Spatial distribution of pediatric cancer patients using Geographic Information System (GIS) across the Philippines

Myra D. Oruga*, Primo G. Garcia, Loyda A. Cajucom, Rita C. Ramos, Queenie R. Ridulme, Ronaldo De Jesus, Bryan Alcazar, Ma Joanna Vinas, Raymund K. Manago, Raya K. Fuentes

Faculty of Management and Development Studies, University of the Philippines Open University, Laguna, Philippines

Abstract

Background: Every year, many children around the world get cancer, and this is a severe health problem. The Philippines is one such country where childhood cancer is a leading cause of death. This study uses unique maps (Geographic Information Systems or GIS) to examine these young cancer patients' locations.
Purpose: By doing this, we hope to find areas with more cases and see if children in those areas have easy access to the medical care they need.
Methods: Methods involved primary and secondary data collection, including surveys and hospital records, with geospatial data analyzed using QGIS 3.4 Madeira. The study focuses on four Department of Health (DOH) tertiary hospitals: Philippine Children Medical Center (PCMC), Bicol Regional Training and Training Hospital (BRTTH), Southern Philippines Medical Center (SPMC), and Vicente Sotto Memorial Medical Center (VMMC) Participants from significant regions contributed to the study.
Results: Results indicate that cancer centers, notably the primary children's hospital, cater to patients from far-reaching areas, causing them to consult distant hospitals despite accessible alternatives. Nearly all (around 92.5%) patients seek care at specialized hospitals, even though only a small proportion (roughly 12.3%) live close to such facilities. Instead, 37.3% reported the closest health facility (within 10 kilometers) is a secondary government hospital, increasing the burden on patients with additional travel and non-medical costs.
Conclusion: The study concludes that pediatric cancer patients face challenges accessing healthcare facilities, necessitating alternative methods like telemedicine and mobile clinics. The findings underscore the need for improved healthcare infrastructure and human resources to address the burdens faced by these patients.

Keywords: cancer patients; geographic information system; GIS; pediatric cancer

Introduction

Prior research on pediatric cancer cases within the Philippines has primarily concentrated on treatment modalities. Notably absent is the application of Geographic Information Systems (GIS) to investigate spatial distribution and clustering patterns and facilitate epidemiological surveillance through case mapping. This project leverages data from the national ABC project or Care for Pediatric Cancer Patients. The project aims to tackle issues related to the geographic spread of the disease, monitor its patterns (epidemiology), and identify areas with higher concentrations of cases (cluster distribution). This project is a collaboration between the Department of Science and Technology and the University of the Philippines Open University (UPOU), the Philippine Council for Health Research and Development (DOST-PCHRD), with funding from the Department of Health (DOH), and four tertiary care hospitals in Luzon: Philippine Children Medical Center (PCMC) and Bicol Regional Training and Training Hospital (BRTTH) in Manila,

Jurnal Keperawatan Padjadjaran (JKP)

Volume 12(1), 57-64

http://dx.doi.org/10.24198/jkp.v12i1.2283

Article Info

Received : April 17, 2023
Revised : January 31, 2024
Accepted : February 13, 2024
Published : April 30, 2024

Corresponding author

Myra D. Oruga*
Faculty of Management And Development Studies, University of the Philippines Open University, Laguna, Philippines; UP Open University, Los Baños, Laguna, Philippines, 4031; Phone: +6349 536 6001-06, E-mail: myra.oruga@upou.edu.ph

Citation

Oruga, M.D. (2024). Spatial distribution of pediatric cancer patients using Geographic Information System (GIS) across the Philippines. *Jurnal Keperawatan Padjadjaran, 12*(1), 57-64. http://dx.doi.org/10.24198/jkp.v12i1.2283

Website

http://jkp.fkep.unpad.ac.id/index.php/jkp

E-ISSN: 2442-7276
P-ISSN: 2338-5324

Southern Philippines Medical Center (SPMC) in Mindanao and Vicente Sotto Memorial Medical Center (VMMC) in the Visayas.

This study used GIS technology to map where pediatric cancer cases occur across the Philippines. This revealed important information about the disease's uneven spread and access to care. By finding areas with higher caseloads and lower access to specialized hospitals, this study shows where resources and improvements are most needed to ensure all children have a fair chance at treatment.

