Socioeconomic inequalities in cancer incidence and access to health services among children and adolescents in China: a cross-sectional study

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Summary

Background Despite the substantial burden caused by childhood cancer globally, childhood cancer incidence obtained in a nationwide childhood cancer registry and the accessibility of relevant health services are still unknown in China. We comprehensively assessed the most up-to-date cancer incidence in Chinese children and adolescents, nationally, regionally, and in specific population subgroups, and also examined the association between cancer incidence and socioeconomic inequality in access to health services.

Methods In this national cross-sectional study, we used data from the National Center for Pediatric Cancer Surveillance, the nationwide Hospital Quality Monitoring System, and public databases to cover 31 provinces, autonomous regions, and municipalities in mainland China. We estimated the incidence of cancer among children (aged 0–14 years) and adolescents (aged 15–19 years) in China through stratified proportional estimation. We classified regions by socioeconomic status using the human development index (HDI). Incidence rates of 12 main groups, 47 subgroups, and 81 subtypes of cancer were reported and compared by sex, age, and socioeconomic status, according to the third edition of the International Classification of Childhood Cancer. We also quantified the geographical and population density of paediatric oncologists, pathology workforce, diagnoses and treatment institutions of paediatric cancer, and paediatric beds. We used the Gini coefficient to assess equality in access to these four health service indicators. We also calculated the proportions of cross-regional patients among new cases in our surveillance system.

Findings We estimated the incidence of cancer among children (aged 0–14 years) and adolescents (aged 15–19 years) in China from Jan 1, 2018, to Dec 31, 2020. An estimated 121 145 cancer cases were diagnosed among children and adolescents in China between 2018 and 2020, with world standard age-standardised incidence rates of 122·86 (95% CI 121·70–124·02) per million for children and 137·64 (136·08–139·20) per million for adolescents. Boys had a higher incidence rate of childhood cancer (133·18 for boys *vs* 111·21 for girls per million) but a lower incidence of adolescent cancer (133·92 for boys *vs* 141·79 for girls per million) than girls. Leukaemias (42·33 per million) were the most common cancer group in children, whereas malignant epithelial tumours and melanomas (30·39 per million) surpassed leukaemias (30·08 per million) in adolescents as the cancer with the highest incidence. The overall incidence rates ranged from 101·60 (100·67–102·51) per million in very low HDI regions to 138·21 (137·14–139·29) per million in high HDI regions, indicating a significant positive association between the incidence of childhood and adolescent cancer and regional socioeconomic status (p<0·0001). The incidence in girls showed larger variation (48·45% from the lowest to the highest) than boys (36·71% from lowest to highest) in different socioeconomic regions. The population and geographical densities of most health services also showed a significant positive correlation with HDI levels. In particular, the geographical density distribution (Gini coefficients of 0·32–0·47) had higher inequalities than population density distribution (Gini coefficients of 0·05–0·19). The overall proportion of cross-regional patients of childhood and adolescent cancer was 22·16%, and the highest proportion occurred in retinoblastoma (56·54%) and in low HDI regions (35·14%).

Interpretation Our study showed that the burden of cancer in children and adolescents in China is much higher than previously nationally reported from 2000 to 2015. The distribution of the accessibility of health services, as a social

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Introduction

Cancer is one of the leading causes of death among children and adolescents worldwide.[1,2] The reported incidence rate of childhood and adolescent cancer is greater in high-income countries than in low-income and middle-income countries (LMICs);[3] however, more than 80% of the total number of childhood cancer cases occur in LMICs.[4] Although two studies in China reported the national incidence of childhood and adolescent cancer using population-based cancer registry data from 2000 to 2015, the results probably underestimated the incidence because of the absence of high-quality reporting of childhood cancers and missing data from the floating populations in China (ie, those who moved out of their household regions for more than 6 months), who are approximately 16% of the population.[5,6] The Global

