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Access to diagnostic facilities in children with cancer in Colombia: Spotting opportunity and distance from a sample

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ABSTRACT

Objectives: Delivering health care timely and geographically accessible are determining factors for the prognosis of children with cancer. This study analyzed geographic access and timeliness to diagnostic services in Colombia.
Methods: In this Colombian national childhood cancer database-based study, patients and their diagnostic facilities were individually and separately space positioned. Distances between the household to the diagnostic facility, and between the clinical date of suspicion and diagnosis were determined.

Using exploratory data analysis, we obtained a probability density function (lambda), which expressed a correlation percentage between the residential location of the patient and either travel time or timeliness of treatment.
Results: 27 % of the sample of 731 patients had access to diagnostic centres in less than 30 min. The travel-distance to diagnostic centres was lowest in the Caribe and Andina Regions (43 % and 32 % distances up to 30 km respectively). However, in Amazonía and Orinoquía Regions, 87 % and 81 % had to travel more than 90 km – representing very long travel times. For more than 23 % of patients, time to diagnosis was more than 90 days, in Orinoquía, this was above 90 days for 1/3 of patients. Despite relatively short travel distances in the Caribe-Region, for 61 % time to diagnosis exceeded 30 days.
Conclusions: This study identified clear shortcomings in the Colombian Health System related to the quality of childhood cancer-related health care in terms of timeliness, cancer networks, and geographic access. These inequities not only depend on sociodemographic-characteristics and should be intervened upon.

1. Background

The quality of childhood cancer care in Colombia is suboptimal, with important aspects like access, early diagnosis, and knowledge of healthcare professionals needing improved [1,2]. The time between clinical suspicion and diagnosis of childhood cancer is a critical factor for the success of treatment and therefore, is often considered an indicator of the quality of healthcare in general [3]. Since most children with childhood cancer visit primary care facilities for their initial complaints, it is of vital importance to have appropriately trained health professionals attending in those primary care facilities in order to make a correct early diagnosis and referral plan [4,5].

According to the National Cancer Institute of Colombia, the estimated annual incidence rate of childhood cancer is 11,4 per 100.000 inhabitants, translating to 1.322 new cases of childhood cancers. These are distributed as follows: the boy to girl ratio is 1,3:1, leukaemias represent 44 % of the cases, lymphomas 13,8 %, and brain tumours 16,1 % [6]. This distribution is similar to the distribution of childhood cancer in other Andean countries in Latin America, with the highest proportion of childhood cancers being leukaemias, followed by tumours of the central nervous systems [7].

In Colombia, geography plays an essential role in some populations in terms of access to diagnosis of and treatment for childhood cancer. Long distances and often poor connections and infrastructure between dwellings and primary care facilities sometimes make visiting those facilities very difficult [8]. Higher mortality has been reported for patients who come from rural regions, likely related to distance, lack of infrastructure, and high expenditure on transportation [9,10]. Consequently, these factors lengthen the average time to initial attention of rural patients compared with urban patients [8,9].

According to the 2016 report of the Registry of Colombian Health Services Facilities (Registro Especial de Prestadores de Servicios de Salud, REPS), there were 71 facilities in Colombia which provided pediatric oncology services, including hospitals, services for outpatient

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chemotherapy, radiotherapy, and oncology emergency services [3]. These services cover the entire Colombian population of around 49 million people [11] and should be able to guarantee a timely diagnosis of any childhood cancer [3,8]. However, many of these services are concentrated in a few large Colombian cities, making access difficult for the population living in rural areas and small towns – they have to travel much longer to reach facilities, which results in increased travel costs as well as lost productivity because of time absent from work [9,12,13].

In 2016, Colombia implemented the Integral Health Attention Policy (Política Integral de Atención en Salud), which includes the formulations of "pathways for integrated health care" (Ruta Integral de Atención en Salud) with the aim of improving primary prevention of disease, and timely access to diagnostic as well as curative care [8,14]. As a result, the Interventions Pathway for Childhood Leukaemias and Lymphomas (IPCLL) was developed. This IPCLL lists detailed procedures to diminish risks of developing childhood leukaemias and lymphomas attributable to substances and other environmental factors and lists interventions and targets to improve early diagnosis and treatment of these diseases in all levels of care [14].

