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Global population-based childhood cancer survival in the 21st century: a scoping review

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Introduction: The development of effective treatment for many childhood cancers has led to dramatic increases in survival rates at the population level, at least in affluent industrialized countries. Studies of survival in numerous populations have been published, but population-based survival estimates that are essential for monitoring and planning are still lacking in many countries. There is no comprehensive account of the type and extent of available information on this topic. A scoping review of population-based studies of childhood cancer in the 21st century was carried out with the aim of repairing this omission.
Methods: The electronic databases PubMed and Web of Science were searched, supplemented by the author's bibliographic files.
Results: The searches produced 5,490 references, of which 303 reported population-based studies containing at least one estimate of 5-year survival for children with cancer diagnosed during a period whose central year was 2001 or later. Overall, 75% of high-income countries with a child population ≥50,000 were represented in these studies, compared with 47% of upper middle income countries, 16% of lower middle income countries and 8% of low income countries. Among countries that were represented in population-based studies, 29% of high income countries were only represented in studies involving multiple countries compared with 75% of those in lower income categories. Similar contrasts were found between countries with very high Human Development Index and those in lower categories of Human Development Index.
Discussion: Wider availability of robust information on survival at population level will be essential for monitoring progress toward the goal set by the World Health Organization's Global Initiative for Childhood Cancer of 60% survival globally for children and adolescents with cancer by the year 2030. Increasing the coverage and quality of cancer registration and death notification in as many lower-resource countries as possible would in turn increase the volume and geographic spread of the data from which survival rates can be estimated for those countries. International collaborations whose results are underpinned by uniform procedures for data validation and analysis will continue to play a vital part in enabling comparison of childhood cancer survival between populations.

KEYWORDS

childhood cancer, leukemia, survival, population-based, cancer registry, international

1 Introduction

The development of effective treatments for many childhood cancers over the past 60 years is one of the great success stories of oncology (1, 2). In consequence, there have been dramatic increases in survival rates for childhood cancer at the population level, at least in affluent industrialized countries (3, 4). Some of these increases have been shown to occur concurrently with the adoption of successive trial protocols for particular types of childhood cancer (5, 6).

Impressive results have also been reported from specialist centers in many less well-resourced settings. However, population-based estimates of survival of all patients, including those not treated at specialist centers, are essential for monitoring and planning but are still lacking in many countries. This absence prompted Ward et al. (7) to carry out a simulation study to estimate survival for virtually every country in the world including those for which hard data were missing. In the same year, Girardi et al. (8) published a systematic review of worldwide trends in survival from two principal types of childhood brain tumor. Since then, studies of survival from childhood cancer in numerous populations have continued to be published, but there has apparently been no comprehensive delineation of the type and extent of the available information on this topic. The present scoping review was carried out in order to repair this omission.

2 Materials and methods

Eligible publications were defined as those that provided at least one population-based estimate of survival for children diagnosed with cancer according to the following criteria.

Data had to refer to cases arising in a defined population, usually compiled by a population-based cancer registry (PBCR) and were not restricted to patients receiving any particular treatment modality or modalities.

Following Girardi et al. (8), survival estimates had to be at 5 years after diagnosis. Eligibilty was broadened, however, to include endpoints other than death from any cause, thus papers reporting relative survival, net survival, event-free survival, cancer-specific survival or disease-specific survival could also be included.

Age range at diagnosis: lower bound $\leq$14 years and upper bound <20years.

Calendar period of diagnosis: wholly contained within a period whose central year was 2001 or later (including periods of an even number of years in length whose central years were 2000 and 2001).

Two online databases, PubMed and Web of Science, were searched for publications satisfying the above criteria. The search strategies are presented in the Appendix. The results of these searches were supplemented by review of additional publications from 2001 onwards in the author's bibliography files on descriptive epidemiology of childhood cancer. Eligible papers were restricted to those published in peer-reviewed journals. Conference abstracts were excluded. There were no language restrictions.

Throughout this review, the French West Indies have been treated as a single territory and Hong Kong and Macau have been included with China. For analyses by world region, Mexico, which is geographically in North America but more closely aligned socioeconomically and culturally with Latin America, was included in the category of America (Central and Caribbean); for similar reasons, Cyprus, which is geographically in western Asia, was included in the category of Europe.

3 Results

3.1 Literature searches

The searches of PubMed and Web of Science together yielded 5,490 references, with a further 383 from the author's bibliography files giving a grand total of 5,873 (Figure 1). After elimination of 1,010 duplicates and 574 articles published before 2001, 4,289 records remained for further assessment. On the basis of title and abstract, 3,190 references were excluded because they did not satisfy the eligibility criteria listed above. Full text was unavailable for 32 records. The remaining 1,067 were subjected to full-text review, leading to the exclusion of 764 because of failure to satisfy one or more of the eligibility criteria. There were thus a final total of 303 eligible publications, 29 of which were editions of two series of American annual reports.

3.2 United States annual series

The American Cancer Society "Cancer Statistics" reports for 2009 onwards have reported 5-year relative survival for childhood cancer diagnosed mainly or entirely in the 21st century, based on data from the Surveillance, Epidemiology and End Results (SEER) Program, thus the 16 reports issued in 2009–2024 were eligible for this review (9–24). The 2009–2016 editions (9–16) documented survival trends from 1975 onwards, with the most recent year of diagnosis being 5 years before the year of publication. Survival data in the editions for 2017 onwards (17–24) have covered a single 7-year period of diagnosis, the most recent year of diagnosis again being 5 years before the year of publication. Diagnoses have been classified according to the International Classification of Childhood Cancer, Third Edition (ICCC-3), in which the categories are defined by ICD-O-3 codes (25). Non-malignant central nervous system (CNS) tumors are excluded with the sole exception of pilocytic astrocytoma, which continued to be defined as malignant for the purposes of SEER when it was downgraded to uncertain behavior in ICD-O-3.

The annual statistical reports of the Central Brain Tumor Registry of the United States (CBTRUS) were initially self-published, but from 2012 they have been issued as supplements to *Neuro Oncology*. Each of these reports has presented 5-year relative survival for children under 15 years of age who were diagnosed during the 5-year period beginning 7 years before the year of publication, thus all 13 of the reports for 2012–2024 were eligible (26–38). Survival data were derived from the SEER-18 registries in the reports for 2012–2018 (26–32), and from NPCR registries in those for 2019 onwards (33–38). Diagnoses have been classified according to a scheme developed by CBTRUS and based on ICD-O-3 codes. Malignant and non-malignant tumors have been included throughout. Additional CBTRUS reports on childhood and adolescent patients that were published in 2022 and 2023 and are considered under "Other publications" below.

3.3 Other publications

Details of the remaining 274 eligible publications are shown in Table 1. Of these, 245 reported survival within a single country or territory, with 44 different countries represented. Data from the United States were analyzed in 93 (38%) of the 245 single-country studies. The great majority of these United States studies (75/93) were based exclusively on data from the SEER Program, though a substantial number of the analyses were conducted in

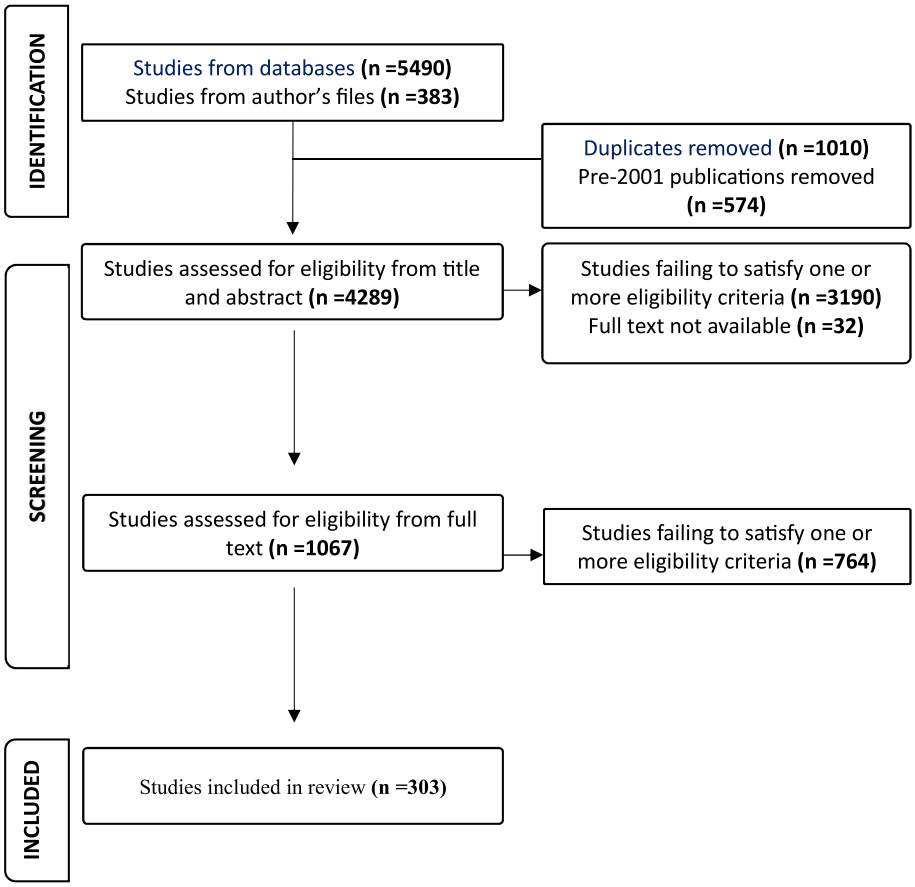

FIGURE 1
PRISMA flow diagram for scoping review of global population-based childhood cancer survival.

other countries. Other countries represented by at least five single-country studies were the Netherlands ($n = 17$), Australia ($n = 15$), the United Kingdom ($n = 11$), France (Metropolitan) and Spain (n=8 each), Canada, South Korea and Germany ($n = 7$ each), Thailand ($n = 6$), Brazil and Sweden ($n = 5$ each).

The other 29 publications were based on data from more than one country and were mostly products of established international collaborations. Eight papers from successive iterations of EUROCARE and its associated studies RARECARE and HAEMACARE have between them covered all types of childhood cancer in a large number of European countries (39–46). Five papers have presented international results from the CONCORD collaboration on population-based cancer survival worldwide (47–51) and a further paper reported detailed analyses of CONCORD data from 37 states in the United States (52). Leukemia was the only childhood cancer included in CONCORD-2 (50–52). CONCORD-3 expanded its coverage of childhood cancers to leukemia, lymphomas and CNS tumors (47–49). A collaboration between varying numbers of population-based cancer registries in Southern and Eastern Europe reported on survival from various childhood cancers in their respective countries in a series of seven papers, four of which also included United States data from the SEER Program (53–59). Finally, nine papers were from one-off studies that compared results between two, three, or four countries (60–68).

The 29 multinational papers included data not only from many countries that were represented by single-country studies, but also from a further 37 countries that did not have any eligible single-country publications in this review. Thus, a total of 80 countries and territories worldwide had their survival data included in at least one eligible paper, but for 37/80 (46%) this only occurred in the context of multinational studies. The proportion of countries that were only represented in multinational papers varied by continent, from zero in North America and Oceania to 12/35 (34%) in Europe, 5/11 (45%) in the Caribbean, Central and South America, 10/18 (56%) in Asia and 10/12 (83%) in Africa. Transferring Mexico and Cyprus to the groups of North American and Asian countries respectively would make little difference to this pattern.

3.4 Disease classifications and outcome measures

Definition and classification of diagnostic categories included in studies was nearly always by ICCC-3, by the CBTRUS classification of CNS tumors, or by ICD-O-3.

