RESEARCH ARTICLE

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Relative Survival Rates of Pediatric Patients with Solid Tumours in Khon Kaen, Thailand

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Abstract

Background: Pediatric solid tumours constitute a subgroup of childhood cancers that continue to pose a significant global health challenge due to limitations in diagnostic techniques and treatment options. This study aimed to explore the relative survival rates of patients with childhood cancer over two decades using population-based data from a cancer registry. **Methods:** This population-based study included pediatric patients with cancer in Khon Kaen, Thailand, and focused on children under 15 years of age who were diagnosed with solid tumours from January 1st, 2000, through December 31st, 2019. A total of 371 childhood solid tumours were diagnosed in Khon Kaen during the study period, with follow-up through 2021. Survival analysis was conducted via relative survival rate (RSR) estimates. **Results:** The most common solid tumours were CNS and miscellaneous intracranial and intraspinal neoplasms (27.7%). The overall 5-year RSR for pediatric patients with solid tumours was 0.57 (95% CI: 0.52–0.62). Compared with male patients, female patients had higher 5-year RSRs (0.62, 95% CI: 0.53–0.68 versus 0.53, 95% CI: 0.46–0.60). Survival improved over time, with patients diagnosed between 2010 and 2019 having better 5-year RSRs than those diagnosed from 2000 to 2009 did (0.59, 95% CI: 0.52–0.66 and 0.55, 95% CI: 0.47–0.62, respectively). **Conclusions:** In conclusion, better outcomes were observed among females, patients living closer to health care facilities and those diagnosed in the more recent decade (2010–2019).

Keywords: Relative survival, Childhood cancers, Population-based

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Introduction

Childhood cancer is a significant health concern, and advances in diagnosis and treatment techniques are complicated. Cancer affects over 275,000 children and teens (0–19 years), causing more than 105,000 deaths in 2022 worldwide. The true incidence is likely higher due to diagnostic challenges in numerous countries [1]. Pediatric malignancies, such as central nervous system (CNS) cancers, neuroblastoma, retinoblastoma, hepatoblastoma, and soft tissue sarcomas, constitute approximately 30% of all childhood cancers globally [2]. While overall survival rates for childhood cancers have improved dramatically in high-income countries (HICs), reaching approximately 80% over the past several decades, significant disparities persist in resource-constrained settings, where survival rates can reach as low as 30% in low- and middle-income countries (LMICs) [3]. In response, the World Health Organization (WHO) launched a global initiative aiming to increase childhood cancer survival rates to at least 60% by 2030. This initiative underscores the need to strengthen surveillance systems, health care infrastructure, and research focused on treatment outcomes [4].

Childhood cancer in Asia presents challenges with variations in incidence, mortality, and survival rates among various countries. The region contributes nearly 60% of the worldwide childhood cancer burden, with an estimated 200,000 new cases per year [5]. Thailand is an upper-middle-income country in Southeast Asia whose age-standardized incidence rate for all childhood cancers is 74.9 per million children [6]. The overall 5-year survival rate of childhood cancer patients in Thailand between 2005 and 2012 ranges from 45-70% [7]. A study that analysed data from 2006 to 2008 reported overall survival childhood cancer was 67.2%, demonstrated improving survival trends for most childhood cancers in Thailand [8].

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However, outcomes for solid tumours remain suboptimal compared with those for haematologic malignancies. These poorer outcomes may be attributed to diagnostic challenges, biological heterogeneity, and barriers to accessing the multimodal treatments typically required for solid tumours [9]. The National Cancer Institute of Thailand has identified childhood cancer as a priority area, implementing policies to improve early detection, referral systems, and access to specialized treatment centres throughout the country [10].