Geographic Information Systems have become more powerful and reliable, making creating health maps much more accessible. This allows us to see how well-equipped different areas are to handle pediatric cancer cases compared to how many cases there are. By looking at these maps, we can identify places where cancer outcomes might be worse because of a lack of resources. This information is crucial for planning targeted interventions and improving healthcare infrastructure so that all children, regardless of location, have the same chance of getting good care (Aneja et al., 2011). The geographical aspect is crucial when strategizing healthcare services for pediatric cancer patients. By integrating geography with cancer screening data, valuable insights can be generated to enhance prevention strategies, particularly for pediatric cancer. Utilizing geographical data enables monitoring risk factors, mapping the accessibility of services, and locating hospitals to ensure efficient healthcare provision for pediatric cancer patients (Peng et al., 2017; Sahar et al., 2019). Researchers increasingly turn to GIS for health studies as the software helps analyze and visualize data based on location. This is particularly useful for understanding childhood cancer. With GIS, we can see how well-supplied different areas are with treatment options compared to how many cases there are. We can also track how well children do with treatment in other locations. This reveals any potential inequalities in cancer care. GIS is a powerful tool for policymakers deciding how to best distribute limited resources for cancer care, especially in areas lacking sufficient services (Aneja et al., 2011). Developed initially for environmental studies, Geographic Information Systems have become a valuable tool for health research, especially when tracking disease patterns.

By analyzing data with GIS, researchers can pinpoint areas where specific diseases are more common. This information is then used to plan healthcare services more effectively, like deciding where to place screening centers. Additionally, GIS can help identify areas with clusters of cases, which might provide clues about what's causing the disease (Samat et al., 2010). By examining location data, GIS can reveal why diseases cluster in specific areas, considering factors like environment, economy, and culture (Forrest & Wissink, 2017). By analyzing the geographic patterns of cancer patients, we can identify areas with limited access to screening clinics. This information can be used to improve healthcare policies and prioritize resources for regions with higher spatial clustering of cases (Bansal et al., 2020; Roche et al., 2015).

GIS maps clearly show health data, like cancer rates, across different locations (Sahar et al., 2019) and turn this into clear visuals, informing targeted prevention programs by revealing risk factors and affected populations. A geographic analysis of cancer data in Mashhad, Iran, by Amin et al. (2017) investigated potential risk factors and GI cancer occurrences to guide cancer prevention efforts. Goshayeshi et al. (2019) also explored risk factors for colorectal cancer in high-risk areas to understand geographic disparities. A study by Yoon and Tourassi (2018), using GIS, compared web-based cancer mortality data with official statistics. They found strong agreement in age distribution, geographic spread, and death rates. This suggests that web-based data hold promise for real-time cancer trend monitoring.

The Objective of the Study

This study used Geographic Information Systems to analyze and visualize pediatric cancer patients' spatial distributions across the Philippines, focusing on the three main island groups: Mindanao, Visayas, and Luzon. The objectives were particularly:

Development of a thematic map to visually represent the spatial distribution of pediatric cancer cases across the Philippines. The map will specifically delineate the major island groups.

Determine groupings of pediatric instances indicative of geographical areas demonstrating an increased likelihood of pediatric occurrence.

Evaluate the accessibility: this means assessing the ease with which patients can reach and utilize specialized care facilities.

Delineate and evaluate geographic variations in the incidence of pediatric cancer and accessibility to healthcare services. The analysis will focus on pinpointing specific regions where children encounter significant obstacles in obtaining timely and appropriate medical treatments.

The furnishing of insights aimed at enlightening policymakers and healthcare practitioners in the Philippines regarding the spatial dispersion of pediatric cancer occurrences linked to healthcare inequalities, thereby facilitating the formulation of focused intervention and resource allocation strategies to enhance pediatric cancer management nationwide.

Materials and Methods

Design

A geographic analysis or mapping of the geographic distribution of pediatric cancer patients was conducted using QGIS 3.4 Madeira, a Geographic Information System software program.

Sample and Setting

The study involved 212 participants from four cancer institutes across the Philippines: Davao City, Metro Manila, Cebu City, and Bicol Region.

Variables and Instruments

Data analysis was employed using an existing survey instrument developed for the ABC project. The data obtained from this survey served as the primary source for the study's variables.

Data Collection

This study adopted a multi-source data collection strategy, employing primary and secondary data. Primary data were obtained through surveys administered directly to participants. Secondary data were leveraged by incorporating hospital records from four major Department of Health (DOH) hospitals in the Philippines. Data were collected from four major Department of Health (DOH) hospitals: Philippine Children's Medical Center (PCMC) in Luzon, Bicol Regional Training and Training Hospital (BRTTH), Southern Philippines Medical Center (SPMC) in Mindanao, and Vicente Sotto Memorial Medical Center (VMMC) in Visayas.

Data Analysis

Researchers used the Spatial and Cluster Distribution Geographic Information System (QGIS 3.4 Madeira) to analyze cases' spatial distribution and clustering. They also employed frequency, percentages, and qualitative assessments from survey responses to evaluate healthcare accessibility.