TABLE 1 Studies included in the review. American Cancer Society "Cancer Statistics" annual series and CBTRUS annual statistical reports are excluded.

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Arnett, 2024 (75)	United States	NPCR	2001–2019	Unspec.	0–19	Non-Hispanic White, non-Hispanic Black, non-Hispanic API, Hispanic	ICD-O-3	NA	NA	RS	Hepatocellular carcinoma
Businge, 2024 (76)	Rwanda	National	2013–2017	2021	0–14		ICCC-3	NA	NA	OS, RS	ICCC-3 Ia, IIa, IIb, IIc, V, VIa, VIIIa, IXa
Campbell, 2024 (77)	United States	NPCR	2001–2018	2018	0–19	Non-Hispanic White, non-Hispanic Black, non-Hispanic American Indian/Alaska Native, non-Hispanic API, Hispanic	ICCC-3	NA	NA	OS, RS	ICCC-3 IVa
de Sousa, 2024 (78)	Brazil	Mato Grosso	2001–2017	2022	0–19		ICCC-3	NA	NA	OS, RS	ICCC-3 I, II, and subgroups
Elgenidy, 2024 (79)	United States	SEER-17	2000–2019	Unspec.	0–14	White, Black, American Indian/Alaska Native, API	ICD-O-3	NA	NA	RS	Wilms tumor
Felix, 2024 (80)	French West Indies	National	2011–2021	Unspec.	0–17		Unspec.	NA	NA	OS	Neuroblastoma
Godoy-Casabuenas, 2024 (81)	Colombia	Bucaramanga, Manizales, Pasto	1998–2018	Unspec.	0–18		ICD-O-3	NA	NA	OS, RS	Leukemia
Hoang, 2024 (82)	United States	Texas	1995–2017	Unspec.	0–19	Residence <1 km or >1 km from oil or gas well	ICCC-3	NK	NA	OS	21 ICCC-3 subgroups
Hoffman, 2024 (83)	United States	SEER-18	2004–2019	Unspec.	0–19	Non-Hispanic White, non-Hispanic Black, non-Hispanic American Indian/Alaska Native, non-Hispanic Asian, Hispanic	ICD-O-3	NA	NA	OS, CSS	Ewing sarcoma of axial skeleton

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Hou, 2024 (84)	United States	SEER-18	2000–2018	Unspec.	0–19	White, Black	ICD-O-3	NA	NA	OS	Parotid tumors
Kristiansen, 2024 (69)	Faroe Islands	National	1960–2019	Unspec.	0–19		ICCC-3	NK	Nk	OS	All cancers
Liao, 2024 (85)	Taiwan	National	2006–2019	Unspec.	All ages		ICD-O-3	NA	NA	OS	Retinoblastoma
Lin, 2024 (86)	United States	SEER-18	2000–2019	Unspec.	0–19	White, Other	ICD-O-3	NA	NA	OS	Neuroendocrine tumors of digestive tract
Mashtoub, 2024 (87)	Australia	Northern Territory and South Australia	1990–2017	2017	0–19	Indigenous, non-Indigenous (Northern Territory only)	ICD-10, ICD-O-3	NK	NK	OS	Lymphoid leukemia, Medulloblastoma, Neuroblastoma, Retinoblastoma, Wilms tumor, Hepatoblastoma, Osteosarcoma, Ewing sarcoma, Rhabdomyosarcoma
Mishra, 2024 (88)	United States	SEER (by race and ethnicity)	2000–2020	Unspec.	0–19	White, Black, American Indian/Alaska Native, API, Hispanic	ICD-O-3	NA	NA	DSS	Burkitt lymphoma
Papakonstantinou, 2024 (89)	Greece	National	2010–2021	Unspec.	0–14		ICD-O-3	NA	NA	OS, EFS	Osteosarcoma
Peirelinck, 2024 (60)	Belgium, Netherlands	National	2004–2015	2021	0–17		ICCC-3	Yes	BCC excluded	OS	All cancers, ICCC-3 groups and selected subgroups
Pinsuwan, 2024 (90)	Thailand	Khon Kaen	2000–2019	2021	0–14		ICCC-3	NK	NA	RS	ICCC-3 I, II, III, IV, X
Qi, 2024 (91)	United States	SEER	2000–2018	Unspec.	0–19	White, Black	ICD-O-3	NA	NA	OS	Paratesticular rhabdomyosarcoma
Schulpen, 2024 (92)	Netherlands	National	1990–2018	2023	0–17		ICD-O-3	NA	NA	RS	Ewing sarcoma
Schulpen, 2024 (93)	Netherlands	National	1990–2015	2021	0–17		ICD-O-3	NA	NA	RS	NHL
Turanzas, 2024 (94)	Denmark	National	2007–2017	Unspec.	<1		Unspec.	Yes	NA	OS	Brain tumors

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Wang, 2024 (95)	China	Tianjin	2010–2016	2021	0–14		ICD-O-3	NK	NK	OS, RS	All cancers
Wang, 2024 (96)	United States	SEER-17	2001–2020	2020	0–19		ICD-O-3	Yes (pilocytic astrocytoma only)	NA	OS	CNS tumors
Wellbrock, 2024 (97)	Germany	National	2000–2016	2021	0–14		ICCC-3	Yes	NA	OS	CNS tumors and subgroups
Youlden, 2024 (98)	Australia	National	2006–2015	2020	0–14		ICCC-3	Yes	NK	OS, EFS	All cancers, ICCC-3 Ia, Ib, IIa, IIb, IIc, IIIa1, IIIb, IIIc1, IIId, IVa, V, VIa1, VIIa, VIIIa, VIIIc, IXa, IXb-e, Xc-e, XId
Youlden, 2024 (99)	Australia	National	2010–2018	2020	0–14		ICCC-3	Yes	NA	RS	ICCC-3 Ia, Ib, IIb-c, IIIb, IIIc1, IVa, VIa1, IXa
Abdelazeem, 2023 (100)	United States	SEER-18	2000–2018	Unspec.	All ages		ICCC-3	NA	NA	RS	Retinoblastoma
Bednarek, 2023 (101)	Canada	National	2001–2018	Unspec.	0–14		Unspec.	NA	NA	OS, EFS	Bilateral Wilms tumor
Castellanos, 2023 (102)	United States	Texas	1995–2017	2018	0–19	Residence in border or non-border census tracts	ICD-O-3	NA	NA	OS	ALL, AML
Chiriaque, 2023 (103)	Spain	11 PBCRs	1991–2005	2010	0–19		ICCC-3	Yes	NA	OS	ICCC-3 III and subgroups
Cromie, 2023 (104)	United Kingdom	England: Yorkshire and Humber Region	1997–2016	2020	0–14	South Asian, non-south Asian	ICCC-3	Yes	NK	OS	All cancers, ICCC-3 I, II, III, IV-XII
Gera, 2023 (105)	United States	SEER-17	2000–2019	Unspec.	0–17	Non-Hispanic White, non-Hispanic Black, non-Hispanic API, Hispanic	ICD-O-3	NA	NA	OS	Erythroleukemia
Girardi, 2023 (47)	61 countries (CONCORD-3)	Various	2000–2014	2014	0–14		ICD-O-3	Yes	NA	NS	Subgroups and selected other categories within ICCC-3 group III

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Goulding, 2023 (106)	United States	SEER-18	2004–2015	Unspec.	0–19	White, non-White; Hispanic, non-Hispanic; county-level indicators of socioeconomic status	ICD-O-3	NA	NA	RS	Osteosarcoma, Ewing sarcoma
Henau, 2023 (107)	Belgium	National	2004–2018	2020	0–14		ICD-O-3	NA	NA	RS	Hematological malignancies
Hoogendijk, 2023 (108)	Netherlands	National	2003–2017	2021	0–17		ICD-O-3	No	NA	OS	High-grade glioma
Kameda-Smith, 2023 (109)	Canada	Ontario	1996–2017	2017	0–17		WHO-2016	Yes	NA	OS	All CNS tumors and selected subgroups
Karalexi, 2023 (53)	Greece, Slovenia	National	2009–2018	Unspec.	0–14		ICCC-3	NA	NA	OS, EFS	Neuroblastoma
Karimi, 2023 (110)	Iran	National	2008–2014	Unspec.	0–19		ICD-O-3	NA	NA	OS	Osteosarcoma
Li, 2023 (111)	Australia	New South Wales	2003–2015	Unspec.	0–14		ICD-O-3	NA	NA	DSS	ALL, AML
Liu, 2023 (112)	United States	SEER-18	2010–2018	Unspec.	0–18		ICD-O-3	NA	NA	OS	Neuroblastoma
Liu, 2023 (113)	United States	SEER-18	2000–2018	Unspec.	0–19		ICD-O-3	NA	NA	OS	Yolk sac tumor
McEvoy, 2023 (114)	United States	NPCR	2001–2016	Unspec.	0–19		ICCC-3	NA	NA	RS	ICCC-3 IXa
Montes-Rodríguez, 2023 (115)	Puerto Rico	National	2008–2012	2017	0–19	Hispanic	ICD-O-3	NA	NA	RS	ALL
Nissen, 2023 (116)	Denmark	National	1985–2020	Unspec.	0–14		ICD-10	NA	NA	OS, EFS	Liver tumors
Ohlsen, 2023 (117)	United States	Washington State	1992–2013	2013	0–19	Area-level categories of rurality and socioeconomic status	ICD-O-3	No	Yes	OS	All cancers
Price, 2023 (118)	United States	NPCR	2008–2018	Unspec.	0–14		ICD-O-3	Yes	NA	RS	12 categories of less common malignant CNS tumor

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Pugh, 2023 (119)	New Zealand	National	2010–2019	2021	0–14	Māori, Pacific Peoples, Non-Māori	ICCC-3	Yes	NK	OS	All cancers, ICCC-3 main groups
Wang, 2023 (120)	United States	SEER-12	1995–2019	2019	0–19	Non-Hispanic White, non-Hispanic Black, non-Hispanic American Indian/Alaska Native, non-Hispanic API, Hispanic	ICCC-3	No	NK	CSS	All cancers, ICCC-3 selected groups and subgroups
Wellbrock, 2023 (121)	Germany	National	1991–2016	2022	0–14		ICCC-3	Yes	NK	OS	All cancers, ICCC-3 groups and selected subgroups
Wu, 2023 (122)	United States	South Texas	1995–2017	2018	0–19	Non-Hispanic White, Black, Hispanic	ICCC-3	No	No	RS	All cancers, ALL, CNS tumors, bone tumors
Wu, 2023 (123)	United States	SEER-18	2000–2018	Unspec.	0–19	White, Black, API	ICD-O-3	NA	NA	OS	Malignant mediastinal germ cell tumors
Wu, 2023 (124)	United States	SEER-18	2000–2019	Unspec.	0–19	White, Black, Other	ICD-O-3	NA	NA	OS	Gastrointestinal NHL
Youlden, 2023 (125)	Australia	National	2007–2016	2017	0–14		ICCC-3	Yes	NK	RS	All cancers, ICCC-3 groups and selected subgroups
Youlden, 2023 (126)	Australia	National	2000–2017	2020	0–14		ICCC-3	Yes	NA	OS (stage specific)	ICCC-3 Ia, IIb-c, IIIa1, IIIb, IIIc1, IVa, VIa, VIIa, VIII, IXa, IXb-e
Zhao, 2023 (127)	United States	SEER-18	2000–2018	Unspec.	0–19		ICD-O-3	NA	NA	OS	Renal cell carcinoma