The Khon Kaen population-based cancer registry is located in Khon Kaen Province, the northeastern region of Thailand. The cancer registry covers hospitals that treat cancer patients in the province, which serves as a significant health care hub for pediatric oncology in the region. The cancer registry is served primarily by Srinagarind Hospital, a tertiary care university hospital affiliated with Khon Kaen University, which houses specialized pediatric oncology services for the northeastern region [11, 12]. Previous studies conducted in Khon Kaen have primarily focused on adult cancers and have reported suboptimal survival outcomes, likely reflecting challenges such as late-stage diagnosis and limited access to specialised oncology care [13-15]. These findings provide important context regarding the local cancer care setting. However, data on survival outcomes among pediatric patients with solid tumours in this setting remain limited. Prior study has revealed regional differences in childhood cancer survival within Thailand. The study on childhood solid tumours in Thailand exist, and comprehensive long-term survival data are limited. Earlier reports on solid tumours indicated most common 5-year survival rates of approximately 71.1% for renal tumours, 64.5% for gonadal and germ cell neoplasms, and 61.1% for malignant epithelial neoplasms during the 1990-2011 period [16]. The Khon Kaen Cancer Registry started in 1988 and has encouraged researchers to study the cancer situation over 20 years, helping to understand changes over time and what affects childhood cancer outcomes in this area.

Despite prior studies, there are currently no thorough studies on pediatric solid tumour survival in this area covering the period between 2000 and 2019. This indicates a significant gap in the literature that needs to be addressed to understand the effectiveness of treatment protocols and identify factors affecting survival outcomes in this specific region. This study aimed to fill this gap by exploring the relative survival rates of patients with childhood cancer over two decades via population-based data from a cancer registry. This study provides valuable insights and information for health care planning and resource allocation and, furthermore, results in targeted interventions to improve childhood cancer outcomes in the northeastern region of Thailand.

Materials and Methods

The Khon Kaen cancer registry is a population-based system that includes all 26 districts within Khon Kaen Province, Thailand. For childhood cancer surveillance, the data were collected from multiple health care facilities, including 23 community hospitals, 3 private medical centres, Khon Kaen Hospital, and Srinagarind Hospital. All collected data were examined by the Khon Kaen Cancer Unit. The data quality evaluation followed the four components established by Thailand's National Cancer Institute: comparability, completeness, validity, and timeliness. The quality metrics revealed that only 4% of the cases were identified through death certificates (DCOs), whereas 90% had morphological verification (MV), with both numbers falling within the satisfactory range. Recent trends indicate that data quality is improving, with more cases being verified through morphological verification (MV) and fewer being identified through death certificates (DCOs) and clinical-based diagnoses.

Study population

This research focused on pediatric cases in Khon Kaen, Thailand, in children who were younger than 15 years and who received a diagnosis of tumour cancer during the twenty-year period from January 1st, 2000, through December 31st, 2019. Cases were excluded if they had hematologic malignancies, such as leukaemia and lymphoma. The tumours were identified via International Classification of Diseases for Oncology (ICD-O-3) coding standards included 1) CNS and miscellaneous intracranial and intraspinal neoplasms; 2) neuroblastoma and other peripheral nervous cell tumours; 3) retinoblastoma; 4) renal tumours; 5) hepatic tumours; 6) malignant bone tumours; 7) soft tissue and other extraosseous sarcomas; 8) germ cell tumours, trophoblastic tumours, and neoplasms of the gonads; 9) other malignant epithelial neoplasms and malignant melanomas; and 10) other and unspecified malignant neoplasms (Figure 1).

Data collection

All data for this study were obtained from the Khon Kaen population-based cancer registry system and were accessed for research purposes on July 1, 2023. Patients with pediatric cancer diagnosed before the age of 15 years were classified using ICD-O-3 coding standards. These cases were subsequently classified according to the International Classification of Childhood Cancer (ICCC-3, third edition) categories, with a focus on the ten most common types of pediatric solid tumours. The data collected included age at cancer diagnosis, sex, year of diagnosis, current status, and residential distance from the treatment centre. Patient enrollment started from January 1st, 2000, through December 31st, 2019, with follow-up continuing until December 31st, 2021. Patients were followed from the date of their cancer diagnosis