Ethical consideration

The researcher received ethical approval from all four participating tertiary Department of Health (DOH) hospitals involved in the ABC project. This ensured the study adhered to ethical guidelines for conducting the survey.

Results

Spatial Distribution of Pediatric Oncology Patients

Table 1. Spatial Distribution of Pediatric Oncology Patients in terms of Province, Frequency, and Percentage consulting in the four referral-retained DOH tertiary hospitals in the Philippines, 2018 (n=212)

Province	Frequency	Percentage
Metropolitan Manila Area		
National Capital Region (NCR)	58	27.4%
Bulacan	20	9.4%
Rizal	15	7.1%
Laguna	8	3.8%
Quezon	7	3.3%
Nueva Ecija	7	3.3%
Cavite	5	2.4%
Pampanga	4	1.9%
Occidental Mindoro	4	1.9%
Bataan	3	1.4%
Romblon	3	1.4%
Bicol Area		
Albay	9	4.2%
Sorsogon	6	2.8%
Camarines Norte	3	1.4%
Cebu Area		
Cebu	7	3.3%
Davao Area		
Davao del Sur	8	3.8%
Sarangani	3	1.4%
Agusan del Sur	3	1.4%
Camarines Sur	7	3.3%

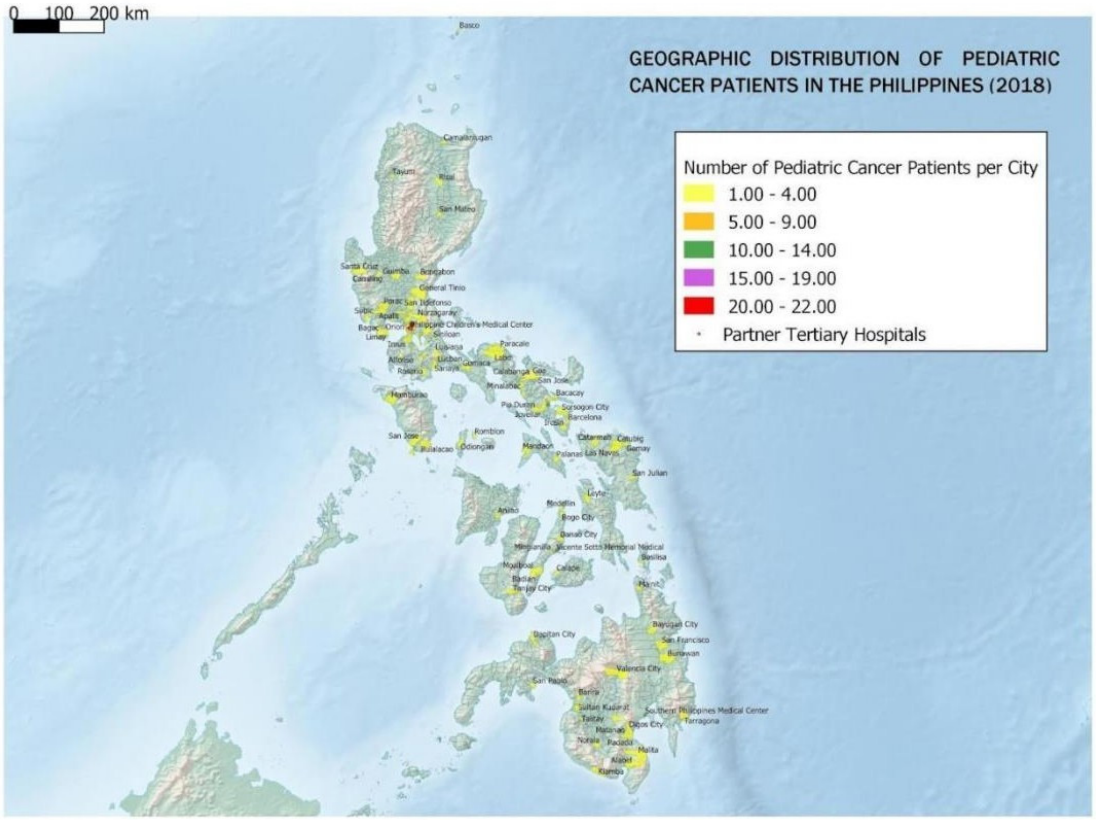

Figure 1. The Spatial Distribution of pediatric cancer patients seeking consultation across four cancer institutes per city/municipality in the Philippines in the year 2018 (n=212)