The Colombian Health System is based on insurance and covers nearly 97 % of the population. It is set up mainly by two regimes: contributive and subsidized, each covering slightly under 50 % of the population [15]. Around 3 % of the population are affiliated to so-called "other regimes": which insure persons working in public services like the police, military, workers of the petrol industry and teachers of public educational institutions. The insurance packages between these regimes are quite similar on paper, but not equal in practice, including differences on providers offered within each regime and generally longer waiting time and more paperwork involved for those in the subsidized regimes [16].

In this paper, we analyzed geographic access to diagnosis services in a sample of children with neoplasms in Colombia.

2. Methods

2.1. National Health Institute childhood cancer database

This study is based on the data of patients diagnosed with cancer at ages between 0 and 18 years of age reported to the database of childhood cancer of the Colombian National Institute of Health. This database gathers the information of living patients who were diagnosed and notified with any cancer based on the International Classification of Childhood Cancer, third edition (ICCC-3). The notification process is mandatory by law and was created as a surveillance system, with the aim to inform decision-makers with actual data, allowing them to formulate public policies in order to tackle this group of diseases.

This database is composed of 30 variables, most of them are related to household and demographic characteristics, such as departments, address, socioeconomic level, gender, ethnics and other social and health features like migrant and refugee conditions, pregnancy, non-related cancer disabilities and type of cancer. Other variables include information on clinical suspicion date, diagnosis date, and name of the diagnostic centres.

2.2. Diagnosis centres information

The facilities address data obtained were confirmed based on the information available in the Special Registry of Colombian Health Care Services Facilities (Registro Especial de Prestadores de Servicios de Salud, REPS).

2.3. Sample characteristics

All childhood cancer patients living anywhere in Colombia and reported to the database between January 1 and December 31 of 2016, who had complete information on household and diagnostic facilities as well as clinical suspicion and date of diagnosis were included in the analysis. From a total of 1520 patients reported to the database, we finally obtained a total of 731 records fulfilling these inclusion criteria.

2.4. Geopositioning, distances and timeliness analysis

Patients and facilities were individually and separately space positioned using STATA geocode [17] according to the reported addresses of household and diagnostic facilities. As a tool of location, STATA used the HERE platform in order to settle the distance between the patients' household to a diagnostic centre. All of the above was based on the available information on Colombian country roads. Hence, patients without specific information about either household addresses or facility addresses or both were discarded.

The time between clinical suspicion and confirmation of diagnosis was calculated as the difference between the two reported dates in the database.

Using exploratory data analysis with STATA commands spmap, and spkde [18], the maps' attributes, were drawn, including points and heatmaps. Data on distance, time, and opportunity were normalized using the best fit, in all cases, by taking the square root, before the exploratory data analysis on the maps data could be performed. The maps show a probability density function that matches with the measure of the intensity function.

2.5. Exploratory analysis of two-dimensional spatial point patterns

Looking for distribution point patterns, we were keen on recognizing if there was some relation between the values of every point and if these were capable of clustering. In this process, it is necessary to describe the point distribution in terms of the probability density function and intensity function [19,20].

Probability density function: This measurement defines the probability of observing an object per unit area in a location giving a statistic known as lambda (λ), this statistic allows establishing associations between independent and dependent variables on the analysis [18,21]. Thresholds for exploratory analysis were defined based on the maximization of the association measures of the probability density function.

Lambda is a statistic defined as the proportional reduction in error [22], and its resultant value, in this case, relates the capabilities of prediction of knowing patients household and meaning over the outcome in terms of travel-time, travel-distance, and timeliness in days [22].

Intensity density function: This measurement defines the expected value of these points per unit area, and its relations gave it scatter pattern and proximity in this writing as, hours, kilometres and days [18].

Patients were clustered into Colombian's main regions (the political-administrative departments) as follows:

Colombia's region names	Administrative political departments	Boys population below 18 years for 2016	Girls population below 18 years for 2016
Caribe	Atlántico, Bolívar, Cesar, Córdoba, La Guajira, Magdalena, Sucre, Cartagena, Santa Marta D.E, Barranquilla, Archipiélago de San Andrés Providencia y Santa Catalina	1.819.714	1.938.145
Pacífico	Chocó, Valle del Cauca, Cauca, Nariño.	1.250.207	1.346.297
Amazonía	Amazonas, Caquetá, Guainía, Guaviare, Putumayo, Vaupés.	216.022	231.793
Orinoquía	Meta, Vichada, Casanare, Arauca.	295.926	314.959
Andina	Antioquia, Boyacá, Cundinamarca, Huila, Norte de Santander, Quindío, Risaralda, Santander, Tolima, Caldas, Bogotá D.C., Extranjeros	3.874.991	4.146.361

Table 1
Demographics, and other sample characteristics.

