (42·9–49·7)	49·4% (43·0–55·8)	29·6% (19·9–39·2)	68·4% (54·3–82·5)§	..	25·8% (20·1–31·4)
2010–14	51·8% (48·1–55·4)	49·4% (42·0–56·8)	43·3% (31·7–54·9)	70·7% (50·7–90·8)	..	35·2% (28·2–42·1)
Cyprus†						
2000–04	64·3% (40·3–88·3)§	..	..	..	..	..
2005–09	74·0% (62·0–86·1)§	80·6% (67·9–93·3)‡§	..	..	..	..
2010–14	87·3% (78·3–96·3)	84·3% (75·1–93·5)‡	..	..	..	..
India (two registries)						
2000–04	44·3% (25·4–63·3)§	55·7% (33·6–77·9)§	..	..	..	..
2005–09	48·5% (30·1–67·0)§	62·9% (40·0–85·9)§	..	..	..	..
2010–14	50·0% (32·8–67·1)	71·9% (49·0–94·9)§	..	..	..	..
Israel†						
2000–04	77·0% (73·6–80·4)	77·6% (73·3–81·9)	63·3% (54·1–72·5)	93·9% (87·1–100·0)§	66·8% (47·2–86·4)§	71·5% (56·8–86·2)§
2005–09	78·5% (75·2–81·9)	80·6% (76·5–84·8)	58·9% (50·0–67·7)	97·0% (94·3–99·7)	84·7% (65·9–100·0)§	77·6% (64·8–90·3)§
2010–14	79·7% (76·1–83·3)	83·4% (79·1–87·7)	63·2% (53·6–72·8)	93·8% (88·5–99·2)	..	73·9% (59·9–87·9)
Japan (16 registries)						
2000–04	69·6% (66·6–72·5)	71·5% (67·8–75·2)	59·4% (53·3–65·5)	74·0% (59·3–88·7)	58·5% (39·3–77·7)§	74·4% (58·6–90·3)§
2005–09	75·1% (73·0–77·3)	77·3% (74·6–80·0)	67·4% (62·8–72·0)	89·6% (81·7–97·5)	69·4% (57·4–81·3)	50·6% (39·2–61·9)
2010–14	80·7% (78·4–82·9)	82·7% (79·9–85·6)	70·2% (64·8–75·6)	92·2% (83·4–100·0)	78·5% (69·5–87·4)	78·9% (65·5–92·3)
Jordan†						
2000–04	69·5% (65·2–73·8)‡	70·9% (65·6–76·2)‡	58·7% (47·9–69·4)‡	80·4% (63·3–97·4)‡§	..	63·8% (46·9–80·8)‡§
2005–09	78·5% (74·9–82·1)‡	79·0% (74·7–83·4)‡	62·7% (53·5–72·0)‡	96·2% (88·3–100·0)‡§	..	85·4% (73·7–97·2)‡§
2010–14	74·1% (70·2–78·0)‡	80·8% (76·3–85·4)‡	48·7% (38·7–58·7)‡	97·8% (94·0–100·0)‡	..	66·6% (52·6–80·7)‡
South Korea†						
2000–04	61·2% (59·5–63·0)	64·4% (62·2–66·7)	47·6% (44·1–51·1)	56·7% (47·5–65·9)	67·0% (58·9–75·2)	52·0% (43·7–60·4)
2005–09	69·3% (67·7–71·0)	70·8% (68·6–73·1)	54·6% (51·0–58·3)	91·4% (86·4–96·4)	69·2% (62·2–76·3)	57·9% (50·3–65·4)
2010–14	76·5% (75·0–78·1)	76·7% (74·6–78·8)	62·1% (58·4–65·8)	92·6% (88·3–97·0)	77·0% (70·4–83·5)	66·7% (57·9–75·5)
Kuwait†						
2000–04	79·6% (73·0–86·3)	82·1% (74·6–89·5)	76·0% (59·7–92·4)§	..	..	..
2005–09	74·6% (67·7–81·4)	77·3% (69·6–85·0)§	68·9% (51·4–86·4)§	..	..	..
2010–14	77·7% (70·8–84·6)	74·0% (65·7–82·3)	72·7% (53·7–91·8)	..	..	..
Malaysia (Penang)						
2000–04	..	..	..	..	..	..
2005–09	63·9% (54·3–73·5)	66·7% (53·6–79·9)‡	41·0% (21·2–60·8)‡§	..	..	84·7% (65·9–100·0)‡§
2010–14	68·3% (60·7–75·9)	76·8% (65·5–88·0)‡	65·9% (51·0–80·8)‡§	..	..	63·3% (39·9–86·7)‡§
Qatar†						
2000–04	57·4% (39·8–75·0)§	69·5% (49·0–90·1)‡	..	..	..	..
2005–09	76·2% (60·2–92·3)	78·3% (59·2–97·4)‡	53·3% (24·0–82·7)‡§	..	..	..
2010–14	81·1% (64·1–98·0)	94·2% (89·1–99·3)‡	38·3% (6·0–70·5)‡§	..	..	..