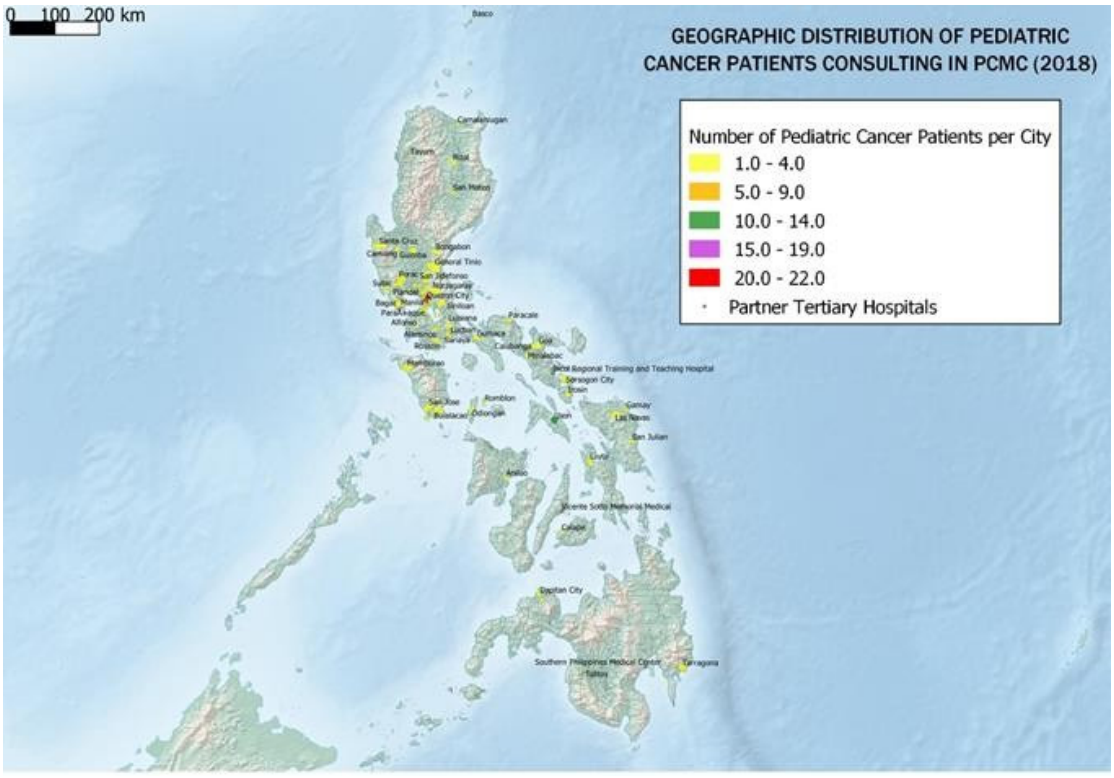

Figure 2. The spatial clustering analysis of pediatric cancer patients seeking consultation at the PCMC disaggregated by urban centers and municipalities across the Philippines in 2018 (n=161)

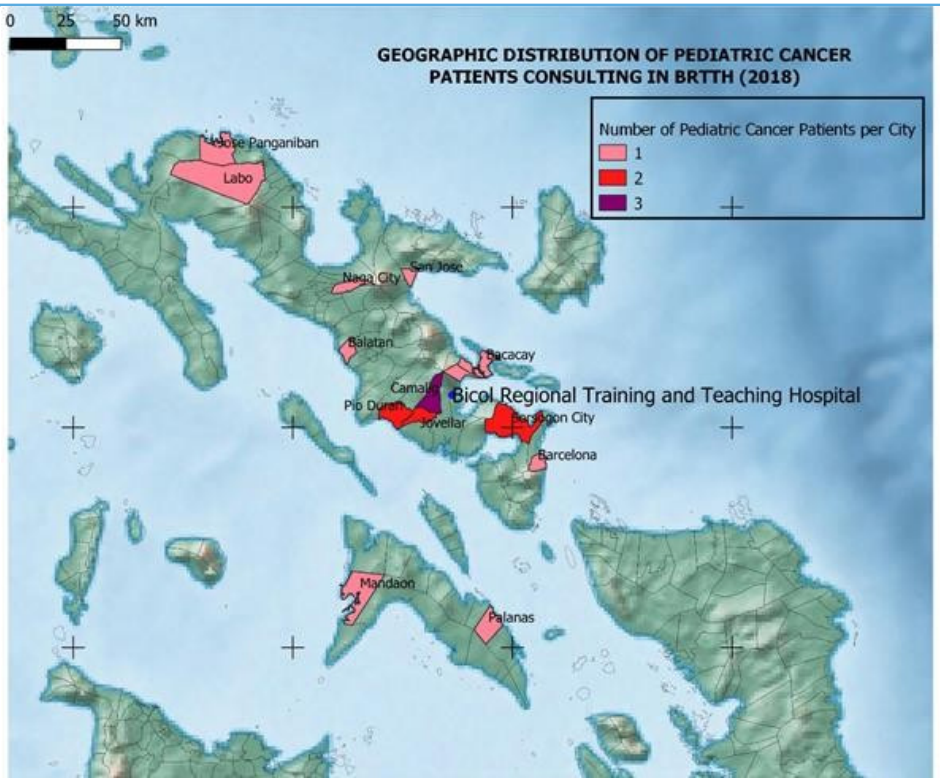

Figure 3. The spatial clustering analysis of pediatric cancer patients seeking consultation at BRTTH disaggregated by urban centers and municipalities across the Philippines in 2018 (n=20)

