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Review Article

Pediatric Central Nervous System Cancers in the Democratic People's Republic of Korea

Abstract

Purpose: Central nervous system (CNS) cancers rank as the most frequent solid tumors and the leading cause of cancer-related deaths in children and adolescents. There is less information available about pediatric brain and CNS tumors in low-income and middle-income countries, suggesting a lack of surgical accessibility or limited capacity to treat these conditions. In this study, we chose to study the epidemiology of CNS cancers in the Democratic People's Republic of Korea (DPRK). **Methods:** We extracted the prevalence, incidence, deaths, and disability-adjusted life years (DALYs) associated with CNS cancers in individuals under the age of 20 from the 2017 Global Burden of Disease study from the Institute for Health Metrics and Evaluation. DALYs, which signify the number of healthy life years lost due to ill health, disability, or early death. Economic impact was calculated from DALYs. **Conclusions:** Given the large burden of brain and CNS cancers among all pediatric cancers in the DPRK, scaling up and strengthening surgical services for children is an essential component to improving care of pediatric CNS cancers in the DPRK. Childhood cancers are time sensitive, and early diagnosis and treatment are vital in ensuring improved survival for the vulnerable pediatric cancer patient population. As surgical treatment can often prolong lives and even prevent premature deaths from these cancers, further analysis of current surgical capacity can inform the path to meeting these critical pediatric surgical needs.

Keywords: *Central nervous system cancers, Democratic People's Republic of Korea, neurosurgery, pediatrics*

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Introduction

Over the past several decades, substantial improvements have been made in treatment outcomes for children with cancer who live in high-income countries (HICs).[1] Meanwhile, the same progress has not been translated to low-income and middle-income countries (LMICs), where outcomes remain poor and 90% of children at risk of developing childhood cancer live.[1] Childhood cancers can rapidly progress to fatality without timely diagnosis and treatment and in contrast to adult cancers, cannot be prevented by reducing risks in lifestyle, it is imperative that efforts to expand and improve access to and quality of health care includes cancer care for this vulnerable group.

With central nervous system (CNS) cancers ranking as the most frequent solid tumors and the leading cause of cancer-related deaths in children and adolescents, it is important to recognize that the incidence of this disease varies considerably among different regions.[2] Very little data about pediatric brain and CNS tumors in LMICs are available, suggesting a lack of accessibility or limited capacity to treat these conditions.[1] However, treatment of childhood cancer in LMICs has demonstrated to be cost-effective according to the World Health Organization's Choosing Interventions that are cost-effective criteria, and due to finite resources and competing health priorities, identifying and quantifying childhood cancer disease burden is critical in informing health policy decisions.[1]

In this study, we chose to study the epidemiology of CNS cancers in the Democratic People's Republic of Korea (DPRK).[3,4] As surgical treatment can often prolong lives and even prevent premature deaths from these cancers, further analysis of current surgical capacity can inform the path to meeting these critical pediatric surgical needs.

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Methods

We extracted the prevalence, incidence, deaths, and disability-adjusted life years (DALYs) associated with CNS cancers in individuals under the age of 20 from the 2017 Global Burden of Disease (GBD) study from the Institute for Health Metrics and Evaluation (IHME). DALYs which signify the number of healthy life years lost due to ill health, disability, or early death. Economic impact was calculated from DALYs using methods by Dalal and Park.[5]

Results

According to the IHME estimates, out of all solid cancers among pediatric population in the DPRK, CNS cancers such as brain and spinal cord tumors are responsible for the highest DALYs, prevalence, incidence, and number of deaths [Table 1]. In 2017, North Korea had 952 total cases of CNS cancer with 189 new cases arising during the year [Table 2]. They estimated 80 deaths associated with this disease. The IHME estimates that 6334 DALYs were lost due to brain and spine cancers in this population.