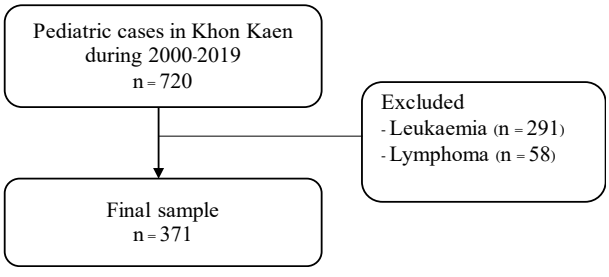

Figure 1. Flow Diagram of Sample Selection

until December 31, 2021, for event (death) assessment and "Censored" in this study refers to alive or lost follow-up. The authors had access to information that could potentially identify individual participants during data collection; however, all data were de-identified prior to analysis to ensure confidentiality and protect participant privacy.

Statistical analysis

The demographic data are reported as frequencies and percentages for categorical data and means with standard deviations (SDs) for continuous data.

Survival analysis was conducted via relative survival rate (RSR) estimates. RSRs were calculated on the basis of mortality and life tables obtained from the National Statistics Office in Thailand for the period from January 1st, 2000, through December 31st, 2019. RSR results were calculated via the Pohar Perme method and reported at 1-, 3-, 5-, and 10-year intervals. Survival functions were estimated via the Kaplan–Meier method. All the statistical computations and data management were completed via Stata statistical software version 15 [17].

Age was categorized into 0-4, 5-9, and 10-14 years to reflect differences in cancer incidence and biological characteristics across developmental stages, which may influence survival outcomes. In addition, this categorization is consistent with age groupings commonly used in national reporting systems by the Ministry of Public Health and in previous population-based pediatric oncology studies, allowing for comparability with existing literature [18]. Distance grouping is based on geographical location and distance. Khon Kaen province has a radius from the city center to the outer districts of approximately 80 km, so the distances are grouped into short & intermediate distance (0 to 79.9 km) versus long distance (≥ 80 km).

Ethics approval and consent to participate

This study was approved by the Khon Kaen University Ethics Committee for Human Research on the basis of the Declaration of Helsinki and the International Conference on Harmonization Good Clinical Practice Guidelines (HE661255). Informed consent was waived by the Khon Kaen University Ethics Committee for Human Research because this is a secondary analysis of population-level data from the Khon Kaen cancer registry and lacks personally identifiable data.

Results

Patient characteristics

This study enrolled 371 childhood solid tumour patients who were diagnosed in Khon Kaen, Thailand, between 2000 and 2019. The distributions of males (49.3%) and females (50.7%) were nearly equal. The highest proportion of patients were in the 0–4 years age group (42.0%), followed by the 10–14 years age group (34.5%) and the 5–9 years age group (23.5%) (Table 1).

Most of the patients (68.2%) resided at short and intermediate distances from health care facilities, whereas 31.8% lived at long distances. Disease stage data were available for 124 patients (33.4%) after excluding missing and unknown cases, and 69.4% of these patients were diagnosed with advanced-stage disease (stages 3-4), whereas 30.6% had early-stage disease (stages 1–2). The study population was equally distributed across the two decades of the study period: 49.1% from 2000–2009 and 50.9% from 2010–2019.

The most common solid tumour types were CNS and miscellaneous intracranial and intraspinal neoplasms (27.7%), followed by germ cell tumours, trophoblastic tumours, and neoplasms of the gonads (13.5%), and neuroblastoma and other peripheral nervous cell tumours (10.5%). Other malignant epithelial neoplasms and malignant melanomas accounted for 9.4% of the cases,

Table 1. Demographic Data of Pediatric Patients with Solid Tumours (N=371)