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Botta, 2022 (39)	31 European countries (EUROCARE-6)	Various	2000–2013	2014	0–14		ICCC-3	No	Yes	OS	All cancers, selected ICCC-3 groups and subgroups
Caetano dos Santos, 2022 (128)	Poland	National	1999–2017	2020	0–15		ICD-O-3	NA	NA	OS	Burkitt lymphoma/leukemia
Cañete, 2022 (129)	Spain	Selected PBCRs	1999–2011	2016	0–14		ICD-O-3	NA	NA	OS	Neuroblastoma
Castro-Ríos, 2022 (130)	Mexico	Central-South Region	2006–2012	2017	0–17		ICCC-3	Yes	NK	OS	All cancers, ICCC-3 groups and subgroups
Cioffi, 2022 (131)	United States	NPCR	2004–2017	Unspec.	0–14		WHO 2016	Yes	NA	OS	CNS tumors
Cole, 2022 (132)	United States	SEER-18	2000–2017	Unspec.	0–9	White, Black, American Indian/Alaska Native, API, Hispanic	ICD-O-3	NA	NA	RS	Osteosarcoma
Hart, 2022 (133)	United States	SEER-18	1990–2015	Unspec.	0–19		ICCC-3	Yes (pilocytic astrocytoma only)	NA	OS	ICCC-3 III, Xa
Helligsoe, 2022 (134)	Denmark	National	1997–2019	2019	0–14		ICCC-3	Yes	NA	OS	ICCC-3 III, Xa and subgroups
Kahla, 2022 (135)	United States	NPCR	2001–2016	2016	0–19	Non-Hispanic White, non-Hispanic Black, non-Hispanic American Indian/Alaska Native, non-Hispanic API, Hispanic	ICCC-3	NA	NA	OS, RS	ICCC-3 VIIa
Klangjorhor, 2022 (136)	Thailand	5 PBCRs	2001–2015	2019	0–19		ICD-O-3	NA	NA	OS	Bone sarcomas
Lee, 2022 (137)	South Korea	National	1999–2017	Unspec.	0–14		ICD-O-3	NA	NA	OS	Ewing sarcoma
Liu, 2022 (138)	United Kingdom	England	2013–2019	2021	0–14		ICD-O-3	NA	NA	OS	Langerhans cell histiocytosis

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Liu, 2022 (139)	Taiwan	National	1999–2014	Unspec.	0–2		ICD-O-3	NA	NA	OS	Atypical teratoid/rhabdoid tumor
Loap, 2022 (140)	United States	SEER-18	2000–2018	Unspec.	0–19		ICD-O-3	NA	NA	OS	Plasma cell neoplasms
Lv, 2022 (141)	United States	SEER-18	2000–2019	Unspec.	0–19		ICD-O-3	NA	NA	OS	Adrenal cancers: Neuroblastoma, Adrenocortical carcinoma, Other
Nakata, 2022 (142)	Japan	Osaka	2002–2011	Unspec.	2014		Unspec.	No	NK	OS	All cancers
Ravaioli, 2022 (143)	Italy	12 PBCRs	2010–2014	2018	0–14		ICCC-3	Yes	NK	OS	All cancers, ICCC-3 I, Ia, Ib, IIa, IIb, III, VI, VII, VIII, IX, XIb, XId
Reedijk, 2022 (144)	Netherlands	National	1990–2015	2019	0–17		ICCC-3	NA	NA	OS	NHL
Schulpen, 2022 (145)	Netherlands	National	1990–2014	2021	0–18		ICCC-3	NA	NA	OS	ICCC-3 VI and subgroups
Schulpen, 2022 (146)	Netherlands	National	1990–2015	2021	0–17		ICCC-3	NA	NA	RS	ICCC-3 Ib
Ssenyonga, 2022 (48)	61 countries (CONCORD-3)	Various	2000–2014	2014	0–19		ICCC-3	NA	NA	NS	ICCC-3 I and subgroups
van de Bergh, 2022 (147)	Netherlands	National	2000–2016	2021	10–17		ICD-O-3	NA	NA	OS	Papillary and follicular thyroid carcinoma
van der Linde, 2022 (148)	Netherlands	National	2004–2013	2020	10–17		ICD-O-3	NA	NA	OS	ALL
Wellbrock, 2022 (149)	Germany	National	1991–2015	021	0–14	Former West Germany, Former East Germany	ICCC-3	NA	NA	OS	ALL, AML
Xing, 2022 (150)	United States	SEER-18	2000–2018	Unspec.	0–18		Unspec.	NA	NA	OS	Hepatoblastoma, hepatocellular carcinoma
Youlden, 2022 (151)	Australia	National	1997–2016	2017	0–14	Aboriginal and Torres Strait Islander, Other	ICCC-3	Yes	NK	CSS	ICCC-3 I-II, III-XII

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Zbitou, 2022 (152)	France	National (metropolitan)	2000–2018	2021	0–17		ICD-O-3	NA	NA	OS	Thyroid carcinoma
Curry, 2021 (153)	United States	SEER-18	2004–2013	Unspec.	0–19		ICD-O-3	NA	NA	OS	Rhabdomyosarcoma of head and neck
Di Giuseppe, 2021 (61)	Australia; Canada; United States	National; Ontario; SEER-9	2005–2013	2015	0–14		ICCC-3	NA	NA	RS	ICCC-3 VII
Ellison, 2021 (154)	Canada	All except Quebec province	2003–2017	2017	0–14		ICCC-3	No	NK	OS	All cancers, ICCC-3 main groups and selected subgroups
Hoogendijk, 2021 (155)	Netherlands	National	1990–2017	2019	0–17		ICCC-3	Yes	NA		ICCC-3 III and subgroups, Xa
Karalexi, 2021 (156)	Greece	National	2001–2019	2019	0–14		ICD-O-3	NA	NA	OS	Hepatic tumors
Karalexi, 2021 (157)	Greece	National	1996–2019	2019	0–14		ICCC-3	NA	NA	OS, EFS	ICCC-3 IIa, IIb-c
Kelm, 2021 (158)	United States	SEER-18	2000–2015	Unspec.	0–19		ICCC-3	NA	NA	CSS	ICCC-3 XId
Loizou, 2021 (159)	Cyprus	South	1998–2017	2018	0–19		ICCC-3	NA	NA	OS	Thyroid carcinoma
Miller, 2021 (160)	United States	NPCR	2009–2015	2016	0–19		CBTRUS	Yes	NA	RS	All CNS tumors and selected subgroups
Nakata, 2021 (161)	Japan	Osaka	2000–2011	Unspec.	0–14		ICD-O-3	NA	NA	OS	All leukemia, ALL, AML, CML
Park, 2021 (162)	South Korea	National	1999–2017	2018	0–19		ICD-O-3	NA	NA	RS	Ovarian germ cell tumors and subtypes

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Person, 2021 (163)	France	National (metropolitan)	2000–2015	2018	0–14		ICCC-3	NA	NA	OS	Head and neck cancers
Poulalhon, 2021 (164)	France	National (metropolitan)	2000–2015	2018	0–14		ICCC-3	Yes	NK	OS	All cancers, ICCC-3 main groups and selected subgroups
Reedijk, 2021 (165)	Netherlands	National	1990–2015	2019	0–17		ICD-O-3	NA	NA	OS	ALL
Sasaki, 2021 (166)	United States	SEER-18	2000–2017	Unspec.	0–19		ICD-O-3	NA	NA	OS	ALL
Schraw, 2021 (167)	United States	Texas	1995–2011	2012	0–19	Hispanic enclave status	ICCC-3	NA	NA	OS	Precursor B-cell ALL
Schulpen, 2021 (168)	Netherlands	National	1990–2015	2020	0–17		ICCC-3	NA	NA	OS	All cancers, ICCC-3 main groups and selected subgroups
Soon, 2021 (169)	United States	SEER-18	2000–2011	Unspec.	0–19		ICD-O-3	Yes (pilocytic astrocytoma only)	NA	OS	Ependymoma, pilocytic astrocytoma, anaplastic astrocytoma, glioblastoma, medulloblastoma, supratentorial embryonal tumor, CNS germinoma
Wang, 2021 (170)	United States	SEER-9	2005–2014	2014	<1		ICCC-3	NK	NK	OS, RS	All cancers, ICCC-3 I, II, III, IV, V, VII
Youlden, 2021 (171)	Australia	National	2006–2016	2017	0–14		ICCC-3	Yes	NA	RS	ICCC-3 III and subgroups
Chen, 2020 (172)	United States	SEER-18	2004–2013	Unspec.	0–16		ICD-O-3	NA	NA	OS	Neuroblastoma

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
de Oliveira, 2020 (173)	Brazil	Goiania	1996–2012	2017	0–19		ICCC-3	NK	Yes	RS	All cancers, selected ICCC-3 main groups
Desandes, 2020 (174)	France	National (metropolitan)	2000–2014	2018	<1		ICCC-3	Yes	NA	OS	All cancers, ICCC-3 main groups and selected subgroups
Fineberg, 2020 (175)	United States	SEER-18	2000–2015	Unspec.	0–19		ICCC-3	No	NA	OS	Malignant CNS tumors
Ji, 2020 (176)	China	Pudong	2002–2015	Unspec.	0–14		ICCC-3	NK	Yes	OS	All cancers
Jones, 2020 (177)	Australia	National	2004–2013	2015	0–14		ICCC-3	NA	NA	CSS, EFS	Renal tumors
Krejci, 2020 (178)	Czech Republic	National	1995–2012	2017	0–14		ICCC-3	Yes	NK	OS	All cancers, selected ICCC-3 groups and subgroups
Leong, 2020 (179)	Brunei Darussalam	National	2002–2017	Unspec.	0–19		ICCC-3	NK	NK	OS	All cancers, ICCC-3 main groups
Liu, 2020 (180)	China	Hong Kong	1999–2018	Unspec.	0–17		Unspec.	Yes	NA	OS, PFS	Craniopharyngioma
Liu, 2020 (62)	China; United States	Hong Kong; SEER-18	1999–2016	2016	0–17	SEER: API	ICD-O-3	Yes	NA	OS	All CNS tumors, ependymoma, choroid plexus tumors, glial, and neuronal tumors (incl. astrocytoma, and glioma), medulloblastoma, other embryonal tumors, germinoma, teratoma, other germ cell tumors
Martin, 2020 (181)	Netherlands	National	1989–2017	Unspec.	0–17		ICD-O-3	NA	NA	OS	Malignant peripheral nerve sheath tumor
Mitchell, 2020 (182)	United States	SEER-18	2000–2015	2015	0–19	Non-Hispanic White, non-Hispanic Black, Hispanic	ICD-O-3	No	NA	OS	All cancers, ICCC-3 main groups and subgroups
Moreno, 2020 (183)	Argentina	National	2000–2015	Unspec.	0–14		ICCC-3	NA	NA	OS	ICCC-3 VIIa, VIIb