(Table 2 continues on next page)

	All leukaemias	Lymphoid leukaemia	Acute myeloid leukaemias	Chronic myeloproliferative diseases	Myelodysplastic syndrome and other myeloproliferative diseases	Unspecified and other specified leukaemias
(Continued from previous page)						
Singapore†						
2000–04	68·4% (62·8–74·1)	68·8% (62·6–74·9)	41·4% (27·4–55·4)§	84·4% (68·4–100·0)§	..	..
2005–09	80·1% (75·4–84·9)	83·3% (78·0–88·6)	66·0% (52·1–79·8)§	60·1% (36·4–83·9)§	..	91·7% (76·7–100·0)§
2010–14	84·0% (79·4–88·6)	86·0% (80·6–91·4)	75·8% (62·5–89·1)	67·3% (44·4–90·1)§	..	..
Taiwan†						
2000–04	61·6% (59·1–64·0)	63·6% (60·5–66·8)	46·9% (41·7–52·1)	69·3% (56·2–82·4)	46·0% (26·6–65·3)§	53·2% (36·3–70·2)§
2005–09	69·9% (67·4–72·3)	72·0% (69·0–75·1)§	54·8% (49·3–60·2)	89·1% (81·7–96·6)	45·6% (29·0–62·2)§	50·1% (32·6–67·6)§
2010–14	71·7% (69·2–74·2)	72·9% (69·7–76·1)	57·7% (51·8–63·6)	98·3% (96·9–99·7)	50·8% (29·2–72·4)	61·4% (44·9–77·9)
Thailand (six registries)						
2000–04	37·9% (33·4–42·3)‡	46·3% (40·5–52·1)‡	30·5% (19·2–41·8)‡	50·2% (21·3–79·1)‡§	..	9·9% (4·9–15·0)‡
2005–09	44·5% (40·7–48·4)	51·7% (46·1–57·3)	38·0% (28·6–47·4)	64·6% (47·2–82·1)§	..	19·9% (13·5–26·3)
2010–14	54·0% (49·7–58·2)‡	57·4% (51·8–63·0)‡	41·1% (31·7–50·6)‡	65·8% (47·4–84·1)‡	..	36·6% (25·7–47·5)‡
Turkey (eight registries)						
2000–04	59·7% (53·7–65·6)‡	64·7% (58·0–71·4)‡	27·1% (14·1–40·2)‡§	..	47·2% (24·5–69·9)‡§	..
2005–09	68·5% (65·8–71·1)	72·0% (68·8–75·2)	44·2% (37·8–50·6)	86·9% (71·9–100·0)	66·9% (51·7–82·0)§	57·4% (43·8–71·1)§
2010–14	72·1% (69·7–74·5)	72·9% (69·9–75·9)	50·8% (44·7–57·0)	99·1% (97·4–100·0)	79·5% (66·8–92·1)§	69·0% (56·9–81·1)
Europe						
Austria†						
2000–04	78·0% (74·8–81·3)	82·8% (78·9–86·7)	59·9% (51·2–68·6)	74·2% (59·3–89·2)§	..	59·3% (41·5–77·1)§
2005–09	81·5% (78·5–84·5)	82·3% (78·6–85·9)	61·4% (52·6–70·3)	100·0% (78·2–100·0)§	..	81·8% (60·2–100·0)§
2010–14	82·7% (79·8–85·7)	85·4% (81·8–88·9)	63·5% (55·0–71·9)	97·7% (94·0–100·0)	..	66·9% (41·8–91·9)§
Belarus Childhood*						
2000–04	71·6% (66·7–76·5)	78·9% (73·7–84·1)	47·8% (36·0–59·7)	..	..	..
2005–09	80·8% (76·2–85·4)	88·2% (83·9–92·5)	54·3% (40·4–68·2)	..	..	..
2010–14	83·9% (80·0–87·9)	88·3% (84·5–92·1)	59·8% (44·2–75·4)	..	44·6% (16·7–72·5)§	..
Belgium†						
2000–04	78·9% (71·7–86·1)	80·2% (72·3–88·0)	53·4% (29·3–77·5)§	..	..	..
2005–09	81·1% (78·0–84·2)	84·3% (80·4–88·1)	55·0% (44·8–65·1)	92·7% (84·7–100·0)§	84·9% (72·9–97·0)§	..
2010–14	85·1% (82·3–87·9)	86·3% (82·8–89·7)	65·6% (55·7–75·4)	96·0% (89·1–100·0)	84·9% (75·7–94·2)§	..
Bulgaria†						
2000–04	50·9% (45·3–56·6)	59·5% (52·7–66·4)	23·2% (12·5–33·9)	35·1% (15·1–55·1)§	..	33·4% (12·7–54·0)§
2005–09	66·3% (61·7–70·8)	67·2% (62·2–72·2)	39·3% (26·5–52·2)	90·5% (80·3–100·0)§	..	25·0% (2·9–47·2)§
2010–14	71·7% (67·0–76·4)	70·8% (65·2–76·4)	57·7% (42·6–72·8)	99·3% (98·1–100·0)§	76·4% (53·5–99·2)§	..
Croatia†						
2000–04	75·8% (71·1–80·6)	75·1% (69·9–80·4)	62·6% (46·1–79·0)§	..	..	70·7% (49·8–91·6)§
2005–09	73·8% (68·5–79·1)	77·9% (71·7–84·1)	43·2% (29·0–57·5)§	81·9% (60·2–100·0)§	..	..
2010–14	76·1% (70·9–81·3)	79·0% (72·3–85·7)	60·9% (45·9–75·9)	..	..	..
Czech Republic†						
2000–04	75·8% (71·7–79·9)	80·3% (75·8–84·9)	49·4% (37·1–61·7)	79·2% (63·3–95·1)§	..	..
2005–09	78·3% (74·4–82·2)	80·5% (76·0–85·0)	56·0% (40·9–71·2)	84·8% (71·2–98·3)§	..	61·2% (39·4–82·9)§
2010–14	79·6% (75·2–84·0)	81·6% (76·5–86·6)	53·7% (34·7–72·6)	96·7% (92·5–100·0)	..	..
Denmark†						
2000–04	80·4% (76·1–84·7)	83·5% (78·4–88·6)	69·3% (58·2–80·4)	80·1% (60·5–99·6)§	63·7% (37·4–90·0)§	66·7% (41·4–92·0)§
2005–09	83·4% (79·5–87·3)	87·6% (83·2–92·1)	70·6% (59·5–81·8)	94·2% (83·3–100·0)§	68·8% (46·9–90·7)§	..
2010–14	87·3% (83·8–90·8)	90·8% (86·9–94·8)	71·8% (60·2–83·5)	100·0% (100·0–100·0)§	73·0% (54·5–91·4)§	67·4% (38·5–96·3)§
Estonia†						
2000–04	51·6% (40·7–62·5)	53·6% (38·9–68·3)	35·1% (15·1–55·1)§	..	..	..
2005–09	75·2% (66·1–84·4)	79·6% (67·9–91·4)	65·3% (46·3–84·3)§	..	..	..
2010–14	70·7% (58·5–82·9)	76·6% (64·4–88·8)	..	..	..	..