	Girls n = 336	Boys n = 395	Total n = 731
Mean age	8.,82 SD (5,02)	9,09 SD (5,22)	8,96 SD (5,13)
Insurance type			
Contributive	173	200	373
Subsidized	134	165	299
Other types of insurance	29	30	59
Cancer type (grouped according to ICCC-3 codes)			
Leukaemias, myeloproliferative diseases, and myelodysplastic diseases	154	188	342
Lymphoma and reticuloendothelial neoplasms	26	65	91
CNS and miscellaneous intracranial and intraspinal neoplasms	40	48	88
Other and unspecified malignant neoplasms	30	23	53
Soft tissue and other extraosseous sarcomas	14	19	33
Malignant bone tumours	18	18	36
Renal tumours	11	10	21
Neuroblastoma and other peripheral nervous cell tumours	14	8	22
Germinal tumours, trophoblastic tumours, and neoplasms of gonads	15	8	23
Retinoblastoma	4	4	8
Hepatic tumours	5	2	7
Other malignant epithelial neoplasms and malignant melanomas	5	2	7
Facility where the patients were diagnosed			
Private clinic	91	92	183
Other	39	66	105
Public	23	16	39
Foundation	100	127	227
Public and private hospital	83	94	177
Time and distance			
Mean time spent in hours to diagnostic facility	5,6 hours SD (5,9)	5,9 hours SD (6)	5,75 hours SD (6,17)
Distance spent in kilometres to diagnostic facility	178 km SD (200)	189 km SD (221)	184 km (212)
Regions			
Caribe	53 (7,25 %)	72 (9,84 %)	125 (17,09 %)
Amazonía	5 (0,68 %)	3 (0,41 %)	8 (1,09 %)
Andina	258 (35 %)	296 (39,8 %)	554 (75,78 %)
Orinoquía	14 (1,91 %)	13 (1,77 %)	27 (3,69 %)
Pacífico	6 (0,82 %)	11 (1,5 %)	17 (2,32%)

In summary, we calculated the distance between each patients' household address and their diagnostic facility and summarized this information for the regions under study. Similarly, the time between clinical suspicion and cancer diagnosis was summarized.

3. Results

A total of 1520 childhood cancer cases were reported to the childhood cancer database of the Colombian National Institute of Health, out of which only 731 patients had complete information on household and diagnostic facility data.

Colombia had 171 pediatric oncology services registered for 2016, for a country with a population density of 42 people per square kilometre (km^2) and a surface area of 1.141.748 km^2. The 731 included patients were registered in 100 centres (Table 1).

From these 100 units, 48 provided general practitioner services and pediatric inpatients and outpatients' services, 67 provided paediatrician services, 39 provided general oncology services, and 11 provided pediatric oncology services.

3.1. Population composition

The majority of the included patients lived in Andina Region 75,8 % (n = 554), while just 4,8 % (n = 35) resided in the Orinoco and Amazonian region. The median age of the included patients was nine years (interquartile range 4–14 years). A slight majority of patients was male (54 %, Table 1).

Of 731 cases with complete information, 27 % (n = 199) had access to a diagnostic centre in less than 30 min of travel time.

3.2. Exploratory data analysis

Fig. 1a shows the Colombian conterminous highlighting patients' household location drawn with black dots, and diagnostic centres available in the data with hollow circles. Colours are drawn in maps as part of the exploratory data analysis, and these colours are the consequence of dots' covariance time weights given its geographical proximity associations.

Therefore, outcomes shown in the maps present two legends that relate a number of measures for the parallel reading of each choropleth in terms of a determined intensity gauge with its correspondent measurement of the probability function.

The reading of the two legends allows establishing the strength of the relationship between patients' household and the measurements of time-travel, travel-distance, or timeliness to diagnosis facility. The drawn colours in both legends are part of the same picture; the gauge of intensity and probability function is utterly joined and have the same representation in terms of colour code over the map.

