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Original Articles

Incidence, mortality and survival of childhood cancer in China during 2000–2010 period: A population-based study

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ABSTRACT

The objective of this study is to assess Chinese nationwide incidence, mortality and survival of childhood cancers, which has not been reported. Data from 145 Chinese Cancer Registries, which covered 158,403,248 populations, were pooled for analyses. Cancer patients were diagnosed during 2000–2010 at age 0–14 years. Age-standardized incidence and mortality rates and relative survival rates were calculated. Survival was estimated by the classic cohort approach. New cancer cases were projected using a Bayesian age–period–cohort model. Overall age-standardized incidence was 87.1 per million and age-standardized mortality was 36.3 per million. We found a statistically significant increase in incidence rate annually with 2.8% (95% CI: 1.1–4.6%, $p < 0.05$), a non-significant decreased mortality, and overall 5-year relative survival reaching 71.9% (95% CI: 69.4–77.1%). Projected new cases in 2015 are 22,875. We provide, for the first time, Chinese nationwide incidence, mortality and their temporal trends, and relative survival rates during the period of 2003–2005 for childhood cancer, which will contribute to a better understanding of the etiology and prevention of childhood cancers. The increasing trend of incidence rate and low 5-year relative survival rate suggest that more efforts for prevention and control of childhood cancers shall be invested in China.

Introduction

Due to advances in early diagnosis and effective therapy over the past few decades, childhood cancer (diagnosed at age <15 years) generally has better survival rate compared to adult cancer. Nevertheless, childhood cancer is still an important disease [1]. For example, cancer is the second leading cause of death for children at ages 5–14 years in the United States [2,3]. Although population-based studies on childhood cancer has been reported worldwide, including the United States, Israel, India, and Taiwan [4–7], only a few studies on incidence and mortality rate of childhood cancer were conducted in China. According to the sixth national census in 2010, 16.6% of the population (212,322,621) was aged 0–14 years [8]. Additionally, 84% of childhood cancers occur in low-income or middle-income countries to which China still belongs. Thus, Chinese nationwide data on incidence, mortality and survival of childhood cancer will be of great interest [9].

We aimed at assessing incidence, mortality and their temporal trends, and survival rates during the 2003–2005 period for childhood cancer, using data from Chinese National Central Cancer Registry (NCCR). Our data may provide a comprehensive epidemiologic data on childhood cancer, which may be beneficial for its prevention and control and may guide clinical treatment.

Materials and methods

Incidence, mortality and survival data

We used a pooled Chinese nationwide cancer database and details were described elsewhere [10] and summarized briefly below. In China, a population-based cancer registration network was initiated in 1970s and there were overall 219 cancer registries distributed in varied geographic locations in China in 2010. The annual report on Chinese nationwide cancer status in 2010 used data from NCCR and, among them, childhood cancer comprised approximately 0.6% of all cancers. Incidence data by cancer sites, morphology, and characteristics of cancer patients (e.g., sex and age at diagnosis), selected from 145 (out of 219 in total) cancer registries, were used for further analyses [10]. Cancer mortality data were derived from the vital statistics in local registries.

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Table 1
China childhood cancer incidence[a] (per million) by cancer site, 2010.

Sites	Overall		Boys		Girls		Urban		Rural	
	Case	Incidence	Case	Incidence	Case	Incidence	case	Incidence	Case	Incidence
All sites	19,015	87.1	11,366	96.2	7649	76.4	11,745	92.5	7270	79.7
Leukemia	7764	35.6	4737	40.1	3027	30.2	4646	36.6	3118	34.2
Brain, CNS[b]	3265	15.0	1950	16.5	1315	13.1	2047	16.1	1218	13.3
Lymphoma	1406	6.4	911	7.7	495	4.9	889	7.0	517	5.7
Bone tumors	954	4.4	619	5.2	335	3.3	580	4.6	375	4.1
Kidney tumors	806	3.7	448	3.8	358	3.6	530	4.2	276	3.0

[a] Age-standardized rate.
[b] Central nervous system.

Cancer cases were recorded according to rules set up by the International Agency for Research on Cancer (IARC). Data were checked and assessed by the IARC-crgTools to identify errors and inconsistencies from 145 cancer registries (63 in urban and 82 in rural). The pooled nationwide database represented 158,403,248 populations (92,433,739 in urban and 65,969,509 in rural areas), covering 12% of the whole Chinese population.

Overall 22 registries, providing integrated data from 2000 to 2010, were selected to calculate the time trend of childhood cancer, with 5725 childhood cancer cases from a population of 44,666,665 person years.

Data selected from 17 cancer registries (n = 636 childhood cancer records from 3,417,957 person-years) were restricted to children cancer cases diagnosed during 2003–2005 and followed till 2010 and the details were described elsewhere [11]. Five-year relative survival was used to calculate survival rates for patients with common childhood cancers.

The International Classification of Disease, tenth revision (ICD-10), was used to record new cancer cases for anatomic sites. The details on cancer case included cancer sites, morphology, sex and age at diagnosis [12].