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Paapsi, 2020 (184)	Estonia	National	2000–2016	2016	0–14		ICCC-3	No	NK	OS	All cancers, selected ICCC-3 groups and subgroups
Siegel, 2020 (185)	United States	NPCR	2001–2015	2015	0–19	Non-Hispanic White, non-Hispanic Black, non-Hispanic American Indian/Alaska Native, non-Hispanic API, Hispanic; County-level economic status; US Census Region	ICCC-3	NK	NK	RS	All cancers, selected ICCC-3 groups and subgroups
Silva, 2020 (186)	Brazil	São Paulo	1997–2013	Unspec.	0–14		ICD-O-3	NA	NA	OS	ALL
Tas, 2020 (187)	Netherlands	National	1990–2014	2018	0–17		ICD-O-3	NA	NA	OS	Neuroblastoma
Wang, 2020 (188)	United States	SEER-18	1988–2016	2016	0–19		ICD-O-3	NA	NA	OS	Embryonal rhabdomyosarcoma
Williams, 2020 (189)	United States	SEER-18	2000–2015	Unspec.	0–19	Non-Hispanic White, Black, API, Hispanic	ICCC-3	No	NA	OS	Xa, Xb, Xc, all excluding teratomas
Youlden, 2020 (190)	Australia	National	2004–2013	2015	0–14		ICCC-3	NA	NA	CSS, EFS	Neuroblastoma
Abrahão, 2019 (191)	United States	California - Greater Bay Area	2001–2014	2014	0–19	Non-Hispanic White, non-Hispanic Black, Hispanic, API, Other/Unknown	ICD-O-3	NA	NA	OS	Diffuse large B-cell lymphoma
Bidwell, 2019 (192)	Thailand	5 PBCRs	1990–2011	Unspec.	0–19		ICCC-3	NK	NK	RS	All cancers, ICCC-3 I, Ia, Ib, Ie, II, IIa, IIb, IIc, IIe, III, IIIb, IIIc1–2, IV, V, VI, VII, VIII, IX, IXa, IXb-d, X, XI, XII
Chen, 2019 (193)	United States	SEER-9	2005–2014	Unspec.	0–14	White, Black, Other	ICD-O-3	NA	NA	RS	AML

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Doganis, 2019 (54)	Belarus, Greece, Slovenia; Poland	National; Greater Poland region	1999–2017	Unspec.	0–14		ICD-O-3	NA	NA	OS, EFS	Wilms tumor
Drevinskaite, 2019 (194)	Lithuania	National	2004–2013	2013	0–14		ICD-O-3	NA	NA	RS	Testicular tumors
Faltermeier, 2019 (195)	United States	SEER-18	2000–2009	Unspec.	0–1		WHO 2016	Yes (pilocytic astrocytoma only)	NA	OS	Diffuse astrocytic and oligodendroglial tumors, pilocytic astrocytoma, ependymal tumors, embryonal CNS tumors, medulloblastoma, choroid plexus carcinoma
Feng, 2019 (196)	United States	SEER-18	2004–2015	Unspec.	0–18	White, Black, Other	ICD-O-3	NA	NA	OS	Hepatoblastoma
Janz, 2019 (197)	United States	SEER-18	2004–2014	2014	0–18		ICD-O-3	NA	NA	DSS	Tonsillar cancers
Kang, 2019 (198)	South Korea	National	2005–2014	Unspec.	0–19		CBTRUS	Yes	NA	RS	All CNS tumors and CBTRUS subgroups
Ostrom, 2019 (199)	United States	NPCR	2001–2014	Unspec.	0–14	Appalachian counties, non-Appalachian US	ICD-O-3	Yes	NA	RS	Malignant CNS tumors; non-malignant CNS tumors
Quinlan, 2019 (200)	Ireland	National	1994–2015	Unspec.	0–16		Unspec.	NA	NA	OS	Melanoma
Reedijk, 2019 (201)	Netherlands	National	1990–2015	2018	0–17		ICD-O-3	NA	NA	OS	AML
Rivas-Vilela, 2019 (202)	Spain	Girona	1990–2013	2015	0–19		ICCC-3	Yes	NA	OS	ICCC-3 III

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Rostgaard, 2019 (63)	Denmark, Finland, Norway, Sweden	National	2000–2013	2015	0–14		ICCC-3	Yes	NA	RS	ICCC-3 Ia, Ib, IIb, IIIb, IIIc, IIId, IIIe, VIIb-c, VIIIa, VIIIc, IXa, IXb-e
Siegel, 2019 (203)	United States	NPCR	2001–2008	2013	0–19	Non-Hispanic White, non-Hispanic Black, non-Hispanic Other, Hispanic	ICD-O-3	Yes (pilocytic astrocytoma only)	NA	RS	Brain tumors
Tabash, 2019 (204)	United States	SEER-18	2000–2015	2015	0–19		ICD-O-3	Yes	NA	OS	Pilocytic astrocytoma
Truitt, 2019 (205)	United States	SEER-18	2000–2014	Unspec.	0–14		ICD-O-3	No	NA	RS	12 categories of less common malignant CNS tumor
Allemani, 2018 (49)	63 countries (CONCORD-3)	Various	2000–2014	2014	0–19		ICCC-3, ICD-O-3	Yes	NA	NS	ICCC-3 lymphoid leukemia (61 countries), lymphoma (62 countries), brain tumors (60 countries)
Cooney, 2018 (206)	United States	California	1988–2012	2012	0–19	Non-Hispanic White, Black, API, Hispanic	ICD-O-3	No	NA	RS	High-grade glioma, Medulloblastoma
Deng, 2018 (207)	United States	SEER-18	1990–2013	Unspec.	0–17		ICD-O-3	NA	NA	OS	Pineoblastoma
Doganis, 2018 (55)	Belarus, Bulgaria, Croatia, Cyprus, Greece, Malta, Slovenia, Ukraine; Poland, Portugal, Romania, Turkey; United States	National; Regional; SEER-18	1990–2016	Unspec.	0–14		ICD-O-3	NA	NA	OS	Wilms tumor

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Eggen, 2018 (208)	Netherlands	National	1989–2013	2014	0–19		ICD-O-3	NA	NA	RS	Malignant melanoma
González García, 2018 (209)	Spain	Castilla y Leon	2003–2014	Unspec.	0–14		ICCC-3	Yes	NK	OS	All cancers, ICCC-3 I, II, III, IV-XII
Joko-Fru, 2018 (64)	Kenya; Uganda; Zimbabwe	Nairobi; Kampala; Harare	1998–2009	2011	0–14		ICCC-3	NA	NA	OS, RS	ICCC-3 Ia, IIb, IIc, V, VIa, IXc
Khalid, 2018 (210)	United States	SEER-18	2004–2014	Unspec.	0–17		ICD-O-3	Yes	NA	OS	Spinal cord ependymoma
Marcos-Gragera, 2018 (211)	Spain	10 PBCRs	2001–2005	2010	0–19		ICCC-3	NA	NA	OS	ICCC-3 IIa-c+IIe, IIa, IIb, IIc
Mazzucco, 2018 (212)	Italy	Palermo Province	2003–2012	2017	0–19		ICCC-3	Yes	NK	OS	All cancers
Nakata, 2018 (65)	Japan; United Kingdom	6 PBCRs; England	1993–2008	2013	0–14		ICCC-3	No	Yes	OS	ICCC-3 main groups and selected subgroups
Panagopoulou, 2018 (56)	Belarus, Croatia, Cyprus, Greece, Malta, Slovenia, Ukraine; Poland, Portugal, Romania, Turkey; United States	National; Regional; SEER-18	1990–2016	Unspec.	0–14		ICCC-3	NA	NA	OS	Neuroblastoma
Parikh, 2018 (213)	United States	SEER-18	2000–2010	Unspec.	0–19	White, Black, Other	ICD-O-3	NA	NA	DSS	Melanoma of extremities
Ramirez, 2018 (214)	Colombia	Cali	2009–2013	2015	0–18		ICCC-3	NK	NK	OS	All cancers, ICCC-3 main groups

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Smith, 2018 (215)	United Kingdom	England: Yorkshire	1990–2011	2016	1–17		ICCC-3	NA	NA	RS	ICCC-3 Ia
Strahlendorf, 2018 (216)	Canada	National	2001–2012	Unspec.	1–14		ICD-O-3	NA	NA	OS, EFS	ALL
Wu, 2018 (217)	United States	SEER-18	2004–2013	Unspec.	0–19	White, Black, Other	ICD-O-3	NA	NA	RS	Osteosarcoma
Zhao, 2018 (218)	United States	SEER-18	1992–2006	2011	0–14	Non-Hispanic White, Hispanic White, Black, API	ICD-O-3	NA	NA	RS	Leukemia
Bergqvist, 2017 (219)	Sweden	Stockholm-Gotland Region	2001–2013	2015	0–17		ICD-10, SNOMED	No	NA	OS	Intracranial tumors: all, high-grade, low-grade
Bonaventure, 2017 (50)	53 countries (CONCORD-2)	Various	1995–2009	2009	0–14		ICCC-3	NA	NA	NS	ICCC-3 Ia, Ia1, Ia2, Ib, Ie
El-Fattah, 2017 (220)	United States	SEER-18	2003–2012	Unspec.	0–19	White, Black, Other	Unspec.	NA	NA	RS	CML
Fuentes-Raspall, 2017 (221)	Spain	Girona	1994–2013	2014	0–14		ICD-O-3	Yes	NA	OS, RS	All CNS tumors, WHO 2017 categories
Gatta, 2017 (40)	27 European countries (EUROCARE-5)	Various	2000–2007	2008	0–14		ICCC-3	Yes	NA	OS	CNS tumors, ICCC-3 III, subgroups, all malignant tumors, all non-malignant tumors

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Georgakis, 2017 (57)	Belarus, Croatia, Greece, Malta, Slovenia, Ukraine; Poland, Portugal, Romania, Turkey; United States	National; Regional; SEER-18	1990–2012	Unspec.	0–14		ICD-O-3	Yes	NA	OS	Pilocytic astrocytoma
Jakab, 2017 (222)	Hungary	National	2001–2010	2015	0–14		ICCC-3	NA	NA	OS	Leukemia
Jemal, 2017 (4)	United States	SEER-9	2006–2012	2013	0–14		ICD-O-3	No	NK	RS	All cancers, leukemia, lymphomas, CNS tumors, neuroblastoma, Wilms tumor, bone tumors, soft-tissue sarcomas
Kairiene, 2017 (223)	Lithuania	National	2000–2013	Unspec.	0–17		Unspec.	NA	NA	OS, EFS	AML
Karalexi, 2017 (58)	Belarus, Bulgaria, Croatia, Cyprus, Greece, Malta, Serbia, Slovenia, Ukraine; Portugal, Romania, Turkey; United States	National; Regional; SEER-18	1990–2014	Unspec.	0–14		ICCC-3	NA	NA	OS	Lymphomas
Khanna, 2017 (224)	United States	SEER-18	2001–2013	Unspec.	0–19	White, Black, API	ICD-O-3	No	NA	RS	Medulloblastoma
Lee, 2017 (225)	South Korea	National	2005–2010	2013	0–14		ICD-O-3	No	NA	OS	CNS germ cell tumors
Lins, 2017 (226)	Brazil	Recife	1998–2007	2012	0–19		ICCC-3	NA	NA	RS	ICCC-3 I, Ia, Ib
Marcos-Gragera, 2017 (227)	Spain	10 PBCRs	2001–2005	2010	0–19		ICCC-3	NA	NA	OS	ICCC-3 I and subgroups