Variables	Number	%
Sex		
Male	183	49.3
Female	188	50.7
Age		
0-4 Years	156	42.0
5-9 Years	87	23.5
10-14 Years	128	34.7
Mean (SD)	6.56 (4.85)	
Median (MIN: MAX)	6 (0: 14)	
Distance from treatment centre		
Short & Intermediate distance (0 to 79.9 KM)	253	68.2
Long distance (≥ 80 KM)	118	31.8
Stage of disease (n=124)		
Early stage (stage I-II)	38	30.6
Advance stage (stage III-IV)	86	69.4
Period of diagnosis		
2000-2009	182	49.1
2010-2019	189	50.9
Tumour type		
III. CNS and miscellaneous intracranial and intraspinal neoplasms	103	27.7
IV. Neuroblastoma and other peripheral nervous cell tumours	39	10.5
V. Retinoblastoma	31	8.4
VI. Renal tumours	21	5.7
VII. Hepatic tumours	21	5.7
VIII. Malignant bone tumours	26	7
IX. Soft tissue and other extraosseous sarcomas	29	7.8
X. Germ cell tumours, trophoblastic tumours, and neoplasms of gonads	50	13.5
XI. Other malignant epithelial neoplasms and malignant melanomas	35	9.4
XII. Other and unspecified malignant neoplasms	16	4.3

Abbreviations: CNS Central nervous system, KM Kilometre, MIN Minimum, MAX Maximum, SD Standard deviation

whereas retinoblastoma represented 8.4%.

Relative survival rates

The overall relative survival rates at 1, 3, 5, and 10 years were 0.76 (95% CI: 0.72–0.81), 0.62 (95% CI: 0.57–0.67), 0.57 (95% CI: 0.52–0.62), and 0.56 (95% CI: 0.51–0.61), respectively (Table 2 and Figure 2).

Among the age groups, the 10–14 years age group had the highest 1-year relative survival rate (0.80, 95% CI: 0.72–0.86), followed by the 0–4 years age group (0.76, 95% CI: 0.68–0.82) and the 5–9 years age group (0.73, 95% CI: 0.62–0.81). The 5- and 10-year follow-up data revealed that the 0–4-year and 10–14-year groups had similar relative survival rates, whereas the 5–9-year age group had lower relative survival rates (Figure 3).

Compared with male patients, female patients presented better relative survival rates across all follow-up periods. The 5-year relative survival rate of female patients was 0.62 (95% CI: 0.53–0.68), and that of male patients was 0.53 (95% CI: 0.46–0.60) (Figure S1).

Patients residing at short and intermediate distances from health care facilities reported higher relative survival rates than did those living at greater distances. At 5 years, the relative survival rate for the short- and intermediate-distance groups was 0.61 (95% CI: 0.55–0.68), whereas the long-distance group had a relative survival rate of 0.49 (95% CI: 0.40–0.58). Disease stage was significantly associated with relative survival rates. Patients with early-stage disease had a 5-year relative survival rate of 0.81 (95% CI: 0.66–0.90), which was higher than that of patients with advanced-stage disease, who had a 5-year relative survival rate of 0.46 (95% CI: 0.36–0.55) (Figure S2).

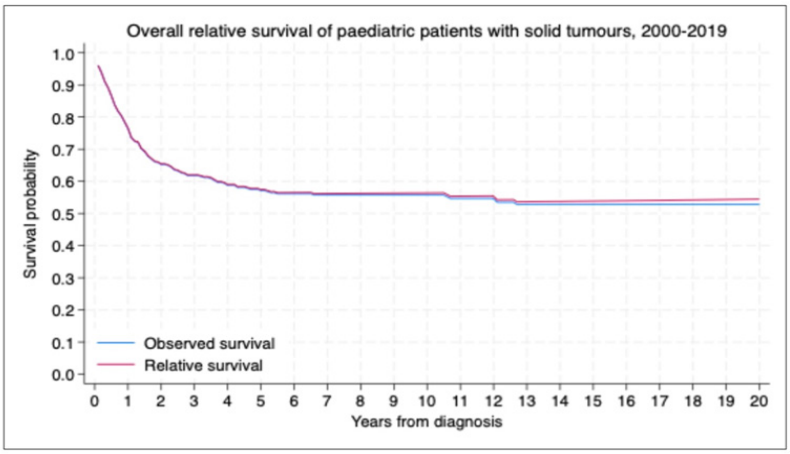

Figure 2. Overall Relative Survival and Observed Survival of Pediatric Patients with Solid Tumours