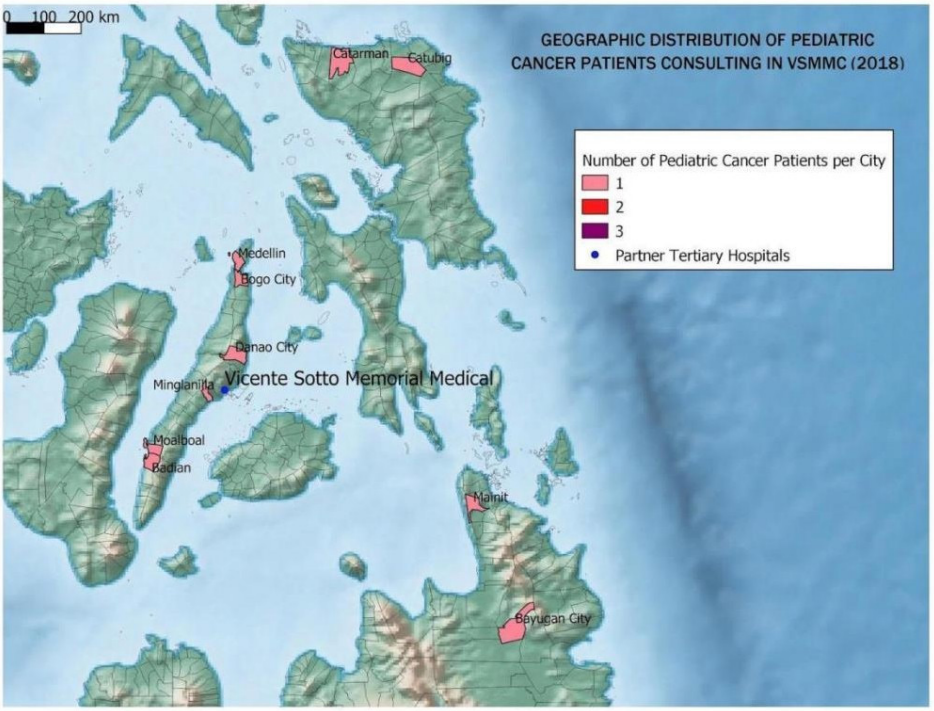

Figure 4. The spatial clustering analysis of pediatric cancer patients seeking consultation at VSM-MC disaggregated by urban centers and municipalities across the Philippines in 2018 (n=10)