Figure 1: Dr. David Hong at Okryu Pediatric Hospital

Liver cancer is ranked as 2nd highest by DALYs, with 1471 health life years lost. Although low in incidence and prevalence, this cancer has a poor prognosis and high mortality rate. DPRK had estimated 588 cases of liver cancer with 24 cases, and 20 deaths associated with the disease. Next on the list is kidney cancer with estimated 730 health life years lost, 70 new cases, and 9 deaths.

To provide some context, we compared the DPRK's prevalence, incidence, DALYs and deaths associated with brain and nervous system cancer to the estimates from South Korea, Cuba, and Myanmar [Table 3]. The numbers were adjusted for population, signifying number per 100,000 people.

According to the IHME database, North Korea and South Korea had the similar rates of new cases of brain and nervous system cancer in 2017. During that same year, North Korea had a prevalence of 952 total cases (37 cases per million), and South Korea had a higher rate of 58 cases per million. The higher prevalence in the ROK may be due to longer survival of the children with CNS cancers given wider availability of chemotherapy and radiotherapy. However, the death rates and DALYs associated with the disease differ drastically. The IHME estimated three deaths (per million) and 249 healthy life years lost due to the disease in North Korea. The same disease is associated with one death (per million) and 95 years of healthy life lost in South Korea.

In 2017, Cuba had 55 cases of brain and nervous system cancer with eight new cases. Myanmar had the lowest prevalence and incidence of 21 and 6, respectively. However, the IHME database estimated Cuba and Myanmar to have the highest mortality rates and DALYs among the four countries. Four (per million) children died due to the disease, and 329 health life years were lost. The low prevalence may be related to the relative higher

Table 1: List of cancers in decreasing order of disability-adjusted life years, prevalence, incidence, and death in North Korea

Number	DALYs	Prevalence	Incidence	Deaths
1	Brain and nervous system cancer	Brain and nervous system cancer	Brain and nervous system cancer	Brain and nervous system cancer
2	Liver cancer	Kidney cancer	Kidney cancer	Liver cancer
3	Kidney cancer	Ovarian cancer	Liver cancer	Kidney cancer
4	Stomach cancer	Thryoid cancer	Ovarian cancer	Stomach cancer
5	Trachea, bronchus, and lung cancer	Nasopharynx cancer	Nasopharynx cancer	Colon and rectum cancer

DALYs - Disability-adjusted life years

Table 2: Disability-adjusted life years, incidence, prevalence and deaths of top three pediatric cancers in North Korea

	DALYs	Incidence	Prevalence	Deaths
Brain and nervous system cancer	6334	189	952	80
Kidney cancer	730	70	588	9
Liver cancer	1471	24	0	20

DALYs – Disability-Adjusted Life Years

Table 3: Disability-adjusted life years, incidence, prevalence, and deaths associated with brain and nervous system cancer in Democratic People's Republic of Korea, Republic of Korea, Cuba, and Myanmar in 2017

	DALYs	Incidence	Prevalence	Deaths
DPRK	6334 (2490)	189 (70)	952 (370)	80 (30)
ROK	4874 (950)	359 (70)	2984 (580)	60 (10)
Cuba	2206 (1950)	91 (80)	626 (550)	27 (20)
Myanmar	17546 (3290)	329 (60)	1137 (210)	221 (40)

Numbers in parentheses represent the population-adjusted rates (Rates per 100,000). DPRK Democratic People's Republic of Korea; DALYs Disability-adjusted life years

mortality rate, i.e., there are not that many survivors from these conditions.

The loss of GDP as the result of the DALYS from these conditions in North Korea is estimated to be about $4.3 million in 2017. This was calculated by multiplying the DALYs with the nation's GDP per capita of the year. The GDP per capita for 2017 was $685 according to the United Nations database.[6] The value represents what each person would have contributed to the economy had they survived the disease.