Complementary, the second legend on each map is showing a measure of time spent in hours, kilometres, or days to commute, travel, or being diagnosed wherever the facility was located. This legend is the intensity probability function, and it is associated with the probability function, for parallel row colour reading of both legends given that each choropleth colour code on both legends is linked to the very attribute.

The red zones of Fig. 1a are the zones with the longest times spent for the patients. They are located on the Coast, in the country centre and some parts of the South Centre Zone. These areas correspond to the Caribe Region, Andina Region, and some parts of Pacífico Region. The patients located at red distribution had a probability of 2,5 %–26,6 % of spending at least 5,5 h to reach a diagnostic facility.

The orange areas (intermediate distance and time) are located in proximity to the cities of Cali, Neiva, Medellín, Montería and Bucaramanga, patients dwelling at those areas had a probability between 1,5 % and 2,5 % of spending 3,3 h to 5,5 h of travel time.

The rest of the areas in yellows, greens and blues have lambdas below 1,5 %, and times spent less than 3,3 h to reach the diagnostic

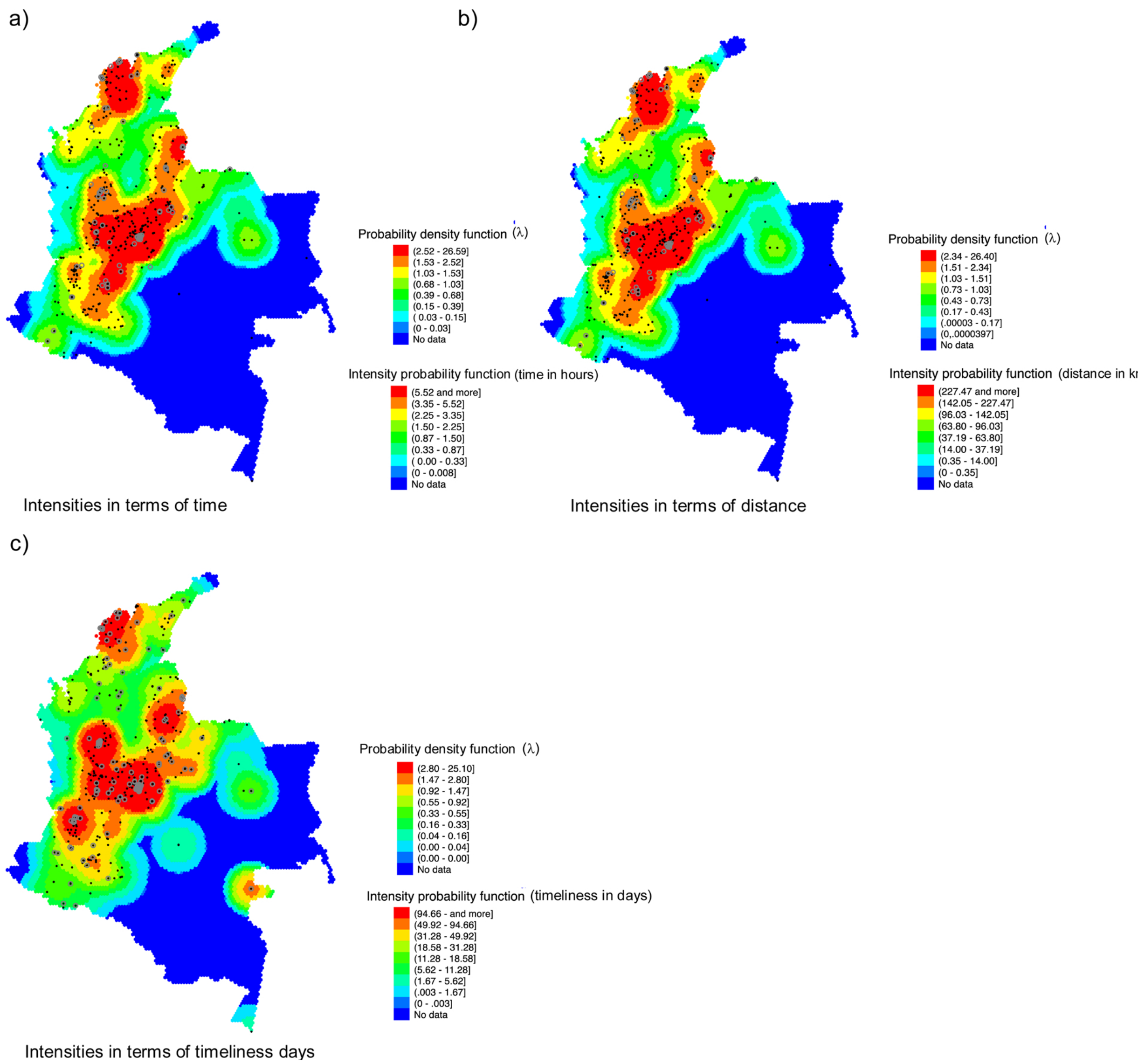

Fig. 1. a), b), c) Colombia conterminous, exploratory analysis, and drawn probabilities. Probability function legends are lambdas expressed in percentages from zero to 100.

facility. These areas are located at the most between in areas between Antioquia and Cordoba, Valle del Cauca and Cauca, and Nariño and Putumayo.

Fig. 1b illustrates the patients' household location drawn with black points and diagnostic centres available in the data with hollow circles. This map shows the distance spent by patients for commuting to the health centre its colour codes corresponds to the exploratory analysis of travel distance, the reddest the more extended the travel distances as described in above the plot, scattered at the most populated cities.

The longest distances travelled (the red zones of Fig. 1b) were found in the Caribbean Coast, in the central areas of the country and some parts of the South-Central Zone (the Caribe, Andina and some parts of Pacífico region). Patients located at the red distribution had a probability of 2,3 %–26,4 %, of traveling at least 227,5 km to reach the treatment facility.

The orange areas are located in proximity to the cities of Cali, Neiva, Medellín, Montería and Bucaramanga, relatively large to large urban areas (~400.000–2,5 million inhabitants each) with weaker lambdas between 1,5 % and 2,3 %, with an intensity probability function between 142 km and 227 km.