(Table 2 continues on next page)

	All leukaemias	Lymphoid leukaemia	Acute myeloid leukaemias	Chronic myeloproliferative diseases	Myelodysplastic syndrome and other myeloproliferative diseases	Unspecified and other specified leukaemias
(Continued from previous page)						
Finland†						
2000–04	80·4% (76·1–84·7)	83·0% (78·1–87·9)	65·7% (52·8–78·5)	88·4% (73·5–100·0)§	..	57·2% (32·5–81·9)§
2005–09	82·3% (78·3–86·2)	84·2% (80·2–88·2)	70·6% (58·7–82·5)	94·5% (84·2–100·0)§	..	69·0% (52·5–85·5)§
2010–14	86·5% (82·8–90·2)	86·7% (82·0–91·4)	64·2% (50·9–77·6)	100·0% (100·0–100·0)§	..	93·9% (82·4–100·0)§
France* (15 registries)						
2000–04	79·3% (77·2–81·4)	82·6% (79·4–85·7)	59·7% (54·6–64·8)	90·9% (83·8–98·0)	60·8% (50·4–71·2)§	58·6% (45·5–71·7)§
2005–09	83·1% (81·2–85·0)	85·4% (82·6–88·3)	68·3% (63·6–73·0)	97·3% (93·7–100·0)	59·5% (47·7–71·3)§	67·0% (56·5–77·6)§
2010–14	83·4% (80·6–86·3)	87·2% (83·0–91·5)	70·0% (63·2–76·7)	95·5% (89·4–100·0)	61·3% (47·9–74·7)§	49·1% (31·7–66·4)§
Germany (ten registries)						
2000–04	81·4% (78·8–84·1)	83·4% (80·5–86·4)	71·6% (63·4–79·9)	75·2% (56·2–94·2)	82·5% (70·8–94·2)§	75·1% (55·0–95·1)§
2005–09	84·6% (82·6–86·7)	86·6% (84·1–89·0)	70·3% (62·7–77·8)	98·8% (97·1–100·0)	83·4% (73·7–93·0)	52·3% (32·6–71·9)§
2010–14	84·4% (82·1–86·8)	86·0% (83·0–89·0)	68·0% (59·2–76·7)	97·5% (95·0–100·0)	83·6% (72·6–94·6)	..
Greek National Paediatric*						
2000–04	81·2% (77·4–85·1)	84·7% (81·0–88·5)	52·7% (37·1–68·2)	..	..	..
2005–09	83·0% (79·4–86·7)	87·9% (84·4–91·3)	45·9% (32·0–59·8)	..	..	..
2010–14	81·7% (78·1–85·2)	86·5% (83·2–89·9)	49·0% (35·8–62·2)	..	..	..
Iceland†						
2000–04	81·3% (62·8–99·8)	75·1% (51·7–98·5)	..	..	..	..
2005–09	77·0% (61·1–92·8)	90·9% (74·7–100·0)	..	..	..	..
2010–14	92·0% (81·8–100·0)	92·9% (79·9–100·0)	..	..	..	..
Ireland†						
2000–04	73·8% (68·6–78·9)	75·5% (69·8–81·2)	58·6% (46·1–71·1)	86·7% (70·1–100·0)§	..	58·3% (32·0–84·7)§
2005–09	84·6% (80·5–88·7)	89·3% (84·8–93·8)	71·1% (58·2–84·0)	93·8% (82·3–100·0)§	..	..
2010–14	83·7% (79·1–88·2)	87·2% (82·6–91·9)	73·9% (60·8–87·0)	..	..	..
Italy (44 registries)						
2000–04	78·5% (76·2–80·8)	76·4% (73·6–79·3)	64·4% (57·6–71·2)	91·1% (83·4–98·9)	84·2% (70·1–98·3)§	50·5% (32·6–68·5)§
2005–09	82·2% (80·4–84·0)	81·8% (79·3–84·3)	65·1% (59·8–70·4)	90·3% (81·9–98·7)	79·9% (69·2–90·7)	73·4% (57·9–89·0)§
2010–14	82·8% (80·3–85·2)	82·4% (79·0–85·8)	68·9% (61·6–76·2)	97·0% (91·2–100·0)	66·3% (50·0–82·6)	..
Latvia†						
2000–04	68·1% (59·7–76·5)	75·0% (66·3–83·7)	42·9% (22·5–63·3)§	..	..	58·4% (32·0–84·7)§
2005–09	73·1% (64·2–82·0)	77·3% (66·5–88·1)	57·2% (32·5–81·9)§	..	..	..
2010–14	81·9% (73·7–90·1)	80·5% (71·4–89·7)	..	..	..	..
Lithuania†						
2000–04	62·1% (55·4–68·9)	71·2% (63·7–78·6)	28·3% (14·5–42·0) §	..	..	..
2005–09	69·2% (62·2–76·1)	73·0% (65·0–81·0)	50·1% (33·6–66·6) §	70·8% (49·8–91·8)§	..	..
2010–14	73·4% (65·1–81·6)	71·6% (62·2–81·0)	61·1% (37·3–84·8) §	..	..	..
Malta†						
2000–04	65·7% (49·5–81·8)§	81·0% (64·6–97·3)§	..	..	..	..
2005–09	74·2% (59·1–89·4)§	89·5% (76·1–100·0)§	..	..	..	..
2010–14	66·7% (45·7–87·8)§	..	..	..	..	..
Netherlands†						
2000–04	75·8% (73·1–78·4)	78·8% (75·7–81·9)	56·6% (49·2–64·0)	91·1% (82·7–99·5)§	60·5% (46·8–74·1)§	45·5% (18·1–72·9)§
2005–09	80·3% (77·8–82·8)	85·0% (82·1–87·9)	56·8% (49·5–64·1)	86·1% (71·1–100·0)	73·2% (62·5–83·8)	..
2010–14	83·7% (81·4–86·1)	86·6% (83·8–89·3)	71·8% (64·8–78·8)	96·5% (92·8–100·0)	57·5% (43·3–71·7)	51·5% (25·2–77·8)§
Norway†						
2000–04	77·3% (72·4–82·2)	78·7% (73·5–83·9)	67·1% (55·3–79·0)	70·1% (43·3–96·8)§	..	..
2005–09	83·1% (78·8–87·3)	84·4% (79·9–88·9)	67·4% (54·5–80·4)§	95·5% (87·0–100·0)§	75·1% (54·6–95·5)§	..
2010–14	82·0% (77·8–86·3)	82·2% (77·0–87·4)	76·5% (65·7–87·2)	99·3% (97·9–100·0)	65·3% (41·8–88·9)§	..