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Moreno, 2017 (228)	Argentina	National	2000–2013	Unspec.	0–14		ICCC-3	NA	NA	OS	ICCC-3 VIIIa
Mukhtar, 2017 (229)	United States	SEER-18	2000–2013	2013	0–14		ICD-O-3	NA	NA	OS, RS	Burkitt lymphoma
Nasioudis, 2017 (230)	United States	SEER-18	1988–2013	2013	0–19		ICD-O-3	NA	NA	OS	Ovarian epithelial tumors
Offor, 2017 (231)	United Kingdom	England: Northern Region	1998–2012	2015	0–14		ICD-O-3	NA	NA	OS	All renal tumors, Wilms tumor
Paapsi, 2017 (232)	Estonia	National	2005–2012	2014	0–17		ICC-3	Yes	NK	OS	All cancers, ICCC-3 main groups, ICCC-3 Ia, Ib
Ramiandrisoa, 2017 (233)	France	Réunion and Mayotte (Indian Ocean Territories)	2005–2011	2013	0–14		ICCC-3	Yes	NK	OS	All cancers, selected ICCC-3 categories
Schindler, 2017 (234)	Switzerland	National	2004–2013	2013	0–14		ICCC-3	Yes	NK	OS	ICCC-3 groups I-X and selected subgroups
Tai, 2017 (52)	United States	37 states (CONCORD-2)	2001–2009	2009	0–14	White, Black	ICD-O-3	NA	NA	NS	Precursor-cell ALL and NHL
Weil, 2017 (235)	United States	SEER-18	1990–2011	Unspec.	0–19		ICD-O-3	No	NA	OS	Medulloblastoma
Ye, 2017 (236)	Canada	Manitoba	2004–2013	Unspec.	0–19		ICCC-3	NA	NA	RS	Lymphoid leukemia, Hodgkin lymphoma, NHL including Burkitt lymphoma

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Acharya, 2016 (237)	United States	Florida, Texas	1995–2008	Unspec.	1–18	Non-Hispanic-White, non-Hispanic Black, Hispanic	ICD-O-3	NA	NA	OS	ALL
Batista, 2016 (238)	Portugal	North	2005–2013	2014	0–18		ICD-O-3	Yes	NA	OS	CNS tumors
Brennan, 2016 (239)	United Kingdom	England	2004–2008	2013	0–19		ICD-O-3	NA	NA	RS	Synovial sarcoma
Desandes, 2016 (240)	France	National (metropolitan)	2000–2009	2013	0–28 d		ICCC-3	Yes	NA	OS	ICCC-3 III-XII, III, IV, V, VI, VII, IX, X and subgroups
Donnelly, 2016 (241)	United Kingdom	Northern Ireland	1993–2008	2013	0–14		Unspec.	Yes	NK	OS	All cancers, leukemia, lymphomas, tumors of brain/eye/CNS
Fairley, 2016 (242)	United Kingdom	England: Northern and Yorkshire Regions	1990–2013	2014	0–14		ICCC-3	NA	NA	OS	Medulloblastoma, Embryonal CNS tumor NOS
Janitz, 2016 (243)	United States	Oklahoma	1997–2008	2014	0–19		ICCC-3	Yes (pilocytic astrocytoma only)	NK	OS	All cancers, ICCC-3 main groups and subgroups
Kaatsch, 2016 (244)	Germany	National	2002–2006	2011	0–14		ICCC-3	NA	NA	OS	ICCC-3 VIII, VIIIa, VIIIc
Kahn, 2016 (245)	United States	SEER-13	2003–2007	2012	0–14	White, Black, non-Hispanic White, Hispanic	ICD-O-3	NA	NA	RS	ALL, AML, Hodgkin lymphoma
Karim-Kos, 2016 (246)	Austria	National	1994–2008	2013	0–19		ICCC-3	Yes	NK	OS	All cancers, ICCC-3 main groups and selected subgroups
Lychou, 2016 (247)	Sweden	National	2000–2010	2013	0–14		ICCC-3	NA	NA	OS, EFS	Rhabdomyosarcoma

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Mogensen, 2016 (248)	Sweden	National	1991–2010	2011	1–14	Parental education levels	ICD-7, ICD-8	Yes	NK	OS	All cancers, leukemia, nervous system tumors, other solid tumors
Moreno, 2016 (249)	Argentina	National	2000–2012	Unspec.	0–14		ICCC-3	NA	NA	OS	ICCC-3 IVa
Park, 2016 (250)	South Korea	National	1993–2011	2012	0–14		ICCC-3	No	No	RS	All cancers, ICCC-3 main groups and subgroups
Rigaud, 2016 (251)	France	National (metropolitan)	1998–2012	2015	0–17		Unspec.	NA	NA	OS	Langerhans cell histiocytosis
Schrøder, 2016 (252)	Denmark	National	2003–2014	Unspec.	0–14		ICCC	Yes	No	RFS	All cancers
Wang, 2016 (253)	United States	SEER-17	1988–2013	Unspec.	0–17	White, Black, Other	ICD-O-3	NA	NA	OS	ALL, AML, CML
Abrahão, 2015 (254)	United States	California	2004–2011	2012	0–19		ICD-O-3	NA	NA	OS	ALL
Allemani, 2015 (51)	53 countries (CONCORD-2)	Various	1995–2009	2009	0–14		ICD-O-3	NA	NA	NS	ALL
Demanelis, 2015 (66)	Thailand; United States	Sonkhla Province; SEER-19	1990–2011	Unspec.	0–19		ICCC-3	NA	NA	RS	ICCC-3 I, Ia, Ib
Dolecek, 2015 (255)	United States	SEER-18	2004–2010	2011	0–19		ICD-O-3	Yes	NA	RS	Meningioma
Dudley, 2015 (256)	United States	SEER-18	2004–2010	Unspec.	0–19		ICD-O-3	Yes	NA	RS	Low-grade ganglioglioma and gangliocytoma
Foresto, 2015 (257)	Australia	National	1997–2008	2011	0–14		ICCC-3	NA	NA	RS	ICCC-3 Ib

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Kaatsch, 2015 (258)	Germany	National	2002–2006	2014	0–14		ICCC-3	Yes	NA	OS	ICCC-3 Xa-c and subgroups
Karalexi, 2015 (59)	Belarus, Bulgaria, Croatia, Cyprus, Greece, Malta, Slovenia, Ukraine; Portugal, Romania, Turkey	National; Regional	1995–2014	2014	0–14		ICCC-3	Yes	NA	OS	ICCC-3 III and subgroups
Katz, 2015 (259)	United States	SEER-18	2003–2010	2011	0–19		ICD-O-3	NA	NA	RS	ALL
Liu, 2015 (260)	China	Hong Kong	1999–2011	Unspec.	0–2		ICCC-3	Yes	NA	OS, EFS	CNS tumors: ICCC-3 groups III+Xa and selected subgroups
Olsson, 2015 (261)	Sweden	National	1997–2011	2011	0–18		ICD-10	Yes	NA	OS	Craniopharyngioma
Ostrom, 2015 (262)	United States	SEER-18	2002–2011	2013	0–14		CBTRUS	Yes (pilocytic astrocytoma only)	NA	RS	All CNS tumors and subgroups
Truong, 2015 (263)	United States	SEER-18	2000–2010	Unspec.	0–9	Non-Hispanic White, Hispanic White, Black, Other	Unspec.	NA	NA	RS	Retinoblastoma
Tulla, 2015 (264)	Germany	National	1991–2010	2010	0–14		ICCC-3	NA	NA	OS	Embryonal tumors, ICCC-3 IIIc1, IIIc2, IIIc4, IVa, V, VIa1, VIIa
Vlenterie, 2015 (265)	Netherlands	National	1989–2013	Unspec.	0–17		Unspec.	NA	NA	OS, RS	Localized synovial sarcoma

(Continued)

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Wang, 2015 (266)	United States	SEER-9	2000–2010	Unspec.	0–19	Non-Hispanic White, non-Hispanic Black, Hispanic, American Indian/Alaska Native, API	Unspec.	NA	NA	OS, DSS	ALL
Waxweiler, 2015 (267)	United States	SEER-18	1998–2007	2010	0–18		ICD-O-3	NA	NA	OS	Non-rhabdomyosarcoma soft tissue sarcoma
Wongmas, 2015 (268)	Thailand	Chiang Mai, Khon Kaen, Songkhla	1990–2009	2009	0–15		ICD-O-3	NA	NA	OS	Retinoblastoma
Youlden, 2015 (269)	Australia	National	2002–2011	2011	0–14		ICCC-3	Yes	NK	OS	All cancers, ICCC-3 main groups
Zheng, 2015 (270)	China	17 PBCRs	2003–2005	2010	0–14		ICD-10	NK	NK	RS	All cancers, leukemia, lymphomas, brain tumors, hepatic tumors, bone tumors
Desandes, 2014 (271)	France	National (metropolitan)	2000–2008	2011 2013	0–14		ICCC-3	Yes	NA	OS	ICCC-3 III, Xa, IX and XId (intracranial and intraspinal sites)
Gatta, 2014 (41)	29 European countries (EUROCARE-5)	Various	1995–2007	2008	0–14		ICCC-3	No	Yes	OS	All cancers, selected ICCC-3 groups and subgroups
Gerth, 2014 (272)	United States	SEER-18	1998–2010	Unspec.	0–19		ICD-O-3	NA	NA	RS	Sinonasal tumors
Golpanian, 2014 (273)	United States	SEER-18	1998–2010	Unspec.	0–19		Unspec.	NA	NA	OS	Langerhans cell histiocytosis, malignant histiocytosiss

(Continued)

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Hassan, 2014 (274)	United States	SEER-18	1996–2005	Unspec.	0–19		ICD-O-3	NA	NA	OS, RS	Orbital rhabdomyosarcoma
Ito, 2014 (275)	Japan	6 PBCRs	2002–2006	2006	0–14		ICD-10, ICD-O-3	No	NK	OS	All cancers, leukemia, ALL, lymphomas, CNS tumors
Kerkhofs, 2014 (276)	Netherlands	National	1989–2010	2012	0–19		ICD-O-3	NA	NA	OS	Adrenocortical carcinoma
Lacour, 2014 (277)	France	National (metropolitan)	2000–2008	Unspec.	0–14		ICCC-3	Yes	NK	OS	All cancers, ICCC-3 main groups and subgroups
Ma, 2014 (278)	United States	SEER-18	2001–2010	2010	0–14		Unspec.	NA	NA	RS	ALL
Madanat-Harjuoja, 2014 (3)	Finland	National	2001–2010	2010	0–14		ICCC-3	Yes	NK	OS	All cancers, ICCC-3 groups I-VI, VIII, IX, and selected subgroups
Ostrom, 2014 (279)	United States	SEER-18	2001–2010	2010	0–19		ICD-O-3	No	NA	RS	Atypical teratoid/rhabdoid tumor
Park, 2014 (280)	South Korea	National	1993–2010	2011	All ages		Unspec.	NA	NA	OS	Retinoblastoma
Vaitkevičiene, 2014 (281)	Lithuania	National	1992–2008	2013	0–15 (2003–2008: 0–17)		Unspec.	NA	NA	OS. EFS	ALL
Ward, 2014 (282)	United States	SEER-9	2003–2009	2010	0–19		ICCC-3	Yes (pilocytic astrocytoma only)	Yes	OS	All cancers, selected ICCC-3 subgroups
Wiangnon, 2014 (283)	Thailand	Khon Kaen	1996–2009	2012	0–14		ICCC	NK	NK	OS	ALL, AML
Yang, 2014 (284)	United States	SEER-18	1990–2010	Unspec.	0–19		ICCC-3	NA	NA	OS	ICCC-3 IXa