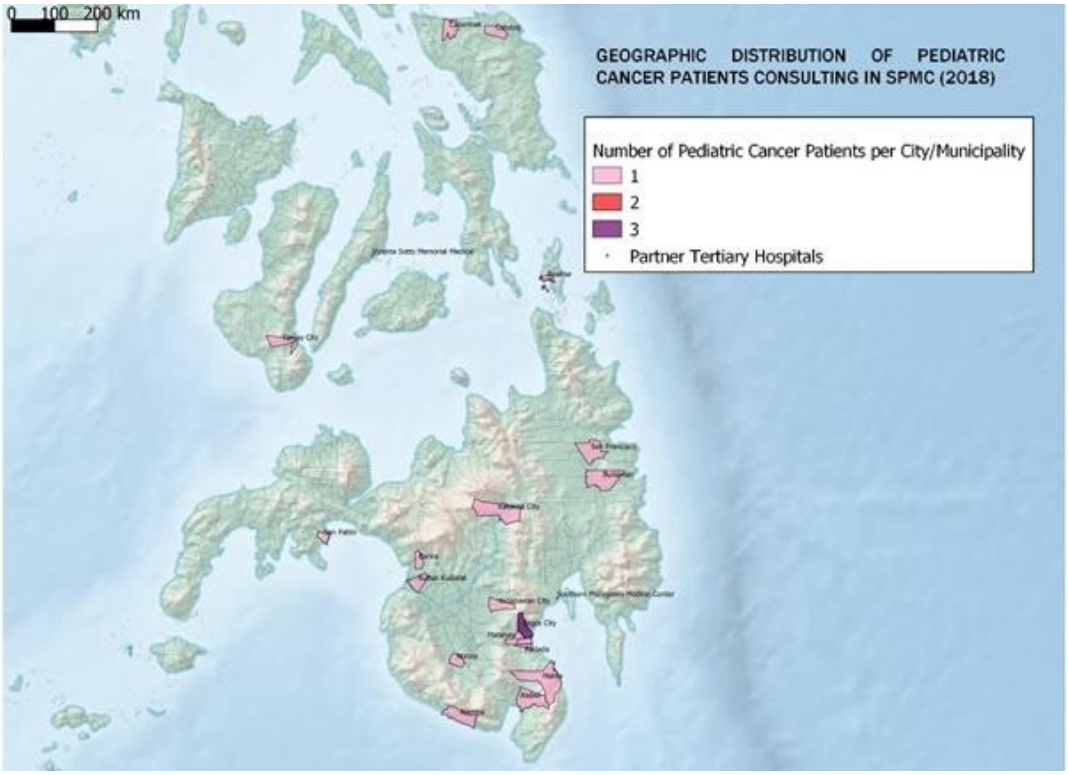

Figure 5. The spatial clustering analysis of pediatric cancer patients seeking consultation at SPMC disaggregated by urban centers and municipalities across the Philippines in 2018 (n=21)

Cluster distribution of pediatric cancer patients in the Philippines (2018)

Using data from 2018, this examines how pediatric cancer patients cluster around four DOH-affiliated tertiary hospitals in the Philippines.

Discussions

Table 1 shows the spatial distribution of pediatric oncology patients in terms of province; an analysis of patient locations in 2018 revealed that Metro Manila exhibited the highest number of cases (58 patients, constituting 27.4%) among the four regions the principal DOH hospitals served. Subsequently, Bulacan accounted for 20 patients (9.4%), Rizal for 15 patients (7.1%), and Albay for nine patients (4.2%). Amin et al. (2017) emphasize the crucial role of cancer patients' classifying. This classification allows doctors to make informed decisions about prognosis and tailor treatment approaches for everyone, ultimately improving patient outcomes (Bansal et al., 2020). Patient survey data from this study suggests a possible correlation between the concentration of pediatric cancer cases in specific regions and accessible, specialized healthcare facilities and doctors (DuGoff et al., 2018; Farazi et al., 2018; Farmer et al., 2010). A map (Figure 1) illustrates the distribution of pediatric cancer patients across various cities and municipalities in the Philippines who visited four cancer institutes in 2018. An examination of the dataset unveiled that Quezon City exhibited the highest incidence of pediatric cancer cases, encompassing 22 patients (constituting 10.5% of the total sample). Subsequently, Caloocan City accounted for 11 patients (5.2%), followed by Manila with seven patients (3.3%).

The study identified a spatial clustering of pediatric cancer cases at the Philippine Children's Medical Center (PCMC) with 161 consultations. Notably, within PCMC's service area, Quezon City exhibited the highest number of cases (22 patients, constituting 13.7% of the total), followed by Caloocan City (11 patients, 6.8%) and Manila (7 patients, 4.3%) (see Figure 2). Similarly, at the Bicol Regional Training and Teaching Hospital (BRTTH), a smaller sample of 20 patients showed clustering. The highest proportions came from Camalig, Albay (3 patients, 15%), Legazpi, Albay (2 patients, 10%), and Pio Duran, Albay (2 patients, 10%) (See Figure 3).

An analysis of patient consultations at the Visayas State Medical Center (VSMMC) revealed ten pediatric cancer cases. Each case originated from a distinct location within the province of Cebu (Argao, Moalboal, Badian, Danao, and Minglanilla) or nearby provinces (Agusan del Sur; Catarman City in Northern Samar; Bayugan City; Mainit, Surigao del Norte). Notably, one patient only received palliative care (Figure 4). Furthermore, a separate study investigating the spatial distribution of pediatric oncology patients at the Southern Philippines Medical Center (SPMC) identified Digos City (Davao del Sur) and Kiamba (Sarangani) as having

the highest concentration of cases. Amongst the 21 patients treated at SPMC, three (14.3%) originated from Digos City, and two (9.5%) from Kiamba. A more detailed illustration of this distribution is provided in Figure 5.

The study's mapping revealed that some pediatric cancer patients travel long distances (up to 968 miles south) for treatment, even when closer cancer centers exist. For instance, patients from Mindanao provinces like Maguindanao and Davao Oriental choose the leading children's hospital in Metro Manila despite having a cancer institute in nearby Davao City. This suggests patients may prioritize access to more advanced treatment technologies, even if it means traveling further. Davao City has facilities comparable to Metro Manila, indicating a potential preference for the most cutting-edge treatments available (Peng et al., 2017; Samat et al., 2010; Siegel et al., 2018; Sundaram et al., 2015).