The rest of the areas in yellows, greens and blues have lambdas below 1,5 % and a travel distance of less than 142 km to a diagnostic facility. These areas are located at the most between in areas between Antioquia and Cordoba, Valle del Cauca and Cauca, and Nariño and Putumayo.

Fig. 1c plots the patients' household location was drawn with black dots, whereas empty grey circles represent deceased patients registered. This map shows the number of days between the clinical suspicion of childhood cancer to the patients' diagnosis, and the colour code corresponds to the exploratory data analysis, reddest colours indicate more extensive timeliness as described above.

The red zones of Fig. 1c) are located in proximity to the cities of Bogotá, Ibagué, Armenia, Pereira, Cali, Neiva, Medellín, Santa Marta, Cartagena, Barranquilla and Bucaramanga with probabilities between 2,8 % and 25,1 %, of being diagnosed between 91 days and more.

The rest of the areas are scarce. Even though, greens areas cover a vast territory that had a no minor number of deceased patients who had better timeliness.

Table 2
Travel distance percentages between the diagnostic centre and patient household.

	Zero to thirty kilometres	Thirty to ninety days kilometres	Ninety and more kilometres
Colombian's Regions			
Caribe n = 125	43 %	10 %	45 %
Pacífico n = 17	10 %	18 %	70 %
Amazonía n = 8	11 %	0 %	87 %
Orinoquía n = 27	10 %	7 %	81 %
Andina n = 554	32 %	11 %	55 %
Sex			
Women n = 336	31 %	13 %	54 %
Men n = 395	33 %	10 %	55 %
Type of insurance			
Contributive n = 373	40 %	9 %	49 %
Subsidized n = 299	24 %	12 %	62 %
Other types of insurance n = 59	29 %	12 %	57 %

Table 3
Percentiles of opportunity between clinical suspect and diagnosis of cancer in children's sample.

	Zero to thirty days	Thirty to ninety days	Ninety and more days
Colombian's Regions			
Caribe n = 125	38 %	33 %	28 %
Pacífico n = 17	49 %	26 %	24 %
Amazonía n = 8	49 %	27 %	23 %
Orinoquía n = 27	41 %	25 %	33 %
Andina n = 554	36 %	36 %	27 %
Sex			
Women n = 336	39 %	32 %	28 %
Men n = 395	39 %	35 %	25 %
Type of insurance			
Contributive n = 373	40 %	32 %	27 %
Subsidized n = 299	39 %	35 %	25 %
Other types of insurance n = 59	34 %	33 %	32 %

3.3. Departments and regions

When we compared the travel distance spent in different departments within its regions (Table 2), this time was lowest for the Caribe Region, indicating better access, around 53 % of the population had access in less than 90 km. It was quite similar to results from the Andina region, where 43 % of patients had access within 90 km. The longest distance was for the Amazonía and Orinoquía Regions, where only 11 and 17 % of the cases had travel distances of less than 90 km. Fig. 2 summarizes these results.