Research in context

Evidence before this study

We searched PubMed, Google Scholar, and China National Knowledge Infrastructure without language restrictions for articles published from Jan 1, 1990, to July 31, 2022, using the search terms "childhood or adolescent", "cancer incidence", "social determinant of health", "health service", and "inequality". Two studies reported the incidence of childhood cancer using data from 2000 to 2015 in China; however, the results appeared to be an underestimation of incidence (eg, one showed that the incidence was 96·03 per million for children and adolescents aged 0–19 years and the other showed 87·1 per million for children aged 0–14 years). Another study by the International Incidence of Childhood Cancer reported an incidence of 135·0 cases per million for children and adolescents aged 0–19 years, but it included only six high-quality registries from 1990 to 2013, all of which were concentrated in more high-income cities, and did not reflect regional variation in China. Some studies have suggested that the distributions in human resources for health were uneven and inequalities in health services could lead to large disparities in incidence rates of childhood cancer. To the best of our knowledge, no studies have reported the association between accessibility to health services and the incidence rates of childhood and adolescent cancers in China, and few studies have provided quantifiable evidence in low-income and middle-income countries.

Added value of this study

Based on the nationwide, largest, specialised, hospital-based childhood cancer surveillance system, we conducted a national cross-sectional study of incidence rates and access to health services among children and adolescents with cancer from different socioeconomic statuses in China using large-scale data from Jan 1, 2018, to Dec 31, 2020. Our findings indicate that the world standard age-standardised incidence rates of cancer were 126·48 (95% CI 125·45–127·

Burden of Disease Study 2019[7] results only used International Classification of Disease (ICD) categories to

established the NCPCS new incidence case database for 2018–20.

Procedures

We extracted information from the NCPCS case database on individuals aged 0–19 years with all cancers, non-malignant tumours, or dynamic undetermined or unknown tumours of the CNS and reproductive system. The standard set of variables included in this study were age, sex, province of diagnosis (the province where the patient was admitted to hospital), province of residence (the province where citizens lived continuously for more than 1 year as their main area of residence, except for official business, labour dispatch, medical treatment, etc), admission event data, and information on the cancer

reported if they were lower than 0·05 per million. We calculated the proportions of cross-regional patients per the total new cases of their region of residence in the NCPCS database. All analyses were done using SAS version 9.4 and R version 4.0.3. This study complies with the Guidelines for Accurate and Transparent Health Estimates Reporting recommendations (appendix p 18).[36]

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

We estimated the incidence of cancer among children (aged 0–14 years) and adolescents (aged 15–19 years) in China from Jan 1, 2018, to Dec 31, 2020. After quality control, 181 471 (98·52%) of 184

(36·71% from lowest to highest) in different HDI regions. Data for the overall incidence of cancer in adolescents also increased with increasing HDI levels (p<0·0001), but with greater fluctuations. The magnitude of the change was smaller in adolescent girls (31·05%) than in adolescent boys (37·09%; table 2).

The regional variations for specific cancer groups were non-monotonic (figure 2). Among children, a clear trend of increasing incidence rate with increasing HDI levels was observed for lymphomas, CNS tumours, neuroblastomas, retinoblastoma, malignant bone tumours, and soft tissue sarcomas.

The geographical density of all health services (Gini coefficients of 0·32–0·47) had higher inequalities than population density (Gini coefficients of 0·05–0·19; figure 3). The geographical density of all health services increased significantly with increasing HDI (p=0·012 for diagnoses and treatment institutions, p=0·0050 for paediatric beds, p=0·012 for paediatric oncologists, and p=0·0060 for pathology workforce), whereas only the population density of paediatric oncologists (p=0·049) and pathology workforce (p=0·0090) had a significant positive correlation with the level of HDI (table 3).

The overall incidence rates of childhood cancer and adolescent cancer showed an increasing trend with increasing geographical density of all health services and population density of the majority health services, except for paediatric beds (figure 4). However, the incidence rate of adolescent cancer sharply decreased in regions with the highest geographical and population densities of almost all health services (appendix pp 31–38).