(Table 2 continues on next page)

	All leukaemias	Lymphoid leukaemia	Acute myeloid leukaemias	Chronic myeloproliferative diseases	Myelodysplastic syndrome and other myeloproliferative diseases	Unspecified and other specified leukaemias
(Continued from previous page)						
Poland (16 registries)†						
2000–04	67·1% (64·9–69·3)	72·3% (69·7–74·8)	45·4% (39·5–51·2)	69·7% (55·4–84·0)	..	52·7% (41·1–64·4)
2005–09	74·9% (72·9–76·8)	77·1% (74·7–79·4)	57·9% (52·2–63·6)	71·1% (57·5–84·7)	..	76·1% (62·9–89·3)
2010–14	79·5% (77·6–81·4)	81·0% (78·8–83·3)	66·6% (61·3–71·8)	93·8% (84·1–100·0)	..	74·5% (63·8–85·2)
Portugal (four registries)†						
2000–04	71·2% (67·4–75·0)	75·0% (70·5–79·6)	52·1% (42·5–61·8)	85·0% (72·9–97·0)§	54·7% (34·6–74·8)§	60·1% (31·6–88·5)§
2005–09	79·8% (76·3–83·2)	80·3% (75·9–84·7)	69·7% (60·9–78·5)	94·9% (87·9–100·0)§	74·0% (54·9–93·1)§	59·2% (39·2–79·2)§
2010–14	79·4% (72·2–86·7)	80·5% (72·2–88·8)	66·9% (48·5–85·4)	..	..	..
Romania (Cluj)						
2000–04	..	..	..	..	..	..
2005–09	62·5% (40·2–84·8)§	..	..	..	..	..
2010–14	63·1% (45·2–80·9)§	53·9% (28·2–79·6)§	..	..	..	..
Russia (three registries)						
2000–04	57·4% (51·0–63·7)	61·7% (54·0–69·5)	37·9% (24·2–51·6)	..	..	52·7% (37·9–67·4)§
2005–09	61·5% (55·6–67·5)	66·4% (59·6–73·2)	26·5% (12·8–40·2)§	..	..	58·7% (38·3–79·2)§
2010–14	62·9% (56·7–69·2)	70·0% (62·6–77·3)	39·9% (26·1–53·6)	..	..	..
Slovakia†						
2000–04	69·8% (64·3–75·3)	73·0% (66·5–79·4)	48·8% (36·3–61·2)	88·3% (73·5–100·0)§	..	..
2005–09	73·4% (68·5–78·3)	77·3% (71·3–83·2)	49·1% (36·4–61·9)	92·0% (81·3–100·0)§	61·6% (36·4–86·8)§	..
2010–14	76·6% (65·5–87·7)§	80·0% (67·7–92·3)§	..	..	..	..
Slovenia†						
2000–04	77·5% (69·5–85·4)	85·9% (79·2–92·6)	50·0% (27·8–72·2)§	..	..	..
2005–09	74·6% (66·3–82·9)	73·5% (62·8–84·2)	60·9% (41·6–80·2)§	100·0% (76·8–100·0)§	..	..
2010–14	79·6% (70·8–88·4)	77·1% (66·6–87·7)	65·9% (42·6–89·1)§	..	..	..
Spain (11 registries)						
2000–04	71·7% (68·5–75·0)	74·3% (69·3–79·4)	55·0% (44·1–66·0)	89·0% (77·4–100·0)§	..	..
2005–09	77·7% (75·1–80·3)	77·6% (73·2–81·9)	62·4% (52·4–72·4)	100·0% (100·0–100·0)§	82·8% (69·3–96·3)§	54·6% (27·0–82·3)§
2010–14	77·8% (73·7–81·9)	81·9% (75·4–88·3)	53·7% (38·8–68·6)	100·0% (100·0–100·0)	..	..
Sweden†						
2000–04	79·9% (76·5–83·3)	82·5% (78·3–86·8)	64·1% (55·0–73·3)	85·3% (72·2–98·5)§	..	68·5% (48·2–88·8)§
2005–09	81·4% (78·0–84·8)	85·2% (81·1–89·3)	66·4% (56·8–76·0)	94·4% (86·8–100·0)§	72·1% (54·9–89·3)§	61·1% (39·4–82·9)§
2010–14	83·3% (80·2–86·4)	86·5% (82·6–90·3)	68·3% (59·1–77·6)	99·3% (97·9–100·0)	..	..
Switzerland (ten registries)*						
2000–04	78·4% (73·8–83·0)	86·2% (77·9–94·4)	52·0% (38·3–65·7)§	..	77·8% (59·2–96·5)§	..
2005–09	86·0% (82·0–89·9)	89·3% (85·5–93·1)	72·4% (59·8–85·0)§	100·0% (73·5–100·0)§	..	..
2010–14	85·2% (81·1–89·3)	90·5% (85·3–95·8)	74·8% (63·5–86·2)	100·0% (100·0–100·0)§	79·5% (61·3–97·7)	..
UK (four registries)†						
2000–04	76·7% (75·3–78·1)	78·4% (76·6–80·1)	60·7% (56·9–64·5)	85·3% (79·0–91·6)	67·8% (58·8–76·9)	63·9% (47·9–79·9)§
2005–09	83·0% (81·8–84·2)	84·7% (83·1–86·2)	65·3% (61·5–69·1)	92·8% (88·0–97·6)	78·6% (70·9–86·3)	66·6% (54·0–79·2)
2010–14	84·6% (83·4–85·7)	87·2% (85·7–88·6)	66·5% (62·8–70·1)	91·1% (85·9–96·3)	76·2% (67·4–85·0)	72·5% (61·0–84·1)