Table 2. Relative Survival Rates of Pediatric Patients with Solid Tumours

Factors	Relative survival rates			
	1 year	3 years	5 years	10 years
	RSRs (95% CI)	RSRs (95% CI)	RSRs (95% CI)	RSRs (95% CI)
Overall	0.76 (0.72-0.81)	0.62 (0.57-0.67)	0.57 (0.52-0.62)	0.56 (0.51-0.61)
Sex				
Male	0.75 (0.68-0.80)	0.59 (0.52-0.66)	0.53 (0.46-0.60)	0.52 (0.44-0.59)
Female	0.78 (0.72-0.84)	0.65 (0.57-0.71)	0.62 (0.53-0.68)	0.61 (0.53-0.68)
Age				
0-4 Years	0.76 (0.68-0.82)	0.63 (0.55-0.71)	0.58 (0.50-0.66)	0.59 (0.50-0.66)
5-9 Years	0.73 (0.62-0.81)	0.55 (0.43-0.65)	0.52 (0.41-0.62)	0.49 (0.38-0.60)
10-14 Years	0.80 (0.72-0.86)	0.65 (0.56-0.73)	0.60 (0.50-0.68)	0.58 (0.48-0.66)
Distance				
Short & Intermediate distance (0 to 79.9 KM)	0.80 (0.74-0.85)	0.66 (0.60-0.72)	0.61 (0.55-0.68)	0.60 (0.54-0.66)
Long distance (≥ 80 KM)	0.69 (0.60-0.77)	0.54 (0.44-0.62)	0.49 (0.40-0.58)	0.48 (0.39-0.57)
Stage of disease (n=124)				
Early stage (stage I-II)	0.95 (0.83-0.99)	0.88 (0.74-0.95)	0.81 (0.66-0.90)	0.81 (0.66-0.90)
Advance stage (stage III-IV)	0.72 (0.63-0.79)	0.51 (0.42-0.60)	0.46 (0.36-0.55)	0.44 (0.34-0.53)
Period				
2000-2009	0.73 (0.66-0.79)	0.59 (0.51-0.66)	0.55 (0.47-0.62)	0.53 (0.45-0.60)
2010-2019	0.79 (0.73-0.84)	0.65 (0.57-0.71)	0.59 (0.52-0.66)	0.59 (0.51-0.66)

Abbreviations: CI, confidence intervals; RSRs, relative survival rates, KM Kilometre

Table 3. Relative Survival Rates of Pediatric Patients with Different Solid Tumour Subtypes from 2000 to 2019 (n=371)

ICCC group	Relative survival rates		
	1 year	3 years	5 years
	RSRs (95% CI)	RSRs (95% CI)	RSRs (95% CI)
III. CNS and miscellaneous intracranial and intraspinal neoplasms	0.64 (0.54-0.73)	0.48 (0.38-0.57)	0.44 (0.34-0.54)
IV. Neuroblastoma and other peripheral nervous cell tumours	0.61 (0.45-0.74)	0.37 (0.23-0.52)	0.29 (0.16-0.44)
V. Retinoblastoma	0.87 (0.69-0.95)	0.74 (0.54-0.86)	0.67 (0.47-0.81)
VI. Renal tumours	0.95 (0.69-0.99)	0.85 (0.61-0.95)	0.80 (0.54-0.92)
VII. Hepatic tumours	0.58 (0.35-0.75)	0.48 (0.26-0.67)	0.48 (0.26-0.67)
VIII. Malignant bone tumours	0.85 (0.64-0.94)	0.46 (0.27-0.63)	0.28 (0.13-0.47)
IX. Soft tissue and other extraosseous sarcomas	0.62 (0.42-0.76)	0.50 (0.31-0.67)	0.47 (0.28-0.63)
X. Germ cell tumours, trophoblastic tumours, and neoplasms of gonads	0.90 (0.78-0.96)	0.84 (0.71-0.92)	0.84 (0.71-0.92)
XI. Other malignant epithelial neoplasms and malignant melanomas	1.00[a]	0.91 (0.74-0.97)	0.88 (0.70-0.95)
XII. Other and unspecified malignant neoplasms	0.93 (0.55-0.99)	0.93 (0.55-0.99)	0.93 (0.54-0.99)