The overall proportion of cross-regional patients among the new cases of childhood and adolescent cancers was 22·16%, and the highest proportions were seen in retinoblastoma (56·54%) and in low HDI regions (35·14%). A clear increasing trend of proportions of cross-regional patients was observed with decreasing HDI levels for 11 main cancer groups, despite some fluctuations among most groups, except for CNS tumours, renal tumours, hepatic tumours, and soft tissue sarcomas, which followed this pattern without fluctuations (figure 5).

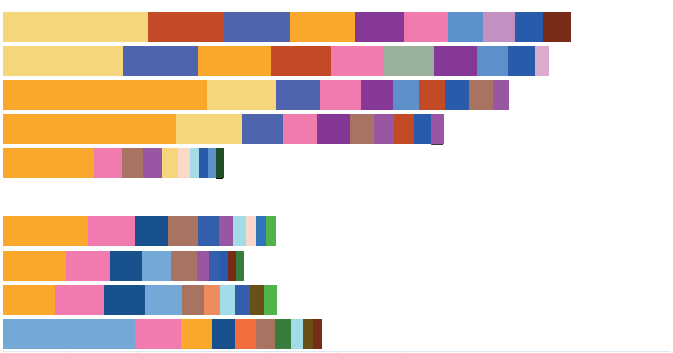

Figure 1: **Incidence rates of the top 10 most common childhood-specific and adolescent-specific cancers for each sex and age group in China, 2018–20.**
NK cell=natural killer cell.

Discussion

To our knowledge, this study is the first to use national, large-scale data from NCPCS and HQMS databases between 2018 and 2020, to provide comprehensive data on the most up-to-date cancer incidence among children and adolescents in China classified using the ICCC-3 system. We also revealed inequalities in cancer incidence and accessibility to relevant health services across socioeconomic regions of China. Our findings provide novel insight into the implications of socioeconomic inequality on the burden of childhood and adolescent cancers in the Chinese population.

Between 2018 and 2020, newly diagnosed cancer cases among children and adolescents in China were approximately 40 000 cases per year, which is similar to the Global Burden of Disease Study 2019 and GLOBOCAN 2020 estimates.[7,37] Our estimated world standard age-standardised incidence rate of childhood and adolescent cancer was similar to the rate reported by the IARC,[33] but much higher than the rate of Chinese National Central Cancer Registry.[5,6] The incidence rates of the main cancer groups were generally lower than those reported in North America, Europe, and Australia, especially among adolescents, but similar to those in Japan.[2,33,38] However, it is worth noting that as a common childhood solid tumour, hepatoblastoma showed a higher incidence rate in China than that reported in most other countries.[38–40] Based on our findings, it is necessary to conduct more research programmes focusing on factors associated with specific cancer types that are common among Chinese children and adolescents.

The IARC incidence reports used data from six high-quality registries of Chinese National Central Cancer Registry from 1990 to 2013,[33] and the overall cancer incidence in China was weighted towards those children and adolescents observed in these registries, which could not reflect regional variation. As the gold standard for providing information on cancer incidence, improving data quality and coverage is a necessary element in the role of population-based cancer registries in cancer control. However, it was inevitable that some childhood cancer cases in population-based cancer registries in China would be missed because of the large floating population, and the fact that the number of cases

among children and adolescents accounts for less than 1% of the total number of cases of cancer.[3,5] The establishment of the NCPCS marks the beginning of an independent childhood cancer registry in China, a milestone in the national plan for oncology and child health. As the largest, specialist, and only nationwide hospital-based childhood cancer surveillance system, the NCPCS covered nearly 70% of hospital admission records from Jan 1, 2017, to Dec 31, 2020, for childhood and adolescent cancer in December 2021. The NCPCS has not only taken into account all variables of the cancer case files of the IARC and the resident cancer case report cards of the Chinese National Central Cancer Registry, but also collected detailed diagnostic and treatment information. Based on the aforementioned details, it is clear that the NCPCS has an indispensable and complementary role in the application of population-based cancer registry data sources to assess the cancer burden in China. The NCPCS can also provide a basis for long-term follow-ups of treatment records and prognosis, to support the standardisation of age-applicable guidelines for cancer detection and treatment, and for the evaluation of future progress.