(Table 2 continues on next page)

the first worldwide analysis of trends in survival for patients diagnosed with leukaemia in this age range (0–24 years). We analysed high-quality data for more than 160 000 patients diagnosed with leukaemia during 2000–14, provided by 258 population-based cancer registries in 61 countries. The most common subtypes in children were acute lymphoid leukaemia and acute myeloid leukaemia. Other subtypes were more common in adolescents and young people aged 15–24 years. The morphology distribution was consistent across the study period (2000–14).

We noted a steady increase of about 5% in 5-year survival during the 15-year period in several high-income countries (the USA, the UK, France, Switzerland, Australia, and New Zealand). The gains in survival were largely driven by improvements in 5-year survival in children. Efforts to ensure that children with cancer have access to adequate care have led to improved

	All leukaemias	Lymphoid leukaemia	Acute myeloid leukaemias	Chronic myeloproliferative diseases	Myelodysplastic syndrome and other myeloproliferative diseases	Unspecified and other specified leukaemias
(Continued from previous page)						
Oceania						
Australia† (eight registries)						
2000–04	80·7% (78·8–82·7)	82·4% (79·8–84·9)	68·3% (63·0–73·6)	84·4% (74·4–94·3)	66·7% (50·2–83·3)§	60·1% (42·9–77·2)
2005–09	84·5% (82·8–86·2)	85·4% (83·2–87·7)	73·0% (67·9–78·1)	93·7% (87·9–99·6)	58·3% (47·7–68·9)	86·3% (74·0–98·7)§
2010–14	87·7% (86·0–89·4)	89·2% (87·1–91·3)	77·7% (72·6–82·9)	93·5% (87·2–99·7)	80·8% (69·8–91·9)	87·0% (74·1–100·0)
New Zealand†						
2000–04	77·7% (73·3–82·1)	80·3% (75·2–85·5)	67·2% (56·5–78·0)	..	..	..
2005–09	84·9% (81·1–88·6)	86·4% (81·7–91·1)	75·3% (64·4–86·2)	95·3% (86·4–100·0)	..	..
2010–14	84·0% (80·2–87·8)	86·6% (81·8–91·5)	69·4% (59·0–79·9)	90·0% (76·8–100·0)	100·0% (100·0–100·0)	..

Data are net survival (%), with 95% CIs. ‡Survival estimate considered less reliable, because 15% or more of patients were either lost to follow-up or censored alive within 5 years of diagnosis (or if diagnosed in 2010 or later, before Dec 31, 2014), registered only from a death certificate or at autopsy, or registered with incomplete dates (ie, unknown year of birth, unknown month or year of diagnosis, or both, or unknown year of last vital status). §Survival estimates that are not age-standardised. *Data with 100% coverage of the national population for childhood malignancies only; data for 15–24 years, if available, were provided from registries with subnational coverage. †Data with 100% coverage of the national population.