Discussion

Brain and spinal cord cancers are the most common solid tumors in children and the second most common childhood malignancy.[7] Treatment and prognosis depend on the type, location, and child's age and health. Despite brain cancers being one of the most common causes of death in children in LMICs, there is a clear paucity of surgical capacity to address the needs. According to Dewan *et al*., there are around 330 pediatric neurosurgeons caring for 1.2 billion children in low-income countries.[8] They also report that more than 85% of pediatric neurosurgeons around the world practice in high-and middle-income countries. To improve the delivery and outcomes of surgery in low-income countries, it is important to appreciate the existing gaps in pediatric surgical services.

The IHME database estimates suggest about a three-fold higher mortality rates associated with brain and nervous system cancer in North Korea, Cuba, and Myanmar when compared to a higher income country such as ROK. This may seem intuitive given that in LMICs, these cancers are generally found later in their course, and more difficult to treat due to advanced diseases. However, we must not discount the importance of surgical care in diagnosing and treating cancer in the LMICs where advanced diagnostics, chemotherapeutic drugs, and radiation therapy are virtually nonexistent. Given the importance in surgical care in these settings, it is particularly worrisome that <8% of the pediatric population in LMICs had access to surgical care in 2017.[9]

According to a study that looked at the global comparison of pediatric surgery workforce and training, the number of pediatric surgeons has a positive correlation with gross domestic product (GDP) in countries with a GDP per capita <US $20,000.[10] Another study notes that LMICs only have 19% of the global surgical workforce.[11] Lack of appropriate human resources for the surgical care of children in low-income countries prevents timely and adequate intervention, adding to the disease burden.

The DPRK uses an extensive network of over 9,000 health-care facilities that function at levels ranging from central, provincial, county, to rural.[12] For the 2016–2020 Medium Term Strategic Plan, it was proposed to improve specialized medical care by providing specialized medicine and equipment to advance diagnostic and treatment methods.

As classifying health facilities is valuable for allocating resources to different levels of the healthcare system, the Optimal Resources for Children's Surgical Care 2019 guidelines present a classification system for the delivery of pediatric surgical care.[13] As seen in Table 4, levels of children's surgical care (basic, intermediate, and complex/advanced) were suggested according to the variable complexity of children's surgical conditions. Cancers of every form, which often involve highly specialized care, were recommended to be treated at facilities offering complex/advanced levels of surgical care by the 2017 Disease Control Priorities Project (DCP3). As suggested by the Global Initiative for Children's Surgery, this treatment is advised to be performed at facilities of the referral level [Table 5].

In contrast to surgical care for emergency cases such as for traumatic injuries, in general, pediatric brain and spinal cord cancers do not present as medical or surgical emergencies. Neurological symptoms such as paralysis or worsening vision are easily recognized and drive families to seek medical care. In a country like DPRK, with a population of 25 million living in a relatively small geographically contained country, a single-center specializing in pediatric brain and spinal cord cancers may be sufficient as a starting point. It should be able to handle the 200 or so new cases expected each year.

The Okryu Pediatric Hospital was built in October of 2013 in Pyongyang to provide latest medical service for children. In this six-storied hospital, treatment rooms, operation rooms, and sick wards are furnished with some of the latest medical equipment. Although official number of pediatric surgeons in North Korea is not available, one of our authors (DSH) has worked alongside pediatric neurosurgeons at the Okryu Pediatric Hospital over the last several years [Figure 1]. He estimates 1 pediatric neurosurgeon at Okryu Hospital with 5 more in various stages of training. Although tasked with providing the most complex level of pediatric care for the nation, this hospital

Table 4: Levels of care based on surgical conditions, recommended care level availability by facility type, and examples of care at each level from the 2018 guidelines for different levels of care by the Global initiative for children's surgery