Consistent with global studies showing disparities in incidence rates across countries with different socioeconomic statuses,[33] we observed a significant positive association between incidence rates of childhood and adolescent cancers and regional socioeconomic status in China; and our results also provide strong evidence that health systems might have an important role in socioeconomic inequalities in cancer incidence. Previous studies have shown that the geographical distribution of general paediatric care services was highly skewed in China.[10,41] Paediatricians with higher education levels and those with well resourced tertiary hospitals are both clustered in well developed regions, which reflects a higher capacity for diagnosis and treatment. The international and intranational unequal distribution of health services for children is a global problem, especially in LMICs, where resources are even more scarce.[42,43]

In 2020, approximately 70% of inpatient medical care expense within the insurance scope was covered by health insurance in China, with the nationwide implementation of the cross-provincial medical insurance payment and settlement system further helping to break the limitations

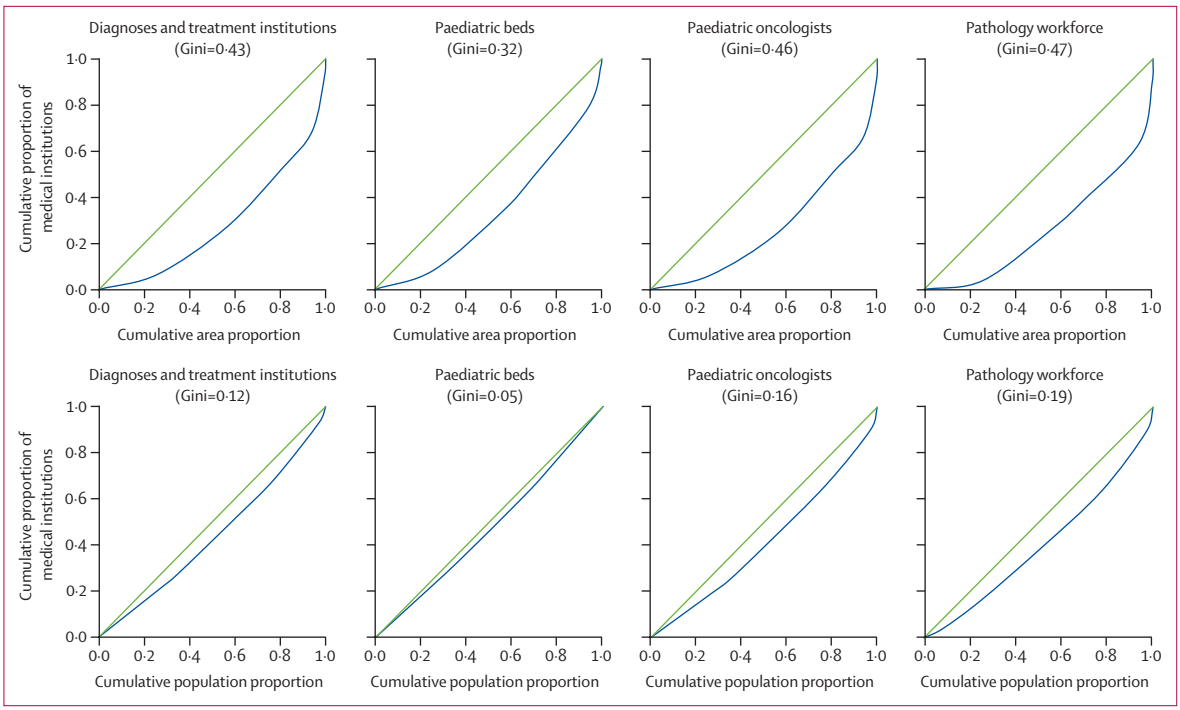

Figure 3: **Distributions of health service indicators adjusted for geographical area or for childhood and adolescent populations in six human development index regions in China, 2020**

The health service indicators included: the numbers of diagnoses and treatment institutions of paediatric cancer, the number of paediatric beds, the number of paediatric oncologists, and the number of pathology workforce.