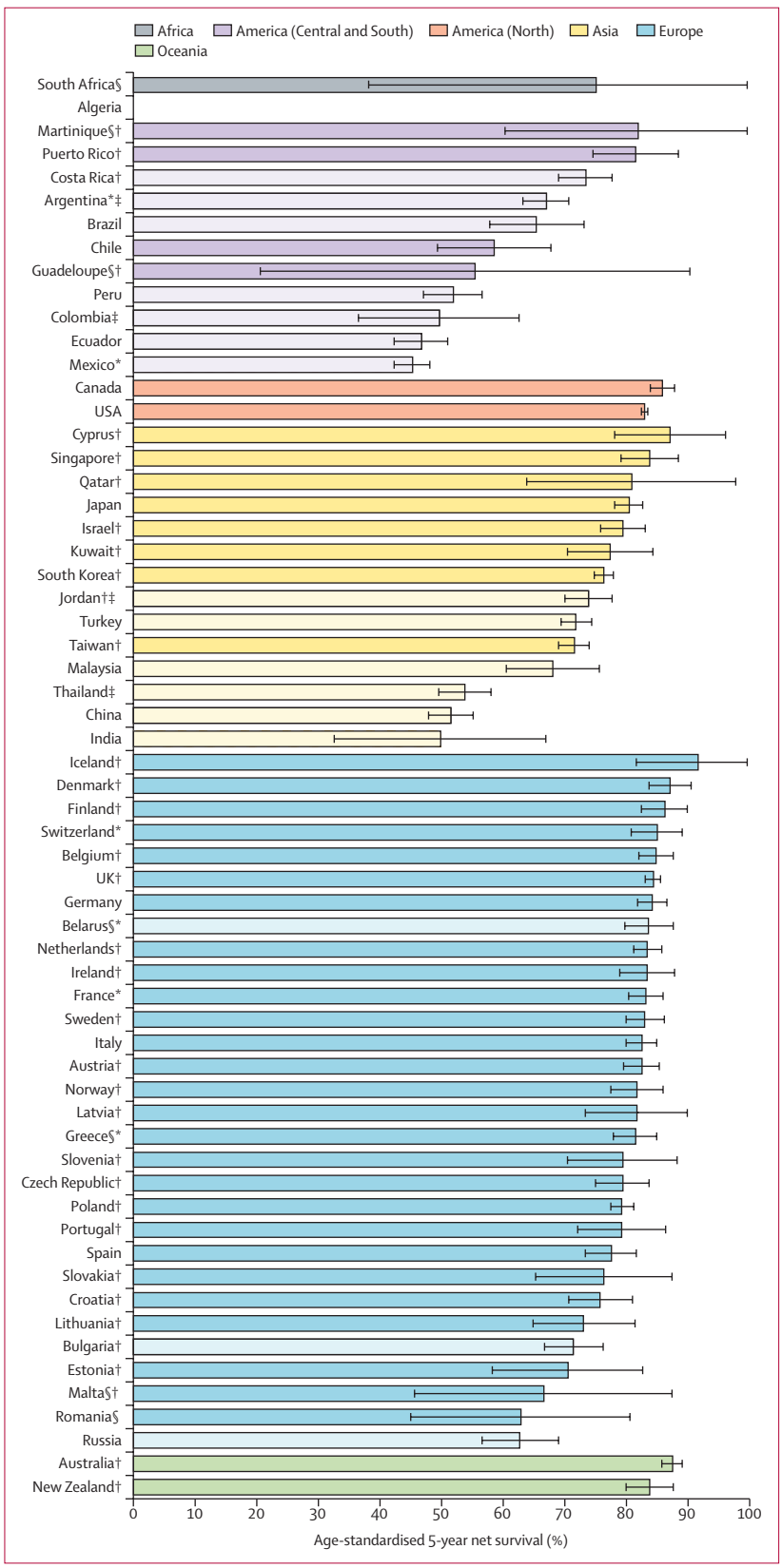
Table 2: **Age-standardised 5-year net survival in children, adolescents, and young adults (0–24 years) diagnosed with leukaemia, by calendar period of diagnosis and morphology subtype**

survival, especially in high-income countries.[9,20,21] In countries such as the UK, Canada, the USA, Australia, and New Zealand, most children with leukaemia have been enrolled in long-running series of clinical trials for many years.[22] Our findings are consistent with those from other studies showing that survival from leukaemia in adolescents and young adults is lower than in children.[6,10,20,23] During 2000–14, we observed a greater improvement in survival for all leukaemias combined among adolescents (aged 15–19 years) than among young adults (aged 20–24 years). The increase in survival over the same period did not mirror what was a much larger improvement in children (aged 0–14 years). Survival improved for adolescents and young adults from the late 1970s to the early 2000s, and the increase was greater in Europe than in the USA.[20]

We also detected sizable improvements in 5-year survival of 10% or more in Puerto Rico and parts of northern Europe (Estonia, Ireland, Latvia, and Lithuania), eastern Europe (Bulgaria), and Asia (China, Japan, South Korea, Singapore, Taiwan, and Turkey). Such increases can be explained in part by optimisation of treatment protocols (eg, for patients with acute myeloid leukaemia in Bulgaria)[24] or the introduction of financial aid to assist in the costs of treatments for children diagnosed with cancer, such as in South Korea.[25]

5-year survival from leukaemia in China has increased markedly, from 38% to 52%. The number of registries contributing to these analyses from China also increased, from ten in 2000–04 to 21 in 2010–14. The additional registries were equally distributed between rural and urban regions, similarly to the initial ten registries. Analysis restricted to the initial ten registries showed the same improvement over the 15-year period, indicating that the increases in survival are not just due to the newer registries (data not shown). In 2005, the Chinese Government introduced a policy to fund treatment for catastrophic diseases, including cancers in children (eg, leukaemia) and in 2011 the rural co-operative medical care system was introduced, ensuring medical insurance coverage for children in rural villages.[26–28] These changes in health expenditure boosted access to treatment, reducing the economic burden for parents and caregivers. Although these gains in survival were sizeable, pooled 5-year survival estimates from the 21 participating registries are still lower than in high-income countries such as Australia and Canada, where survival for all leukaemias had reached 85% or higher by 2010–14. This finding suggests that such initiatives are not without limitations; for example, when rural migrants to cities are no longer able to access such insurance in the urban setting, which might affect their ability to pay for treatment. In the past decade, the Chinese Government initiated the National Cancer Registration and Follow-up Programme, which has markedly accelerated the development of cancer registration in China, and in the long term will be valuable in informing progress on cancer control in China.[27]

During 2000–14, 5-year survival for children with lymphoid leukaemia was consistently high in most high-income countries (>80%), with that of adolescents following closely. In the USA, between 1993 and 1997, 5-year relative survival for individuals with acute lymphoblastic leukaemia ranged from 85% in children aged 10 years to less than 40% in adults aged 30 years.[29] Studies have shown that for adolescents and young adults, there are differences in prognosis depending on whether they are treated in accordance with a paediatric protocol or a protocol for adult patients.[10,29,30] In Japan, trends from 1975 to 2011 showed that among adolescents and young adults, 5-year overall survival for acute lymphoblastic leukaemia improved, especially after a paediatric regimen was introduced in 2000, but was still lower than that among children (65% in those aged



15–39 years *vs* 87% in those aged 0–14 years).[31] Additionally, adolescents and young adults are less likely to be enrolled in clinical trials than children,[3] because of the small number of clinical trials in this population, leading to restricted access to novel drugs that could be more effective for adolescents and young adults than for children or older patients.[32]

Survival for patients diagnosed with acute myeloid leukaemia was generally poorer than for other subtypes. A similar study in the UK showed that for patients diagnosed with acute myeloid leukaemia in 2001–10, 5-year relative survival was higher in younger age groups (66% in children aged 0–12 years *vs* 58% in those aged 13–24 years).[4] We found that children and adolescents with acute myeloid leukaemia had similar survival, whereas young adults had lower survival. Treatment with molecularly targeted tyrosine kinase inhibitors introduced in the early 2000s has led to improved survival for patients with chronic myeloid leukaemia.[33] Survival for chronic myeloproliferative diseases was uniformly higher, with estimates of 90% or higher in most countries during 2000–14. Survival trends for the other subtypes remained fairly steady. Since these subtypes are less common in children, adolescents, and young adults, our results are particularly relevant because, to our knowledge, this is the largest global set of analyses with information about morphological subtypes of leukaemia in young people.