The study found that nearly all patients (92.5%) seek treatment at tertiary hospitals offering the most specialized cancer care. However, only a small proportion (12.3%) of these patients live close to such facilities, highlighting a potential challenge in accessing this critical care (Weaver et al., 2015). While nearly all patients need specialized care at tertiary hospitals, only 12.3% live near one. Most patients (37.3%) have a secondary government hospital closest to them (within 10 kilometers). This reliance on less specialized facilities, often further away from home, increases the burden on patients due to travel, accommodation, and other non-medical expenses. The study's findings suggest that the primary obstacles faced by pediatric cancer patients can be attributed to two key domains, such as limitations experienced at the individual level and in the healthcare system systemic shortcomings (Abu-Odah et al., 2020; Yoon & Tourassi, 2018).

Conclusion

The study revealed significant hurdles regarding healthcare services for pediatric cancer patients in the Philippines. It showed that these patients face challenges beyond just reaching hospitals quickly, placing added burdens on them. Limited healthcare facilities catering to pediatric cancer mean patients must expend considerable physical, emotional, and financial resources to access care. Moreover, there's a shortage of healthcare professionals trained to deal with pediatric cancer, thereby exacerbating the issue. The study suggests exploring alternatives like telemedicine and mobile clinics to address these challenges and reach marginalized patients. Spatial analysis using Geographic Information System mapping provides crucial insights into the landscape of pediatric cancer care in the Philippines, aiding policymakers and healthcare providers in devising strategies to enhance accessibility and deliver timely, efficient care to these patients.

Declaration of Interest

This research was financially supported by a grant from the Department of Science and Technology-Philippine Council for Health Research and Development (DOST-PCHRD) and the University of the Philippines Open University (UPOU), in collaboration with several healthcare institutions, including PCMC in Manila, SPMC in Davao City, BRRTH in Bicol, and VSMMC in Cebu City. The authors affirm that they have thoroughly considered the protection of intellectual property related to their work, and there are no obstacles to publishing the findings, including any concerns regarding intellectual property rights or the timing of publication.

Acknowledgment

The authors gratefully acknowledge the contributions of the institutions and individuals who made this research possible. Financial support was generously provided by the Department of Science and Technology-Philippine Council for Health Research and Development (DOST-PCHRD) and the University of the Philippines Open University (UPOU). The research would not have been feasible without the invaluable cooperation of several healthcare institutions: the Pediatric Children's Medical Center (PCMC) in Manila, the Bicol Regional Training and Teaching Hospital (BRRTH) in Bicol, the Vicente Sotto Memorial Medical Center (VSMMC) in Cebu City, and the Southern Philippines Medical Center (SPMC) in Davao City. In recognition of the collective effort that brought this research to fruition, the authors extend their appreciation to the University of the Philippines Open University.

Funding

This research was conducted with financial support from the University of the Philippines Open University (UPOU) and the Department of Science and Technology (DOST), particularly the Philippine Council for Health Research and Development (DOST-PCHRD).

Data Availability

Due to data privacy regulations outlined in the Philippine Data Privacy Act, the data supporting these findings cannot be publicly shared. However, interested parties can request access to anonymized (aggregate) data by contacting the ABC Initiative via email at abc_initiative@upou.edu.ph or by visiting the project website at arugaproject.com.

References

Abu-Odah, H., Molassiotis, A., & Liu, J. (2020). Challenges on providing palliative care for patients with cancer in low- and middle-income countries: A systematic review of reviews. *BMC Palliative Care, 19*(1), 55. https://doi.org/10.1186/s12904-020-00558-5

Amin, M. B., Greene, F. L., Edge, S. B., Compton, C. C., Gershenwald, J. E., Brookland, R. K., Meyer, L., Gress, D. M., Byrd, D. R., &

Winchester, D. P. (2017). The eighth edition ajcc cancer staging manual: Continuing to build a bridge from a population-based to a more "personalized" approach to cancer staging. *CA: A Cancer Journal for Clinicians, 67*(2), 93–99. https://doi.org/10.3322/caac.21388

Aneja, S., Gross, C. P., Soulos, P. R., & Yu, J. B. (2011). Geographical information systems: Applications and limitations in oncology research. *Oncology (Williston Park, N.Y.), 25*(12), 1221–1225.