	Diagnoses and treatment institutions of paediatric cancer		Paediatric beds		Paediatric oncologists		Pathology workforce	
	Geographical density	Population density	Geographical density	Population density	Geographical density	Population density	Geographical density	Population density
Very low HDI	0·04	$4·11 \times 10^{-3}$	11·848484					

of an unequal distribution of health services. According to our surveillance data, poorer socioeconomic regions had a higher proportion of cross-regional patients, especially for neuroblastomas and retinoblastoma, with proportions of nearly or more than 50%. However, because of increased non-medical expenses, a long time to receiving health services, and the inconvenience of children travelling long distances, health service accessibility inequality is still an obstacle of early diagnosis, which results in a lower reported cancer incidence rate in poor socioeconomic regions than in rich socioeconomic regions.

Of note, the highest sex ratio (boys to girls) was reported in regions with lower HDI levels, which suggested that cancer incidence among girls might be more sensitive to socioeconomic status. Globally, LMICs generally have higher sex ratios (in boys than girls) of cancer incidence among children and adolescents than in high-income

countries.[33] On the basis of the political commitment in the 2030 UN Agenda for Sustainable Development,[18]

cancer are a start to addressing the social and environmental determinants of health that put adolescents at risk, and ultimately affect the overall health of this population.[46]

Given the little understanding of causes of most childhood cancers and their high mortality without appropriate and timely diagnosis and treatment, strategies should focus on increasing the accessibility of health services for early diagnosis to reduce disease burden. A better understanding of the childhood and adolescent cancer burden at the national and regional level is the first step towards developing childhood cancer control plans. The COVID-19 pandemic is likely to further exacerbate previously existing socioeconomic inequalities faced by children and adolescents with cancer. In the post-pandemic period, there is an urgent need for policy makers to increase the allocation of resources, such as improving medical facilities and the paediatric oncology workforce in lower socioeconomic areas. In the process of promoting the hierarchical diagnosis and treatment system in China, the capacity-building of paediatric cancer health services should be one of the criteria for establishing regional centers for children's health and regional centers for cancer. The integration between primary health-care institutions maternal and child health-care hospitals and regional centres for children's health and national centres for children's health should also be strengthened, especially in regions with a lower geographical accessibility of health services. Internet Plus[47,48] medical services and artificial intelligence health care should be boosted as an effective measure to narrow regional gaps, giving patients at the grassroots level, especially those in remote areas, more access to quality health services. Health knowledge disseminations need to be carried out through school and community platforms to promote the recognition and awareness of common symptoms of childhood and adolescent cancer among parents and school doctors. Targeted early diagnosis programmes, such as popularising the early diagnosis of retinoblastoma through eye disease screening and visual acuity assessment among children aged 0–6 years nationwide, are also necessary.

Our study has several limitations. First, our estimates of incidence rates could be underestimated because of the following reasons. The estimation of cases relied on records from the HQMS database, which includes nearly all tertiary hospitals, but only some secondary hospitals.[21] However, based on our surveillance, less than 0·05% of new cases were diagnosed in non-tertiary hospitals. Additionally, there was a paucity of outpatient data in the

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Data sharing

Data sources of HDI, the population aged 0–19, and geographical area are listed by regions in the appendix (p 8). Data sources of health services are listed by regions in the appendix (p 9). References cited by data sources can be viewed. The National Center for Pediatric Cancer Surveillance (NCPCS) hospital admission record database and Hospital Quality Monitoring System hospital admission record database are listed in the appendix (pp 12–14). The NCPCS new incidence case database from this study, including deidentified individual participant data and all codes used for generating the results, will be made available upon publication to members of the scientific and medical community for non-commercial use only, upon email request to ncpcs@bch.com.cn. According to the Personal Information Protection Law of China, individual participant data in our study will not be made available publicly.

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