Abbreviations: ICCC International Classification of Childhood Cancer, CI Confidence intervals; [a], The 95% CI cannot be estimated because the relative survival rate is 1.00 (100%)

When comparing treatment periods, patients who were treated from 2010-2019 presented improved relative survival rates compared with those treated from 2000-2009. The 1-year relative survival rate increased from 0.73 (95% CI: 0.66–0.79) to 0.79 (95% CI: 0.73–0.84), and the 5-year relative survival rate increased from 0.55 (95% CI: 0.47–0.62) to 0.59 (95% CI: 0.52–0.66) (Figure S3).

The relative survival rates of patients with different pediatric solid tumour subtypes are shown in Table 3. Soft tissue tumours, germ cell tumours, malignant epithelial neoplasms, and other or unspecified malignant neoplasms were associated with favourable prognoses, whereas patients with neuroblastoma had the poorest outcomes.

Discussion

The overall 5-year relative survival rate of pediatric patients with solid tumours from 2000–2019 was 0.57 (57%). This finding is greater than that of a study conducted in Thailand from 1990-2011, which reported that the relative survival rate of patients with childhood cancer aged 0–19 years was 34.1% [16]. This finding demonstrates that childhood cancer treatment has become more effective, resulting in a markedly improved 5-year relative survival rate for patients. Furthermore, this finding is comparable to the survival rate of patients with pediatric cancer in the Netherlands from 2010–2015, which was 59.6% [19], and similar to findings from Korea (2007-2011), which relative survival rates was 59.0% [20]. However, the results of this study are still lower than the survival rate of patients with pediatric cancer in Switzerland from 2004–2013, which was 74.3% [21].

This study revealed that female patients had better relative survival rates than male patients across all follow-up periods. The 5-year relative survival rates of females was higher than that of males. This finding is consistent with that of Bidwell et al., who studied childhood cancer survival rates in Thailand between 1990 and 2011 and reported that females had a 5-year survival rate of 35.9%, which was higher than the 32.4% rate for males [16]. The relative survival rates of female patients with adrenal gland cancer was 29.3%, whereas that of male patients was only 9.0%. Additionally, the findings align with Bidwell et al. results for epithelial and skin cancers, where females had significantly higher survival rates than males did (75.6% versus 40.8%). Similarly, in germ cell tumours, females

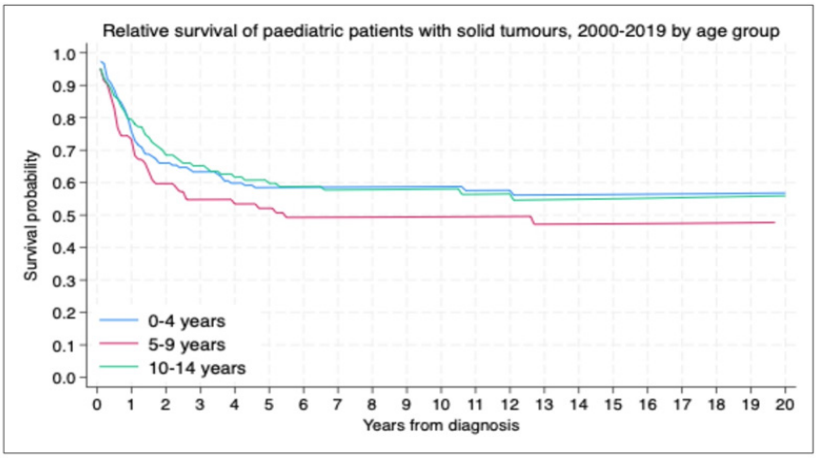

Figure 3. Relative Survival of Pediatric Patients with Solid Tumours by Age Group

demonstrated better survival rates (70.8%) than males did (48.0%) [16]. The sex differences in relative survival rates may be attributed to various factors. Schindler et al. reported that in Switzerland, females had a lower mortality risk (hazard ratio) than males across all cancer groups did, although some differences were not statistically significant [21]. Furthermore, previous studies have found that different genders have a different effect on survival rates [22, 23]. Staging information However, further studies are needed to understand the exact mechanisms behind these sex disparities.