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
AIRTUM Working Group, 2013 (285)	Italy	31 PBCRs	2003–2008	2008	0–14		ICCC-3	N0	Yes	OS	All cancers, ICCC-3 main groups and selected subgroups
Bravo, 2013 (286)	Colombia	Cali	1992–2011	2012	0–14		ICCC-3	Yes	NK	OS	ICCC-3 main groups
Njoku, 2013 (287)	United Kingdom	England: Northern Region	1997–2010	2010	0–14		Unspec.	NA	NA	OS	ALL, AML
Pole, 2013 (67)	Canada; United States	Ontario; SEER-18	1998–2009	2010; 2009	1–19		ICD-O-3, ICCC-3	NA	NA	OS	ALL
Rabinowicz, 2013 (288)	Israel	National	1998–2007	2010	<1	Jewish, Arabic	ICCC-3	Yes	NK	OS	All cancers, ICCC-3 main groups
Valery, 2013 (289)	Australia	National	1997–2007	2008	0–14	Indigenous, non-Indigenous, Unknown	ICCC-3	Yes	NA	CSS	All cancers
Villano, 2013 (290)	United States	SEER-13	1992–2009	Unspec.	0–19	White, Black, American Indian/Alaska Native, API	ICD-O-3	No	NA	RS	Ependymoma
Bao, 2012 (291)	China	Shanghai	2002–2005	2010	0–14		ICCC	NK	NK	OS	All cancers, ICCC main groups
Crocetti, 2012 (42)	21 European countries (RARECARE)	Various	2000–2002	2002	0–19		ICD-O-3	No	NA	RS	Malignant brain tumors
Dores, 2012 (292)	United States	SEER-17	2001–2006	2007	0–19		ICD-O-3	NA	NA	RS	AML and subtypes
Goggins, 2012 (293)	United States	SEER-17	2002–2008	Unspec.	0–19	Non-Hispanic White, Black, East Asian, Hispanic, American Indian/Alaska Native	ICD-O-3	NA	NA	OS	ALL
Jung, 2012 (294)	South Korea	National	1999–2004	2009	0–19		ICD-O-3	No	NA	OS	Malignant brain tumors
Kachanov, 2012 (295)	Russia	Moscow Region	2000–2009	Unspec.	0–14		ICCC-3	NA	NA	OS	ICCC-3 IX, IXa, IXb-e

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Pui, 2012 (296)	United States	SEER-17	2001–2007	Unspec.	0–19	White, Black	ICD-O-3	Yes (pilocytic astrocytoma only)	NA	OS	ALL, AML, Hodgkin lymphoma, NHL, ependymoma, astrocytoma, medulloblastoma, high-grade glioma, other CNS tumors (incl. germ-cell), neuroblastoma, retinoblastoma, Wilms tumor, hepatoblastoma, osteosarcoma, Ewing sarcoma, rhabdomyosarcoma, other soft-tissue sarcoma, non-CNS germ cell tumors, melanoma
Rabinowicz, 2012 (297)	Israel	National	1998–2003	2008	0–19	Jewish, Arabic	ICCC-3	Yes	NK	OS	All cancers, ICCC-3 main groups
Stiller, 2012 (6)	United Kingdom	Great Britain (England, Scotland and Wales)	1997–2005	2010	0–14		ICCC-3	No	NA	OS	ICCC-3 Ia1, Ib, IIa, Ia2+IIb-c, IIIc1, IVa, VIa1, VII, VIIIa, VIIIc, IXa, Xa, Xb, Xc
Visser, 2012 (44)	21 European countries (RARECARE)	Various	2000–2002	2002	0–14		ICD-O-3	NA	NA	RS	Myeloid malignancies
Wiromrat, 2012 (298)	Thailand	Khon Kaen	2000–2010	2012	0–19		ICD-O-3	NA	NA	OS	Osteosarcoma
AIRTUM Working Group, 2011 (299)	Italy	28 PBCRs	2000–2004	Unspec.	0–14		ICCC-3	No	Yes	OS	All cancers, ICCC-3 main groups and selected subgroups

(Continued)

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Gatta, 2012 (43)	21 European countries (RARECARE)	Various	2000–2002	2002	0–14		ICD-O-3	NA	NA	RS	Embryonal tumors: neuroblastoma, retinoblastoma, wilms tumor, hepatoblastoma, pancreatoblastoma, pulmonary blastoma, pleuropulmonary blastoma
Feltbower, 2011 (300)	United Kingdom	England: Yorkshire Region	2000–2004	2009	13–16		Birch TYA	No	NA	OS	Germ cell tumors
Kohler, 2011 (301)	United States	SEER-9	2000–2006	2007	0–19		CBTRUS	Yes (pilocytic astrocytoma only)	NA	RS	All neuroepithelial tumors and selected subgroups
Ljungman, 2011 (302)	Sweden	National	1995–2007	2009	0–14		ICCC-3	NA	Yes	OS	Non-CNS solid cancers
Marcos-Gragera, 2011 (45)	20 European countries (HAEMACARE)	Various	2000–2002	2003	0–14		ICD-O-3	NA	NA	RS	Lymphoid neoplasms and subgroups
Perez, 2011 (303)	United States	SEER-17	1998–2005	Unspec.	0–19		ICD-O-3	NA	NA	OS	Rhabdomyosarcoma
Walsh, 2011 (304)	Ireland	National	2000–2005	2006	0–14		ICCC-3	Yes	NK	OS	All cancers, leukemia, lymphomas, CNS tumors and selected subgroups
Youlden, 2011 (305)	Australia	National	1996–2006	2006	0–14	Area-level categories of remoteness and socioeconomic status	ICCC-3	Yes	NK	RS	All cancers, ICCC-3 I, Ia, II, III, IV-XII
Baade, 2010 (306)	Australia	National	1997–2006	2006	0–14		ICCC-3	Yes	NK	RS	All cancers, ICCC-3 groups and selected subgroups
Peris-Bonet, 2010 (307)	Spain	10 PBCRs	1999–2002	2007	0–14		ICCC-3	Yes	NK	OS, RS	All cancers, hematological cancers, CNS tumors, all other solid tumors

(Continued)

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TABLE 1 (Continued)

1st Author, year (reference)	Countries	Population coverage	Diagnosis years	Latest follow-up	Age at diagnosis	Sub-populations	Diagnostic classification	Non-mal. CNS included	Skin carcinoma/ NMSC excluded	Outcome measures	Diagnostic groups
Redaniel, 2010 (68)	Philippines; United States	Manila and Rizal; SEER-17 (White and Asian American only)	2001–2005	Unspec.	0–14	White, Asian	ICCC-3	NA	NA	RS	Leukemia, lymphomas, ALL, AML, NHL
Smith, 2010 (308)	United States	SEER-9	1999–2002	Unspec.	0–19		ICCC-3	Yes (pilocytic astrocytoma only)	NK	OS	Ia, Ib, IIa, IIb-e, III, IIIc1, III except IIIc1, IVa, VIa1, VIIIa, VIIIc, IXa, Xb-c
Sultan, 2010 (309)	United States	SEER-17	2000–2005	Unspec.	0–18		ICD-O-3	NA	NA	OS	Rhabdoid tumors (all sites)
Ellison, 2009 (310)	Canada	All except Quebec province	2000–2004	Unspec.	0–14		ICCC-3	NK	NK	OS	All cancers, ICCC-3 I, Ia, Ib, II, IIa, IIb, III, IIIb, IIIc, IV, V
Gatta, 2009 (46)	23 European countries (EUROCARE-4)	Various	2000–2002	2003	0–14		ICCC-3	Yes (pilocytic astrocytoma only)	Yes	OS	All cancers, ICCC-3 groups and subgroups
Juárez-Ocaña, 2009 (311)	Mexico	IMSS	1996–2005	Unspec.	0–14		ICD-O-3	NA	NA	OS	Neuroblastoma
Pulte, 2008 (312)	United States	SEER-9	2000–2004	2004	0–14		Unspec.	NA	NA	RS	All leukemias, ALL, AML, all lymphomas, Hodgkin lymphoma, NHL
Spix, 2008 (313)	Germany	National	1996–2005	2006	0–14	Turkish descent, non-Turkish descent	ICCC-3	Yes	NK	OS	All cancers, selected ICCC-3 groups and subgroups
Ellison, 2007 (314)	Canada	All except Quebec province	1999–2003	2003	0–19		ICCC-3	Yes	NK	OS	All cancers, ICCC-3 groups and selected subgroups

IMSS, Instituto Mexicano de Seguro Social (Mexican Social Security Institute); NPCR, National Program of Cancer Registries; PBCR, population-based cancer registry; SEER, Surveillance, Epidemiology and End Results; CSS, cancer-specific survival; DSS, disease-specific survival; EFS, event-free survival; NS, net survival; OS, overall survival; RS, relative survival; ALL, Acute lymphoblastic leukemia; AML, Acute myeloid leukemia; CBTRUS, Central Brain Tumor Registry of the United States; CML, Chronic myeloid leukemia; CNS, Central nervous system; ICCC-3, International Classification of Childhood Cancer, Third Edition; NHL, Non-Hodgkin lymphoma.

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Studies covering CNS tumors usually stated whether non-malignant CNS tumors were included in the analyses. Inclusion or exclusion of skin carcinomas or non-melanoma skin cancer was less frequently specified. A considerable variety of outcome measures were used. The most frequent were observed survival and relative or net survival, but some studies reported event-free, cancer-specific or disease-specific survival.

3.5 Characteristics of countries and territories represented in included publications

The only territory with an estimated child population below 50,000 to be represented among the eligible studies was the Faroe Islands (69). Table 2 shows, for all countries and territories with a child population of at least 50,000, their representation in studies covered by this review and in major international cancer survival studies, together with information on World Bank Income Group, Human Development Index, the presence of population-based cancer registration, and completeness of death registration.

Countries were more likely to be represented in population-based studies of childhood cancer included in this review if they were in higher categories of World Bank income classification and Human Development Index (HDI; Table 3). Overall, 75% of high-income countries (HIC) were represented, compared with 47% of upper-middle-income countries (UMIC), 16% of lower-middle-income countries (LMIC) and 8% of low-income countries (LIC). Similarly, 79% of countries with Very High HDI were represented, compared with 45% of those with High HDI, 11% of those with Medium HDI and 9% of those with Low HDI. This pattern was repeated across all continents except the Caribbean, Central and South America, where there was a marked preponderance of very small countries among those in the highest categories of each of the two indices.

Among countries that were represented in population-based studies, 29% of HICs and 35% of countries with Very High HDI were only represented in multinational papers compared with 75% of those in lower World Bank income categories and 77% of those in the three lower ranges of HDI.

3.6 Coverage of cancer types in included publications

Among all 303 included publications, 84 (28%) covered all cancer types, 60 (20%) were devoted to leukemia and lymphomas, 63 (21%) were devoted to CNS tumors, 74 (24%) were restricted to all or part of a single ICCC-3 main group of non-CNS solid tumors, and 22 (7%) covered a wide range of combinations of cancers, sometimes defined by primary site rather than morphology.

4 Discussion

This review confirms that population-based survival estimates of childhood cancer in the 21st century are available for many affluent countries, although quite often not for all of the principal diagnostic groups. Information is relatively scarce for less well-resourced countries. In many countries it has only been possible to estimate survival for some regions, which may not be representative of the whole country.

The first requisite for calculating cancer survival at the population level is population-based case ascertainment, virtually always by a PBCR. Institutional (including multi-institutional) series often contain richer clinical information than is found in most PBCRs and can yield much valuable information about cancer within a defined population, especially when they contain large numbers of cases (70). However, they necessarily exclude patients from that population who are diagnosed and treated (or remain untreated) outside the participating institutions, and survival estimated from their data will likely be biased upwards compared with the true result in the entire target population.