Investigating in detail diagnostic opportunity within regions, it is striking that three-quarters of the patients residing in the Amazonas and Pacífico Region spent less than 90 days between suspicion to diagnosis. Forty per cent of patients affiliated to the contributive insurance reported a time until the diagnosis of less than 30 days. The "other" types of insurance had the worst access timeliness of diagnosis among Colombian regions for the diagnosis of childhood cancer; in the category other types of insurance, only 34 % of the children with cancer affiliated in these regimes were diagnosed in less than 30 days and 32 % in more than 90 days. However, the difference between this group and the contributive and subsidized affiliations was not statistically significant (Table 3).

To sum up, the Sankey chart in Supplementary Fig. 1 showed the Colombian departments where patients' household was located and concurrently the department of diagnosis, clearly showing the "receiving" and "sending" departments. For example, there were 519

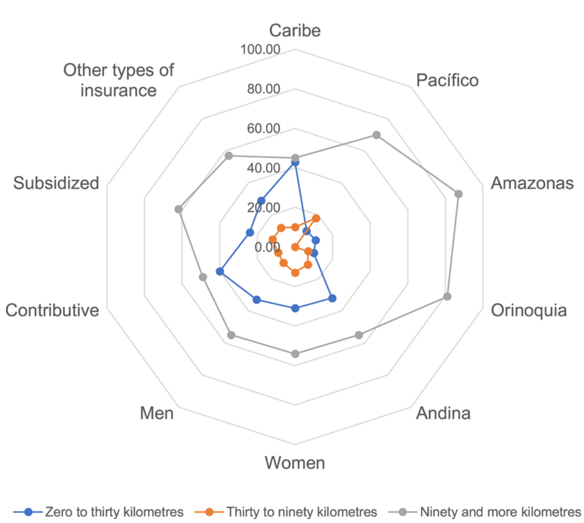

Fig. 2. Radar of distances access by regions, sex, and insurance type.

patients diagnosed in Bogotá, 286 of whom lived in Bogotá, the other 233 were from other departments but diagnosed and notified in Bogotá. Similarly, Santander had a total of 135 patients diagnosed; 187 of them lived in Santander, and 48 came from a different department.

4. Discussion

The access to diagnostic and treatment facilities for Colombian childhood cancer patients in terms of geography, distance, timeliness, and network services is a topic that required a substantive exploration [23]. This work contributes to the jigsaw puzzle of healthcare system factors related to childhood cancer survival outcomes.

Over the past decades, much progress has been achieved in childhood cancer in terms of new treatments, hematopoietic cell transplantation [24]; fortunately, survival drastically has improved [25]. In Colombia, all modern treatment options are available, but patients face challenges to benefit from them, as more "basic" challenges like travel time and travel distance, and access to both diagnostic and curative care are still serious barriers [8,23].

Several international studies have documented the importance of travel burden, measured as the travel distance or travel time for the failure or success of childhood cancer treatment [26–28]. More extended distances and time to primary care might result in delays for diagnosis or earlier stages of the disease [27], being an issue that remains to be explored in Colombia.

The Colombian Social Security and Health System has reached almost complete coverage. The system provides some redistribution of resources to be able to provide care to the poorest part of the population as well as the wealthier parts. Health insurance companies receive a fee for each insured person, based on global actuarial risk. This amount varies by sex, age and geographic areas with difficult access [29]. This mechanism allows patients from remote areas to receive compensation for the costs implied in their transportation, often long distances, to the medical services that they need [29]. A general characteristic of most Colombian health insurers is the vast amount of tedious internal processes, which result in piles of paperwork and permissions to be filed, which complicate the effective access to medical services, including mandatory and lifesaving services [3].

Exploring access outcomes in our country allow us to highlight some of the weaknesses of the Colombian Health Care System. However, some of these problems are not exclusively related to the Health System but also with the vast Colombian geography, its inhabitants' dispersion, the providers' infrastructure disposal, and the human talent capacities of health care staff. A distance of 90 km may not seem too long, but travelling this distance may involve a full day of travelling – depending on the exact location of the residential address and treatment facility.