At present, the burden of leukaemia in adolescents and young adults is poorly defined.[34] Patients in this age range often have unique clinical needs. Over the past few years, in some parts of the world, adolescents and young adults with leukaemia have increasingly been treated under paediatric protocols, which has led to improved outcomes.[31] However, this approach has not been adopted worldwide, and survival for adolescents and young adults with leukaemia is often lower than that of children.

In 2018, WHO launched the Global Initiative for Childhood Cancer (GICC), aiming to improve survival for children with cancer worldwide.[35] The main target of the GICC is to achieve "at least 60% five-year survival

Figure 2: **Age-standardised 5-year net survival from all leukaemias combined for children (0–14 years), adolescents (15–19 years), and young adults (20–24 years) diagnosed during 2010–14, by continent and country**
Survival estimates for each country are ranked from highest to lowest within each continent. High-income countries within each continent are indicated by the dark shades and low-income and middle-income countries are presented by light shades (classified according to World Bank income group). Where data were available for more than one registry in a given country, the survival estimates are derived by pooling the data for that country, but excluding data from registries for which the estimates are considered less reliable. 95% CIs around the net survival estimate are indicated by the error bars for each country. §National estimate not age-standardised. †Data with 100% coverage of the national population. *Data with 100% coverage of the national population for childhood malignancies only; data for 15–24 years, if available, were provided from registries with subnational coverage. ‡National estimate flagged as less reliable because the only available estimates are from a registry or registries in this category.

by 2030". 5-year net survival for children with cancer in low-income and middle-income countries is typically around 20%, compared to 80% in high-income countries. The GICC includes adolescents (aged 15–19 years) as part of the wider definition of childhood, but including young adults (20–24 years) in the target as well could be an important international priority in countries with limited resources. It would raise awareness of the unique clinical needs of patients in this age group, and would help improve the delivery of effective treatment, further reducing global inequalities in survival, even leading to economic gain.[36]

The *Lancet Oncology* Commission on childhood cancer suggested that investment in comprehensive scale-up of resource-appropriate interventions worldwide would probably avert approximately 6 million deaths from cancers in children by 2050.[37] Treatment of cancer in adolescents and young adults has improved over the past decade and is still progressing. Several high-income countries have developed strategies to improve clinical care and produce better outcomes for this age group.[38]

The results of this study are population-based survival estimates, derived from cancer registry data that include all patients with cancer diagnosed in the jurisdiction of the registry. Population-based survival estimates reflect the survival of all patients with cancer in the population covered by the registry and reflect the overall effectiveness of the health system.[39,40] Clinical trials are excellent for deciding whether one treatment is better than another, but they do not provide information about the effectiveness of the health service in delivering improved treatments to everyone who needs them.

In our study, net survival estimates were produced from data collected according to a common protocol, subject to stringent, centralised quality control and analysed with the same robust statistical methods. Data quality was generally high, but data from some registries in Algeria, China, Thailand, and South Africa contained higher proportions (≥25%) of patients with unspecified leukaemias. This is likely to be due to limited access or no access to specialist haematological pathology services, which can in turn lead to inappropriate treatment for a specific subtype of leukaemia.