The second requisite is knowledge of the vital status of individual patients at given time intervals since diagnosis. A large number of countries, predominantly those in the lower categories of per capita income and HDI, are without population-based cancer registration even at sub-national level (Table 2). But even when there is population-based registration of incident cases, follow-up for vital status is not always straightforward. The most efficient method of obtaining this information is passive follow-up by linkage to death registrations, but an acceptable level of accuracy is only achievable if there is a high percentage completeness of death registration in the population. Moreover, for follow-up by a sub-national cancer registry, death registration should ideally be complete not merely within the registry's own territory but nationally, to allow for internal migration. The absence of complete death registration is also more often a feature of less well-resourced countries (Table 2), and follow- up by active tracing of patients becomes necessary. In a recent study of cancer in adults, for example, passive follow-up by linkage with national death registration was possible in only one out of 13 participating PBCRs from Sub-Saharan Africa (71). Active follow-up not only has varying degrees of success, it is also labor intensive, straining already scarce resources. Presumably for this reason, in a study of childhood cancer survival from three PBCRs in Sub-Saharan Africa, active follow-up was carried out by one of the participating registries only for a random sample of patients rather than for the entire patient population (64).

The numerous single-country studies included in this review have made substantial contributions to knowledge concerning population-level survival of children with cancer within their own countries. Multinational studies, however, whether the product of *ad hoc* collaborations involving a few countries or established consortia of much larger numbers of countries, have several important advantages. They pool data processing and analytical resources which may be scarce in some participating countries. The use of common definitions, data validation standards and procedures, outcome measures, and analytical methods enhances comparability between results for individual countries or for

TABLE 2 Countries and territories with child population of at least 50,000. Size of child population (315), World Bank per capita income category (316), Human Development Index (HDI) (317), presence of population-based cancer registration for age 0–14 during the study period (PBCR) (72, 318, 319), completeness of death registration (320), inclusion of published results in this review, and participation in CONCORD, EUROCARE, HAEMACARE, and RARECARE.

	Population aged <15 years (10^6)	World Bank Income Group (Fiscal Year 2025)	HDI 2022	PBCR aged <15	Completeness of death registration (%)*	Publication of survival results included in this review	Childhood data contributed to CONCORD**	Childhood data contributed to EUROCARE, HAEMACARE, and RARECARE
Africa								
Algeria	14.474	UMIC	0.745	Regional	85–89	Yes	2, 3	
Angola	17.454	LMIC	0.591	Regional	0			
Benin	6.654	LMIC	0.504	Regional	0			
Botswana	0.704	UMIC	0.708	National	60–64			
Burkina Faso	9.596	LIC	0.438	Regional	0			
Burundi	5.744	LIC	0.420		0			
Cameroon	12.842	LMIC	0.587	Regional	0			
Cape Verde	0.161	LMIC	0.661	National	95–100			
Central African Republic	2.178	LIC	0.387		0			
Chad	8.752	LIC	0.394	Regional	0			
Comoros	0.293	LMIC	0.586		0			
Democratic Republic of Congo	52.793	LIC	0.481		0			
Congo	2.306	LMIC	0.593	Regional	(40–44); CISSA3			
Côte d'Ivoire	10.828	LMIC	0.534	Regional	15–19			
Djibouti	0.283	LMIC	0.515		(10–14)			
Egypt	37.593	LMIC	0.728	Regional	95–100			
Equatorial Guinea	0.640	UMIC	0.650		0			
Eritrea	2.262	LIC	0.493		0			
Eswatini	0.360	LMIC	0.610	National	65–69			
Ethiopia	45.858	LIC	0.492	Regional	15–19			
Gabon	0.850	UMIC	0.693	Regional	0			
Gambia	0.964	LIC	0.495	National	CISSA3			
Ghana	12.928	LMIC	0.602	Regional	30–34			
Guinea	5.720	LMIC	0.471	Regional	1–4			
Guinea-Bissau	0.902	LIC	0.483		0			

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TABLE 2 (Continued)

	Population aged <15 years (10^6)	World Bank Income Group (Fiscal Year 2025)	HDI 2022	PBCR aged <15	Completeness of death registration (%)*	Publication of survival results included in this review	Childhood data contributed to CONCORD**	Childhood data contributed to EUROCARE, HAEMACARE, and RARECARE
Kenya	20.831	LMIC	0.601	Regional	65–69	Yes		
Lesotho	0.712	LMIC	0.521	National	45–49	Yes	2	
Liberia	2.117	LIC	0.487		0			
Libya	2.377	UMIC	0.746	Regional	90–94	Yes	2	
Madagascar	10.908	LIC	0.487		0			
Malawi	8.213	LIC	0.508	Regional	0			
Mali	10.290	LIC	0.410	Regional	CISSA3			
Mauritania	1.546	LMIC	0.540		0			
Mauritius	0.198	UMIC	0.796	National	95–100	Yes	(3)	
Morocco	9.600	LMIC	0.698	Regional	30–34			
Mozambique	14.898	LIC	0.461	Regional	CISSA3			
Namibia	0.956	UMIC	0.610	National	95–100			
Niger	13.031	LIC	0.394	Regional	0			
Nigeria	95.627	LMIC	0.548	Regional	0	Yes	3	
Réunion and Mayotte				National	WHODB	Yes		
Rwanda	5.070	LIC	0.548	National	30–34	Yes		
São Tomé and Principe	0.081	LMIC	0.613		90–94			
Senegal	7.669	LMIC	0.517		0			
Sierra Leone	3.656	LIC	0.458		0			
Somalia	5.383	LIC	0.380		0			
South Africa	16.422	UMIC	0.717	Regional	80–84	Yes	3	
South Sudan	5.345	LIC	0.381		0			
Sudan	20.228	LIC	0.516	Regional	0			

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TABLE 2 (Continued)

	Population aged <15 years (10^6)	World Bank Income Group (Fiscal Year 2025)	HDI 2022	PBCR aged <15	Completeness of death registration (%)*	Publication of survival results included in this review	Childhood data contributed to CONCORD**	Childhood data contributed to EUROCARE, HAEMACARE, and RARECARE
Tanzania	27.780	LMIC	0.532	Regional	15–19			
Togo	3.449	LIC	0.547		0			
Tunisia	2.943	LMIC	0.732	Regional	95–100	Yes	2	
Uganda	23.176	LIC	0.550	Regional	10–14	Yes		
Zambia	8.756	LMIC	0.569	Regional	35–39			
Zimbabwe	6.570	LMIC	0.550	Regional	30–34	Yes		
America (Central and Caribbean)								
Bahamas	0.088	HIC	0.820		(90–94)			
Barbados	0.051	HIC	0.809		(95–99)			
Belize	0.115	UMIC	0.700		95–100			
Costa Rica	0.989	UMIC	0.806	National	95–100	Yes	3	
Cuba	1.785	UMIC	0.764	National	95–100	Yes	3	
Dominican Republic	2.762	UMIC	0.766		65–69			
El Salvador	1.674	UMIC	0.674		90–94			
French West Indies				National	WHODB	Yes	3	
Guatemala	5.745	UMIC	0.629		90–94			
Haiti	3.584	LMIC	0.552		0			
Honduras	2.731	LMIC	0.624	Regional	(25–29)			
Jamaica	0.672	UMIC	0.706	Regional	90–94			
Mexico	30.402	UMIC	0.781	Regional	95–100	Yes	3	
Netherlands Antilles	0.059	HIC			WHODB			
Nicaragua	1.674	LMIC	0.669		85–89			
Panama	1.119	HIC	0.820		90–94			
Puerto Rico	0.376	HIC		National	WHODB	Yes	2, 3	
Trinidad and Tobago	0.264	HIC	0.814		90–94			

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TABLE 2 (Continued)

	Population aged <15 years (10^6)	World Bank Income Group (Fiscal Year 2025)	HDI 2022	PBCR aged <15	Completeness of death registration (%)*	Publication of survival results included in this review	Childhood data contributed to CONCORD**	Childhood data contributed to EUROCARE, HAEMACARE, and RARECARE
America (North)								
Canada	6.028	HIC	0.935	National	95–100	Yes	2, 3	
United States	61.873	HIC	0.927	National	95–100	Yes	2, 3	
America (South)								
Argentina	10.935	UMIC	0.849	National	95–100	Yes	2, 3	
Bolivia	3.511	LMIC	0.698		75–79			
Brazil	43.114	UMIC	0.760	Regional	95–100	Yes	2, 3	
Chile	3.574	HIC	0.860	National	95–100	Yes	2, 3	
Colombia	11.038	UMIC	0.758	Regional	85–89	Yes	2, 3	
Ecuador	4.901	UMIC	0.765	Regional	85–89	Yes	2, 3	
French Guiana				National	WHODB			
Guyana	0.186	HIC	0.742		85–89			
Paraguay	1.671	UMIC	0.731		80–84			
Peru	8.412	UMIC	0.762	Regional	75–79	Yes	3	
Suriname	0.145	UMIC	0.690		90–94			
Uruguay	0.647	HIC	0.830	National	95–100			
Venezuela	7.799	HIC	0.699		95–100			
Asia								
Afghanistan	15.881	LIC	0.462		10–14			
Armenia	0.526	UMIC	0.786		95–100			
Azerbaijan	2.374	UMIC	0.760		85–89			
Bahrain	0.183	HIC	0.888	National	75–79			
Bangladesh	42.341	LMIC	0.670		25–29			
Bhutan	0.205	LMIC	0.681		80–84			
Brunei	0.107	HIC	0.823	National	90–94	Yes		

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TABLE 2 (Continued)

	Population aged <15 years (10^6)	World Bank Income Group (Fiscal Year 2025)	HDI 2022	PBCR aged <15	Completeness of death registration (%)*	Publication of survival results included in this review	Childhood data contributed to CONCORD**	Childhood data contributed to EUROCARE, HAEMACARE, and RARECARE
Cambodia	4.934	LMIC	0.600		40–44			
China	231.629	UMIC	0.788	Regional	75–79	Yes	2, 3	
India	344.762	LMIC	0.644	Regional	80–84	Yes	2, 3	
Indonesia	66.949	UMIC	0.713	Regional	25–29	Yes	2	
Iran	20.553	UMIC	0.780	Regional	90–94	Yes		
Iraq	14.578	UMIC	0.673	Regional	70–74			
Israel	2.582	HIC	0.915	National	95–100	Yes	2, 3	
Japan	14.941	HIC	0.920	Regional	95–100	Yes	2, 3	
Jordan	3.450	LMIC	0.736	National	75–79	Yes	2, 3	
Kazakhstan	5.596	UMIC	0.802	National	95–100			
North Korea	5.213	LIC			0			
South Korea	5.898	HIC	0.929	National	95–100	Yes	2, 3	
Kuwait	0.723	HIC	0.847	National	95–100	Yes	3	
Kyrgyzstan	1.795	LMIC	0.701		90–94			
Laos	2.396	LMIC	0.620		45–49			
Lebanon	1.015	LMIC	0.723	National	90–94			
Malaysia	7.678	UMIC	0.807	Regional	95–100	Yes	2, 3	
Maldives	0.087	UMIC	0.762		95–100			
Mongolia	0.843	UMIC	0.741	National	90–94	Yes	2	
Myanmar	14.041	LMIC	0.608		50–54			
Nepal	8.034	LMIC	0.601		70–74			
Oman	1.162	HIC	0.819	National	70–74			
Pakistan	86.860	LMIC	0.540	Regional	40–44			
Philippines	35.697	LMIC	0.710	Regional	85–89	Yes		
Qatar	0.335	HIC	0.875	National	75–79	Yes	3	
Saudi Arabia	8.364	HIC	0.875	Regional	75–79			
Singapore	0.881	HIC	0.949	National	95–100	Yes	3	
Sri Lanka	5.962	LMIC	0.780	Regional	95–100			

(Continued)

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TABLE 2 (Continued)