Quality control

All data submitted from each cancer registry were checked and evaluated according to the Guideline on Chinese Cancer Registration by Chinese NCCR. Data quality was assessed according to the relevant data quality criteria adopted in Cancer Incidence in Five Continents Volume IX by the International Agency for Research on Cancer/International Association of Cancer Registries (IARC/IACR) [13–16]. Additionally, data sorting, checking and evaluation were assessed by some applications, e.g., MS-FoxPro, MS-Excel and IARC-crgTools. Proportion of morphological verification (MV%), percentage of cancer cases identified with death certification only (DCO%), mortality to incidence ratio (MI), percentage of uncertified cancer (UB%), and percentage of cancer with undefined or unknown primary site (secondary) (CPU%) were used to evaluate the completeness, validity and reliability of cancer data.

Statistical analysis

Crude incidence rates were calculated as the annual number of new cases per million person-year and were further stratified by sex, and age at diagnosis (<1 year, 1–4, 5–9, and 10~14 years). Age-standardized incidence and death rates were adjusted by Chinese standard population in 2010 and were expressed as per million children.

Survival was estimated by the classic cohort approach, and all patients should have potential at least 5 years follow-up. Observed survival was computed by the life-table method and expected survival was estimated by the Ederer II method [16], using registry-specific life tables by age, sex and single calendar year between 2003 and 2010. Standard errors of relative survival estimates were obtained using Greenwood's formula [17].

Integrated data from 22 registries during the 2000–2010 period were used to project the number of new cases of childhood cancers (diagnosed at age 0–14 years) in the 2011–2015 period, using Bayesian age–period–cohort model by the BAMP software (BAMP v.1.3.0) [18]. 1,010,000 iterations (initial 10,000 iterations) were used for Markov Chain Monte Carlo simulations to minimize the effect of initial values; random walk (RW) priors of different orders were used for the APC parameters; RW2 was used based on the assumption that incidence rates for each age group had a linear trend along with increasing age. The median and 95% confidence intervals (using 2.5% and 97.5% of the 1,000,000 iterated results) of iterative values were used for simulations in the models.

Results

Cancer incidence and mortality rates for Chinese childhood cancers

In total, there were 19,015 patients diagnosed with childhood cancer, with an age-standardized incidence rate of 87.1 per million (Table 1). We found a higher incidence rate in boys compared to girls (96.2 per million versus 76.4 per million), and higher incidence rate in urban areas compared to rural areas (92.5 per million versus 79.7 per million). The most frequent five childhood cancers were leukemia (35.6 per million), brain and central nervous system (CNS) cancer (15.0 per million), lymphoma (6.4 per million), bone cancer (4.4 per million) and kidney cancer (3.7 per million). Similar patterns of incidence rate by sex and residence were found in different sites of childhood cancers. We found the highest incidence rate in patients diagnosed at ≤1 year and the lowest incidence rate in patients diagnosed at 5–9 years (Table 2).

Overall, age-standardized mortality rate was 36.3 per million (7928 deaths) (Table 3). We found mortality rate was higher in boys compared to girls (39.5 versus 32.5 per million) and was higher for rural areas compared to urban areas (37.2 versus 35.7 per million). Leukemia was the leading childhood cancer death (15.0 per million).

Age-specific mortality rate is shown in Table 2. The highest mortality rate was observed in patients diagnosed at <1 year.

Temporal trends in incidence, mortality and survival rates

Trends of incidence and mortality rates during the 2000–2010 period (from 22 cancer registries) are shown in Figs. 1 and 2, respectively. As shown in Table 4, we found an overall significant increase in average annual percent change (AAPC) of incidence rate at 2.8% (95% confidence interval: 1.1–4.6%, $p < 0.05$), while no-significant change in AAPC of mortality rate was found [–1.1% (95% CI: –2.3–0.2%)].

We found that overall 5-year relative survival was 71.9% (95% CI: 69.4–77.1%) and that there was no significant sex difference [70.9% (67.7–74.3%) for boys versus 73.2% (69.4–77.1%) for girls] (Table 5). The worst survival rate was found for liver cancer [52.0% (42.9–63.3%)], while for other cancer sites, we found favorable survival rates, with 5-year relative survival rates reaching 80.5% for bone tumor, 70.5% for leukemia, 69.9% for brain tumor, and 64.7% for lymphoma (Table 5).

Table 2
Age specific incidence and mortality per million of childhood cancer in China, 2010.

	Age group	Overall	Boys	Girls	Urban	Rural
Incidence	0~	113.4	115	111.7	122.5	98.9
	1~	103.5	115.8	88.7	106.9	98.4
	5~	72.3	80.9	62.6	79.8	62.1
	10–14	82.8	90.9	73.2	86.2	78.2
Mortality	0~	47.6	50.1	44.8	50.4	43.3
	1~	44.9	49.1	39.9	42.5	48.4
	5~	31.5	34.9	27.4	30.2	33.1
	10–14	31.7	34.1	29	32.3	31.1