Bansal, S., Dolendo, M., Hoa Nguyen, T., & Sharma, K. (2020). Survival of children with cancers amidst COVID-19: A fight with two enemies. *Cancer Research, Statistics, and Treatment, 3*(2), 281. https://doi.org/10.4103/CRST.CRST_206_20

DuGoff, E. H., Cho, J., Si, Y., & Pollack, C. E. (2018). Geographic variations in physician relationships over time: Implications for care coordination. *Medical Care Research and Review, 75*(5), 586–611. https://doi.org/10.1177/1077558717697016

Farazi, P. A., Watanabe-Galloway, S., Westman, L., Rettig, B., Hunt, P., Cammack, R., Sparks, J. W., & Coulter, D. W. (2018). Temporal and geospatial trends of pediatric cancer incidence in Nebraska over a 24-year period. *Cancer Epidemiology, 52,* 83–90. https://doi.org/10.1016/j.canep.2017.12.006

Farmer, P., Frenk, J., Knaul, F. M., Shulman, L. N., Alleyne, G., Armstrong, L., Atun, R., Blayney, D., Chen, L., Feachem, R., Gospodarowicz, M., Gralow, J., Gupta, S., Langer, A., Lob-Levyt, J., Neal, C., Mbewu, A., Mired, D., Piot, P., … Seffrin, J. R. (2010). Expansion of cancer care and control in countries of low and middle income: a call to action. *The Lancet, 376*(9747), 1186–1193. https://doi.org/10.1016/S0140-6736(10)61152-X

Forrest, R., & Wissink, B. (2017). Whose city now? Urban managerialism reconsidered (again). *The Sociological Review, 65*(2), 155–167. https://doi.org/10.1111/1467-954X.12415

Goshayeshi, L., Pourahmadi, A., Ghayour-Mobarhan, M., Hashtarkhani, S., Karimian, S., Shahhosein Dastjerdi, R., Eghbali, B., Seyfi, E., & Kiani, B. (2019). Colorectal cancer risk factors in North-Eastern Iran: A retrospective cross-sectional study based on geographical information systems, spatial autocorrelation and regression analysis. *Geospatial Health, 14*(2). https://doi.org/10.4081/gh.2019.793

Peng, N.-H., Lee, C.-H., Lee, M.-C., Huang, L.-C., Chang, Y.-C., & DeSwarte-Wallace, J. (2017). Effectiveness of pediatric palliative care education on pediatric clinicians. *Western Journal of Nursing Research, 39*(12), 1624–1638. https://doi.org/10.1177/0193945916680615

Roche, A., Kostadinov, V., Fischer, J., Nicholas, R., O'Rourke, K., Pidd, K., & Trifonoff, A. (2015). Addressing inequities in alcohol consumption and related harms. *Health Promotion International, 30*(2), ii20-35. https://doi.org/10.1093/heapro/dav030

Sahar, L., Foster, S. L., Sherman, R. L., Henry, K. A., Goldberg, D. W., Stinchcomb, D. G., & Bauer, J. E. (2019). GIScience and cancer: State of the art and trends for cancer surveillance and epidemiology. *Cancer, 125*(15), 2544–2560. https://doi.org/10.1002/cncr.32052

Samat, N., Jambi, D., Musa, N. S., Ab Manan, A., & Sulaiman, Y. (2010). Using a geographic information system (GIS) in evaluating the accessibility of health facilities for breast cancer patients in Penang State, Malaysia. *Kajian Malaysia: Journal of Malaysian Studies, 28*(1).

Siegel, D. A., Li, J., Henley, S. J., Wilson, R. J., Lunsford, N. B., Tai, E., & Van Dyne, E. A. (2018). Geographic variation in pediatric cancer incidence — United States, 2003–2014. *MMWR. Morbidity and Mortality Weekly Report, 67*(25), 707–713. https://doi.org/10.15585/mmwr.mm6725a2

Sunderam, S., Kissin, D. M., Crawford, S. B., Folger, S. G., Jamieson, D. J., Warner, L., Barfield, W. D., & Centers for Disease Control and Prevention (CDC). (2015). Assisted reproductive technology surveillance - United States, 2013. morbidity and mortality weekly report. *Surveillance Summaries (Washington, D.C.: 2002), 64*(11), 1–25. https://doi.org/10.15585/mmwr.ss6411a1

Weaver, M. S., Yao, A. J. J., Renner, L. A., Harif, M., & Lam, C. G. (2015). The prioritisation of paediatrics and palliative care in cancer control plans in Africa. *British Journal of Cancer, 112*(12), 1845–1856. https://doi.org/10.1038/bjc.2015.158

Yoon, H.-J., & Tourassi, G. (2018). Investigating sociodemographic disparities in cancer risk using web-based informatics. *Journal of Human Performance in Extreme Environments, 14*(1). https://doi.org/10.7771/2327-2937.1087