	Population aged <15 years (10^6)	World Bank Income Group (Fiscal Year 2025)	HDI 2022	PBCR aged <15	Completeness of death registration (%)*	Publication of survival results included in this review	Childhood data contributed to CONCORD**	Childhood data contributed to EUROCARE, HAEMACARE, and RARECARE
Syria	7.866	LIC	0.557		0			
Taiwan	2.863	HIC		National		Yes	2, 3	
Tajikistan	3.831	LMIC	0.679		65–69			
Thailand	11.064	UMIC	0.803	Regional	95–100	Yes	2, 3	
Timor-Leste	0.583	LMIC	0.566		0			
Turkey	18.292	UMIC	0.855	Regional	95–100	Yes	2, 3	
Turkmenistan	1.405	UMIC	0.744		95–100			
United Arab Emirates	1.645	HIC	0.937	National	75–79			
Uzbekistan	10.811	LMIC	0.727		90–94			
Vietnam	24.533	LMIC	0.726	Regional	90–94			
West Bank and Gaza	2.020	LMIC	0.716		WHODB			
Yemen	11.053	LIC	0.424	Regional	15–19			
Europe								
Albania	0.559	UMIC	0.789	National	95–100			
Austria	1.265	HIC	0.926	National	95–100	Yes	2, 3	E4, E5, E6, H, R
Belarus	1.529	UMIC	0.801	National	95–100	Yes	2, 3	
Belgium	2.029	HIC	0.942	National	95–100	Yes	2, 3	E4, E5, E6, R
Bosnia and Herzegovina	0.498	UMIC	0.779	Regional	95–100			
Bulgaria	0.933	HIC	0.799	National	95–100	Yes	2, 3	E5, E6
Croatia	0.575	HIC	0.878	National	95–100	Yes	2, 3	E5, E6
Cyprus	0.206	HIC	0.907	Regional	95–100	Yes	2, 3	E6
Czech Republic	1.698	HIC	0.895	National	95–100	Yes	3	E4, E6, H
Denmark	0.968	HIC	0.950	National	95–100	Yes	2, 3	E4, E5, E6
Estonia	0.182	HIC	0.899	National	95–100	Yes	2, 3	E5, E6
Finland	0.910	HIC	0.942	National	95–100	Yes	2, 3	E4, E5, E6
France	11.853	HIC	0.910	National	95–100	Yes	2, 3	E4, E5, E6, H, R

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TABLE 2 (Continued)

	Population aged <15 years (10^6)	World Bank Income Group (Fiscal Year 2025)	HDI 2022	PBCR aged <15	Completeness of death registration (%)*	Publication of survival results included in this review	Childhood data contributed to CONCORD**	Childhood data contributed to EUROCARE, HAEMACARE, and RARECARE
Georgia	1.010	UMIC	0.814		95–100			
Germany	11.614	HIC	0.950	National	95–100	Yes	2, 3	E4, E5, E6, H, R
Greece	1.441	HIC	0.893	National	95–100	Yes	3	E6
Hungary	1.438	HIC	0.851	National	95–100	Yes		E5, E6
Iceland	0.072	HIC	0.959	National	95–100	Yes	2, 3	E4, E5, E6, H, R
Ireland	0.976	HIC	0.950	National	95–100	Yes	2, 3	E4, E5, E6, H, R
Italy	7.231	HIC	0.906	Regional	95–100	Yes	2, 3	E4, E5, E6, H, R
Kosovo	0.449	UMIC						
Latvia	0.265	HIC	0.879	National	95–100	Yes	2, 3	E5, E6
Lithuania	0.400	HIC	0.879	National	95–100	Yes	2, 3	E5, E6
Luxembourg	0.112	HIC	0.927	National	95–100			
Malta	0.068	HIC	0.915	National	90–94	Yes	2, 3	E4, E5, E6, H, R
Moldova	0.533	UMIC	0.763		85–89			
Montenegro	0.106	UMIC	0.844	National	95–100			
Netherlands	2.697	HIC	0.946	National	95–100	Yes	2, 3	E4, E5, E6, H, R
North Macedonia	0.341	UMIC	0.765		95–100			
Norway	0.900	HIC	0.966	National	95–100	Yes	2, 3	E4, E5, E6, H, R
Poland	5.506	HIC	0.881	National	95–100	Yes	2, 3	E4, E5, E6, H, R
Portugal	1.294	HIC	0.874	National	95–100	Yes	2, 3	E4, E5, E6, H, R
Romania	2.804	HIC	0.827	Regional	95–100	Yes	(2), 3	
Russia	23.270	HIC	0.821	Regional	95–100	Yes	2, 3	
Serbia	0.957	UMIC	0.805	Regional	95–100	Yes		
Slovakia	0.853	HIC	0.855	National	95–100	Yes	2, 3	E5, E6, R
Slovenia	0.301	HIC	0.926	National	95–100	Yes	2, 3	E4, E5, E6, H, R
Spain	6.160	HIC	0.911	Regional	95–100	Yes	2, 3	E4, E5, E6, H, R

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TABLE 2 (Continued)

	Population aged <15 years (10^6)	World Bank Income Group (Fiscal Year 2025)	HDI 2022	PBCR aged <15	Completeness of death registration (%)*	Publication of survival results included in this review	Childhood data contributed to CONCORD**	Childhood data contributed to EUROCARE, HAEMACARE, and RARECARE
Sweden	1.815	HIC	0.952	National	95–100	Yes	2, 3	E4, E5, H, R
Switzerland	1.336	HIC	0.967	National	95–100	Yes	2, 3	E4, E5, E6, H, R
Ukraine	4.401	UMIC	0.734	National	95–100	Yes		
United Kingdom	11.466	HIC	0.940	National	95–100	Yes	2, 3	E4, E5, E6, H, R
Oceania								
Australia	4.896	HIC	0.946	National	95–100	Yes	2, 3	
Fiji	0.235	UMIC	0.729		90–94			
French Polynesia	0.062	HIC		National				
New Caledonia	0.063	HIC		National				
New Zealand	0.979	HIC	0.939	National	95–100	Yes	2, 3	
Papua New Guinea	3.728	LMIC	0.568		10–14			
Samoa	0.056	LMIC	0.702		85–89			
Solomon Islands	0.222	LMIC	0.562		40–44			
Vanuatu	0.099	LMIC	0.614		10–14			

HIC, High-income country; UMIC, Upper-middle-income country; LMIC, Lower-middle-income country; LIC, Low-income country; En, EUROCARE-n; H, HAEMACARE; R, RARECARE.

*Entries in parentheses for countries where latest data are pre 2015.

CISSA3, existence of death certificates mentioned in Cancer in Sub-Saharan Africa, Vol. III (319), but not always used by the cancer registry.

WHODB, no estimate given by Adair et al. (320), but data included in WHO Mortality Databank.

**Entries in parentheses where registration data were contributed but survival results for the country were not published for age 0–14.

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TABLE 3 Publication of survival results included in this review for countries in each continent with child population of at least 50,000 by World Bank per capita income category and Human Development Index (HDI).

	Africa	America (Central and Caribbean)	America (North)	Asia	Europe	Oceania	Total
World Bank Income Group (Fiscal Year 2025)							
High-income countries	–	2/10	2/2	8/12	31/32	2/4	45/60
Upper-middle-income countries	4/8	8/15	–	7/13	3/10	0/1	22/47
Lower-middle-income countries	5/23	0/4	–	3/18	–	0/4	8/49
Low-income countries	2/22	–	–	0/4	–	–	2/26
HDI 2022							
Very high (0.800+)	–	3/8	2/2	10/15	32/35	2/2	49/62
High (0.700–0.799)	5/7	6/11	–	6/16	2/6	0/2	19/42
Medium (0.550–0.699)	3/16	0/8	–	1/11	–	0/3	4/38
Low (<0.550)	3/30	–	–	0/3	–	–	3/33

larger groups of countries based on factors including geography, socioeconomic indicators and characteristics of healthcare systems. The contrasts in the proportions of countries represented only in multinational studies between HICs and those in lower income categories and between countries with Very High HDI and those with a lower HDI show that multinational studies present especially valuable opportunities to less well-resourced countries for their results to be made visible and available for comparison.

There should generally be a high degree of comparability of ostensibly similar diagnostic categories between studies because of the widespread use of ICCC-3, other systems defined in terms of ICD-O-3, and ICD-O-3 itself. There are, however, two points on which there may be systematic differences between datasets. The first is uncertainty in most instances as to whether the overall category of all cancers includes skin carcinomas or non-melanoma skin cancer, but this is unlikely to have a substantial influence on survival rates for all cancers combined because these tumors are rare among children (72). More problematic is the continuing exclusion of CNS tumors with non-malignant behavior codes by some PBCRs, although increasing numbers of registries do include non-malignant intracranial and intraspinal tumors. The effect of excluding non-malignant tumors of these sites became more severe when pilocytic astrocytoma, the most frequent of childhood CNS tumors, was downgraded to uncertain behavior in ICD-O-3, having been regarded as malignant in earlier editions of ICD-O. Survival rates could in principle be compared between registries that include non-malignant CNS tumors and those that exclude them by restricting the comparison to malignant tumors, but such comparisons could still be unreliable because astrocytoma, not otherwise specified, is still assigned a malignant behavior code and it is impossible to know how many astrocytomas of unspecified subtype are in fact pilocytic (40, 73). International comparison of survival rates for CNS tumors, whose overall frequency is second only to that of leukemias, would be greatly simplified if non-malignant tumors of intracranial and intraspinal sites were routinely ascertained and followed up by all PBCRs.

The World Health Organization's Global Initiative for Childhood Cancer has the target of achieving 60% survival globally for children and adolescents with cancer by the year 2030, and wider availability of robust information on survival at population level will be essential for monitoring progress toward this goal (74). Reliable population-based information is available and extensively published from a large proportion of the most affluent countries, where 5-year survival is already well above 60%. Increasing the coverage and quality of cancer registration and death notification in as many lower-resource countries as possible would in turn increase the volume and geographic spread of the raw data from which survival rates can be estimated for those countries. International collaborations will continue to play a vital part in enabling comparison of childhood cancer survival between populations with confidence that the results are underpinned by uniform procedures for data validation and analysis.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: https://pubmed.ncbi.nlm.nih.gov/, https://

clarivate.com/academia-government/scientific-and-academic-research/research-discovery-and-referencing/web-of-science/, https://www.cia.gov/the-world-factbook/field/age-structure, https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups, and Human Development Reports. Human Development Index. (2022) https://hdr.undp.org/data-center/human-development-index#/indicies/HDI.

Author contributions

CS: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing.

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Conflict of interest

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Appendix

PubMed search strategy

(infant, newborn[mh] OR newborn Infant*[tw] OR newborn*[tw] OR neonate*[tw] OR infant[mh] OR infan*[tw] OR child[mh] OR child*[tw] OR pediatric[tw] OR paediatric[tw])
AND
(neoplasms[mh] OR neoplas*[tw] OR tumor*[tw] OR tumour*[tw] OR cancer*[tw] OR malignan*[tw] OR benign neoplasm*[tw] OR leukaemia[tw] OR leukemia[tw] OR lymphoma[tw] OR sarcoma[tw] OR carcinoma[tw])
AND
(survival rate[mh] OR survival rate*[tw])
AND
nationwide[tw]

Web of Science search strategy

TS=((infants, newborn OR newborn infant* OR newborn* OR neonate* OR infant* OR child*)
AND
(neoplas* OR tumo$r* OR cancer* OR malignan* OR benign neoplasm*)
AND
(survival* OR survival stud* OR studies, survival OR survival rate*)
AND
(registr* OR population registr* OR population based OR populational based))