This study revealed that among the different age groups, children aged 10–14 years presented the highest relative survival rates at 1, 3, and 5 years following diagnosis. This finding is notable when the age-related patterns of childhood cancer survival are considered. The age-specific survival trend is partially consistent with findings from Bidwell et al., who reported varying survival rates across different age groups in Thailand from 1990–2011 [16]. Several biological and treatment-related factors may contribute to improved survival in older children. Schindler et al. [21] demonstrated in their Swiss study that age was a significant predictor of survival outcomes ($p<0.001$) across several cancer types. Additionally, older children might present with different subtypes of cancers that have inherently better prognoses. Improved treatment adherence and better communication of symptoms in this age group may also facilitate earlier diagnosis and more effective management of treatment-related complications. In contrast, children aged 5–9 years had the lowest relative survival rates. This may be explained by the distribution of cancer types within this age group. A greater proportion of CNS neoplasms and neuroblastomas both associated with poorer prognoses were observed among 5–9 year olds (S1 Table). In comparison, the 10–14 years age group had a greater frequency of germ cell tumours and malignant epithelial neoplasms, which are generally associated with more favourable outcomes. According to Pinsuwan et al. [18], germ cell tumours are associated with excellent 5-year survival rates 0.84 (84%) compared with CNS neoplasms 0.44 (44%). Additionally, the 5–9 years age group had the highest proportion of patients diagnosed at advanced stages of disease (S2 Table), which likely contributed to the poorer survival outcomes observed in this group. Patients residing at short and intermediate distances from health care facilities presented higher relative survival rates than did those living at greater distances. These distance-related survival disparities may be attributed to several factors. Patients living farther from tertiary care facilities are more likely to reside in the rural areas and may have limited financial resources, reduced access to transportation, and fewer local healthcare services or treatment capacity. Beyond geographic barriers, the financial burden of travel, accommodation, and loss of income may contribute to treatment delays, interruptions, or abandonment. In addition, longer distances may be associated with delays in referral pathways, which can further impact timely diagnosis and initiation of treatment. Together, these factors may partially explain the observed survival disparities. Massarweh et al. demonstrated that longer travel distances to health care facilities were associated with more advanced disease at diagnosis, potentially explaining some of the survival differences observed in our study [24]. This finding aligns with the results reported by Schindler et al., who examined survival predictors in Swiss childhood cancer patients. They reported that, compared with living in urban areas, living in rural areas was associated with lower survival rates for several cancer types [21]. These findings underscore the need for policies to reduce disparities in access to care, including strengthening referral systems and expanding standard and advanced cancer care services to regional and rural centers, in order to reduce inequities in treatment outcomes.

Disease stage was significantly associated with relative survival rates. Patients with early-stage disease have a higher 5-year relative survival rate than patients with advanced-stage disease. The marked survival difference between early-stage disease and advanced-stage disease can be attributed to several factors. Advanced-stage cancers often present with metastatic spread, which complicates treatment approaches and necessitates more intensive, multimodal therapy. These cancers may also demonstrate more aggressive biological behaviour and treatment resistance. Additionally, the increased tumour burden in advanced disease can lead to greater organ dysfunction and treatment-related toxicity, further compromising survival outcomes. This stage-dependent survival pattern is consistent with findings from multiple studies examining childhood cancer survival predictors. Schindler et al. reported that disease stage was a highly significant predictor of survival across multiple childhood cancer types in Switzerland [21]. Moreover, a cohort study of cancer patients in Khon Kaen, Thailand, showed that patients in the distant stage had twice the chance of death compared to those with localized disease [14]. However, staging information in this study was available only for a subset of patients, which may introduce selection bias, as patients with documented staging could differ systematically from those without staging data. Therefore, the association between disease stage and survival outcomes should be interpreted with caution. Despite this limitation, these findings highlight the importance of accurate disease staging for risk stratification and treatment planning, and underscore the potential value of early detection strategies, including screening and educational programs for healthcare providers, to improve survival outcomes.