Level of care	Definition	Examples of care
I: Basic	Recognizing and treating minor surgical conditions without requiring a general aesthetic. Referring more complex surgical conditions and patients with more serious comorbidities to higher levels of care Considered essential to every type of healthcare facility	Injuries: Resuscitation with basic life support, suturing and dressing simple wounds Congenital anomalies: Screening Infections: Screening, treating superficial abscess with incision and drainage Tumors: Screening
II. Intermediate	Recognizing and treating common emergencies and essential childhood surgical conditions. May or may not require a general aesthetic. Referring more complex surgical conditions and patients with more serious comorbidities to higher levels of care Considered essential to every hospital	Injuries: Resuscitation with advanced life support measures, closed and open fractures, trauma laparotomy, diagnosis and stabilization of neurological trauma Congenital anomalies: Incision and draining of abscesses, inguinal hernia repair in older children Infections: Thoracostomy tube for empyema, drainage and debridement of osteomyelitis Tumors: Excision of benign tumors
III. Complex/ advanced	Treating complex children's surgical conditions. Care is highly specialized and multidisciplinary Recommended to be present at second-level hospitals depending on available resources and geography; desirable at third-level hospitals and essential at national children's hospitals	Injuries: All traumatic injuries referred from lower levels of care, neurovascular injuries included Congenital anomalies: All congenital anomalies referred from lower levels of care Infections: All surgical infections referred from lower levels of care Tumors: All benign and malignant tumors

Table 5: Description and examples of different healthcare facilities in low-income and middle-income countries based on the classification system used in 2017 disease control priorities project and the 2018 guidelines for different levels of care by the global initiative for children's surgery

Level of care	Facility classification DCP3 (2017)	Description	Examples
Basic	Health center	Healthcare facility usually located in a rural community Provides basic and general healthcare services	Community health center Primary health center Comprehensive health center
Intermediate	First-level hospital	Provides general services that are not specialized General anesthesia is available	General hospital District hospital Cottage hospital
Complex/ Advanced	Referral hospital		
	Second-level hospital	Provides clinical services specialized by function but with limited technical equipment	Regional hospital Provincial hospital General mission hospital
	Third-level hospital	Provides highly specialized services with similarly specialized staff and technical equipment Highly differentiated clinical services	Academic/teaching/university hospital National hospital Central hospital Niche/specialized mission hospital
	National children's hospital	Provides highly specialized services with similarly specialized staff and technical equipment dedicated to pediatric care Highly differentiated clinical services in all areas of children's specialties Care is available for complex multidisciplinary and chronic conditions	Children's hospital

DCP3 Disease control priorities project

experiences the typical challenges found in similar hospitals in LMICs: routine reusing of surgical supplies, limited imaging capabilities, inconsistent emergency transport, and variable availability of critical medications, among others.

As the capacity (both technical and volume) for the care of pediatric brain and spinal cord cancers are strengthened at the Okryu Pediatric Hospital, then the Hospital will likely serve as the primary training center for additional pediatric neurosurgeons who can staff the provincial hospitals to manage simpler cases. Ultimately, only the most complex and difficult cases should be referred to the national hospital.

Our study is timely. The DPRK is planning to strengthen the surgical care capacity nationally per their 2016–2021 MTSP for the Health Sector. The WHO is partnering with the DPRK Ministry of Public Health to support surgical system strengthening in the DPRK. A key project specifically targets improving pediatric surgical care, and our study may help in better understanding the surgical needs for pediatric cancers.

Conclusions

Given the large burden of brain and CNS cancers among all pediatric cancers in the DPRK, scaling up and strengthening surgical services for children is an essential component to improving care of pediatric CNS cancers in the DPRK. Childhood cancers are time sensitive, and early diagnosis and treatment are vital in ensuring improved survival for the vulnerable pediatric cancer patient population. Fortunately, the need is being prioritized by the DPRK and there are external partners with shared interests. The current MoPH project with the support of the WHO country office should serve as a pilot project with an intent to strengthen surgical care nationally. We hope the international community will step up and help fund this important initiative.

Limitations

As primary data were unavailable, the data used for this study were estimates from the GBDs, injuries, and risk factors (GBD) studies coordinated by the IHME. While there is criticism of the lack of transparency in the methods and complex statistical methods used to calculate the data, no better credible dataset for the DPRK exists.

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Conflicts of interest

There are no conflicts of interest.

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