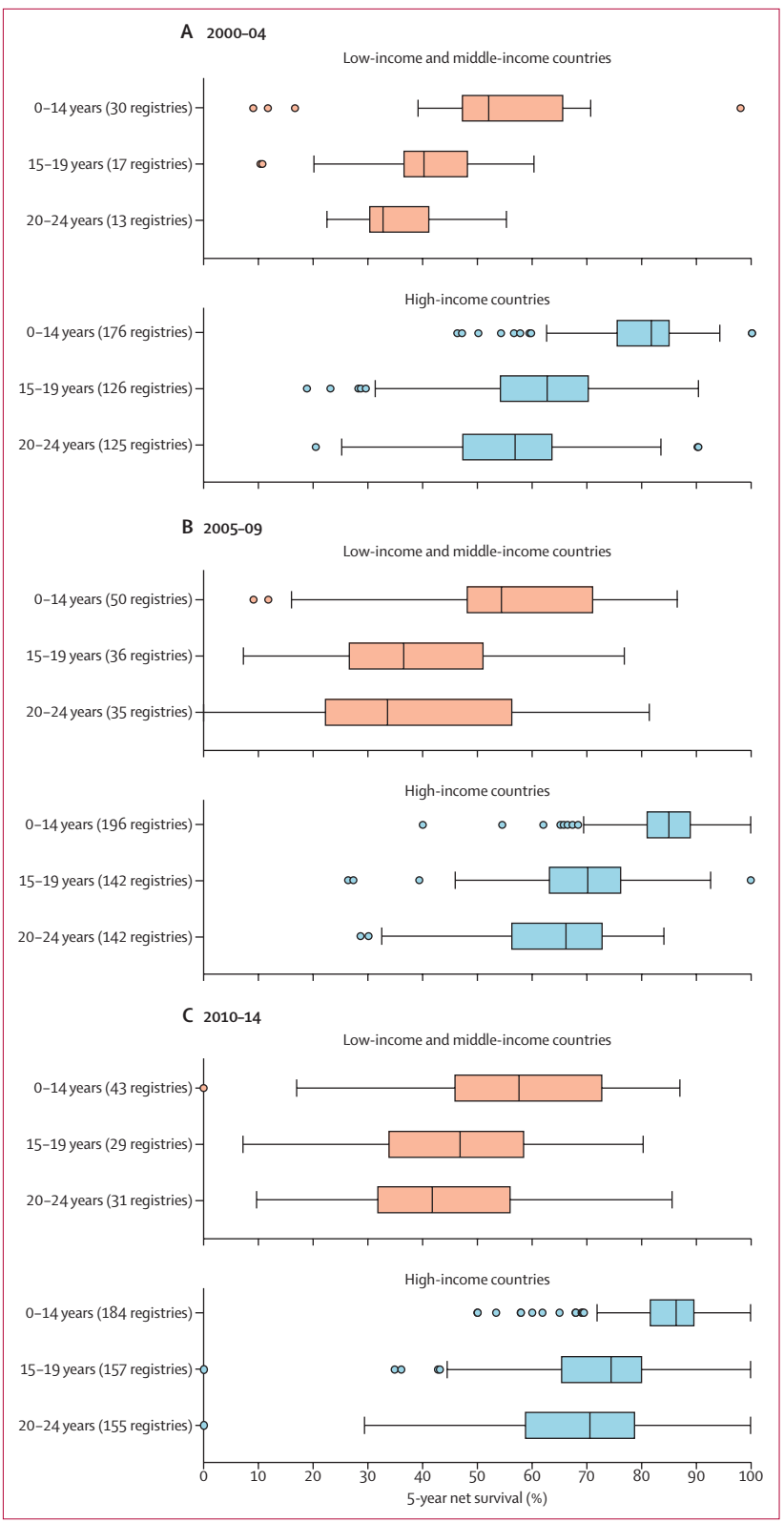


Figure 3: **5-year net survival (%) for all leukaemias combined, in patients aged 0–24 years diagnosed during 2000–14, according to World Bank income group and calendar period of diagnosis**

The number of registries for which suitable estimates could be obtained are shown in parentheses. Each box plot shows the range of survival estimates among all cancer registries for which suitable estimates could be obtained for patients diagnosed in each calendar period, in each age group. Survival estimates considered less reliable are not included. The vertical line inside each box represents the median survival estimate among all contributing registries (the central value in the range, or 50th centile). The box covers the IQR. Where there are only a few widely scattered estimates, the median might be close to the lower or upper quartile. The extreme limits of the box plot are 1·5 × IQR below the lower quartile and 1·5 × IQR above the upper quartile. Open circles indicate outlier values outside this range.

No internationally recognised set of weights exists for standardising cancer survival estimates across the age range 0–24 years. We therefore derived weights from the age distribution of all patients diagnosed with leukaemia during 2000–14 who were included in our analyses, to enable comparison of summary estimates of survival over time and between countries. The weights used for age standardisation of cancer survival in children have usually been a simple average of the estimates for children aged 0–4, 5–9, and 10–14 years,[19] but patients aged 15–24 years are usually included with adults in the age range 15–44 years, which makes it easier to apply the International Cancer Survival Standard (ICSS) weights.[41] A recently proposed set of weights covers the age range 0–85 years and older.[42] We rescaled the weights within the age range 0–24 years, and a sensitivity analysis produced similar results (data not shown).

A classification has recently been proposed for adolescents and young adults (15–39 years),[43] but as far as we are aware, there is no standard classification that includes children as well as adolescents and young adults. Therefore, we adapted the standard ICCC-3 classification[14] for children (aged 0–14 years) to include those aged 15–24 years.

We will shortly examine trends and inequalities in conditional net survival at 5 years for children, adolescents and young adults with leukaemia who have survived at least 1 year after diagnosis. This is one approach for assessing the impact on 5-year survival of leukaemia treatment (or remission) during the first year after diagnosis. In CONCORD-4, we will also extend the period covered by survival trends to include patients diagnosed in the past 20 years, to bring the global surveillance of survival trends as up to date as possible (2000–19 or later, depending on the availability of data).

In conclusion, this study offers the first worldwide direct comparison of survival between children, adolescents, and young adults diagnosed with leukaemia. The gap in survival between high-income countries and low-income and middle-income countries for children with leukaemia persists, and adolescents and young adults with leukaemia continue to have lower survival than children worldwide. Exploring trends in survival for adolescents and young adults is an important indicator of the quality of cancer management in this age group. Lasting progress in survival will result from investing in the human and financial resources that are required to manage and treat all young people with cancer appropriately, and eventually translating these investments into better outcomes overall.

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CA, MPC, and NS contributed to study design. MPC and CA contributed to acquisition of statutory and ethical approvals. VDC, CA, and MPC contributed to construction of life tables. NS, VDC, CA, and MPC contributed to data quality control and had full access to all the data in the study. NS did the formal analyses. NS, CA, and MPC were responsible for writing the original draft. CS, KN, JS, SR, and FG contributed to review and editing, and provided advice on methods and interpretation of results. All authors checked and contributed to writing the final report. All CONCORD Working Group members had access to the results of all steps of data preparation, quality control, and analyses, and contributed to interpretation of the findings. CA was responsible for acquisition of funding.

Declaration of interests

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Data sharing

This publication contains the results of secondary analysis of sensitive personal data, carried out with approval from the UK's statutory Health Research Authority and from the NHS Research Ethics Service. The individual records for CONCORD-3 were provided by more than 300 population-based cancer registries in more than 70 countries. We hold these data in trust from each participating registry to perform only the analyses agreed in the protocol, which prohibits sharing of the raw data without express approval from the participating registries.

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