When the treatment periods were compared, patients treated from 2010–2019 presented improved relative survival rates compared with those treated from 2000–2009. The improved relative survival rates in the more recent treatment period can be attributed to several factors. Advancements in treatment protocols, including more effective chemotherapeutic regimens, precision in radiation therapy, and enhanced surgical techniques, have likely contributed significantly to better outcomes. In 2006, the National Health Security Office (NHSO) of Thailand launched a nationwide disease management program for childhood leukaemia and lymphoma, which was later expanded to include protocols for childhood

solid tumours. These standardized protocols have been implemented nationwide since 2016, leading to substantial improvements in access to healthcare facilities ties and advanced treatments for pediatric cancer patients [6, 25]. This positive trend is consistent with findings from several international studies that have documented improvements in childhood cancer survival over time. Schulpen et al. reported significant improvements in survival for Dutch children with cancer, with hazard ratios showing reduced mortality in 2010-2015 compared with 1990–1999 across multiple cancer types [19]. The trend becomes even more evident compared with earlier studies conducted in Khon Kaen, Thailand, where the 5-year survival rate was 46.7% from 2000–2012 and 44.0% from 1985–2009 [26, 27]. This comparison clearly illustrates the progressive improvement in childhood cancer outcomes in the region over successive time periods.

A key strength of this study is the use of data from the Khon Kaen Cancer Registry, established in 1984 and quality-assured by the National Cancer Institute of Thailand for completeness, validity, comparability, and timeliness. The death certificate only (DCO) and morphological verification (MV) rates of the registry fall within acceptable standards.

However, several limitations should be noted. Previous studies rarely used relative survival rates, so in this discussion, we used the results of observed survival (survival rates) to discuss the findings. Data on childhood cancer remain limited, particularly from earlier years preceding the registry's establishment. Important prognostic factors such as sociodemographic and environmental influences were not available. Although there is specific treatment data, it is still insufficient for use in this study. Additionally, staging information was missing in most cases, with only approximately 30% of records including this variable, potentially affecting outcome interpretation. To address these gaps and enhance childhood cancer outcomes, future research should explore the role of sociodemographic and other risk factors.

In conclusions, this study revealed a 5-year relative survival rate of 0.57 (57%) for childhood solid tumours in Khon Kaen, Thailand an improvement over previous national reports. Better outcomes were associated with female sex, older age (10–14 years), proximity to health care facilities, early-stage disease at diagnosis, and treatment during the more recent period (2010–2019). These findings align with international studies and highlight the progress made in childhood cancer management in Thailand over the past two decades. The significant impact of geographical distance to health care facilities and disease stage on survival underscores the importance of early detection initiatives and addressing health care access disparities. These results provide valuable insights for health care policy planning and resource allocation to continue improving childhood cancer outcomes in Thailand.

Limitation

In this study, solid tumours in pediatric patients were investigated however, it was challenging to classify the stage of disease, resulting in only partial staging being recorded and limited data available regarding the stage of disease.

Author Contribution Statement

SP, PS and KS conceptualized and designed the study. SP analysed the patient data and was a major contributor to the writing of the manuscript. PS managed the patient data and defined the statistics for analysis. CP and CS collected and generated a dataset from the Khon Kaen Cancer Registry. SP, KS, PS and PK interpreted the patient data regarding oncology. All the authors reviewed and approved the final manuscript.

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Data availability

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Competing interests

The authors declare that they have no competing interests.

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