Our results in Fig. 1 showed intuitively conflicting results, for instance, the Caribe region which had favourable outcomes in terms of better timeliness despite very long travel distances, in particular in Sucre and Córdoba. The department of Santander is on the other extreme with a long time between suspicion and confirmation of diagnosis despite its shorter travel distances. The same situation occurred in some areas of the central and southwest regions with relatively good geographic access but very bad diagnostic timeliness. These delays in diagnoses may, in these cases, be caused by a high patient density per facility, leading to higher saturation of some health providers, leading to waiting times.

It would be worthwhile to explore which were the "factors" behind the success in the Caribe Region to see if they can be applied in other regions like Santander.

Considering the distribution of the facilities, it is clear that these are most scattered over the Andina and Caribe Region, contrasting with other zones with no coverage at all such as Córdoba, Sucre, Bolívar, La Guajira, Cesar, and Antioquia (Urabá Antioqueño). In these regions, primary care facilities, which should refer to cases suspected of childhood cancer, do exist but reported no cases. This may reflect a complete absence of cases in these populations, which seems unlikely. It seems more plausible that this lack of reports from facilities reflects a lack of ability or awareness in these territories of childhood cancer symptoms and diagnosis and the need to report. If the network of health care providers would work optimally, this should reduce travel times and improve the diagnostic opportunity.

Even in zones with a reasonable offer of healthcare facilities, there was an apparent increase in the scattering of the fatal cases. On the one hand, this illustrates the need of rapid diagnosis, fast access to adequate and continuous treatment, and on the other hand, settling that many of these units are referral centres, whereby the more complex cases could be referred.

Although this study did not take into account an association measure for predicting the distribution of deceased patients, childhood cancer mortality patterns are essential to study to raise consciousness in primary care facilities in rural Colombian areas. Identifying all factors which simultaneous lead to distinct types of delays that drive fatal outcomes in these children.

The health care providers network requires improvements to reduce travel time, distance, and improve timeliness seeking to strengthen the reference and counter-reference communication systems between insurers and providers.

Colombian regions are conformed by states defining more extensive areas allowing the centralization process for diagnosis and treatment, providing the necessary logistics for the transfer of patients. Bearing in mind that, there were identified diagnostic clusters all over the regions except for Amazonia and Orinoco. Precisely, some patients' inhabitants of those zones naturally were sent to its closer diagnosis centre, for example, from Putumayo to Valle del Cauca.

As mentioned, there seems to be a certain degree of "surplus capacity" in the main cities. Whereas diagnostic capacities should be more decentralized, it is essential to provide complex childhood cancer care in just a few centres in order to assure a high standard of quality – these large cities become the "childhood cancer hub" for their region.

The reported deficiencies in access on regions like Amazonía, Orinoco, and Pacífico Regions with the longer travel distances contrasts with shorter times to attain a diagnosis. These long distances may exist because of the low communication capacities between health providers and insurers and insufficient or non-existing cancer-care networks in these regions. The apparent timely diagnosis in these and other regions demands further explorations based on other data, as our data lack information on stage at diagnosis.

5. Limitations

Interpretation of our data depends strongly on the quality and completeness of reporting of childhood cancer patients to the surveillance system. Unfortunately, because of incomplete data, an important number of cases were not included in the analyses, and an unknown number of cases never got reported. It is of vital importance to know that not show all the system providers were present in this study, limiting its inference solely over the visualized ones.

5.1. Information of excluded cases

As an important number of reported cases was not included for analyses, we decided to provide a brief description of these 789 patients. These were excluded because of missing or unclear information on home address or address of the diagnostic facility. Home addresses were missing all over Colombia: in Andina Region 317 out of 871 total reported cases were not included (36,39 %); Pacífico 251 out of 268 (93,65 %); Caribe 104 out of 229 (45,41 %); Amazonas 33 out of 41 (80,48 %); and Orinoquía 30 cases out of 57 (52,63 %); for 54 patients there were confusing information for categorized their regions.

Independently of the patients' dwelling region, most of the excluded cases could be related to particularly rurality settlements difficulty of locating, associated with scarped geography, all of the above combined with profound differences in territorial development, infrastructure, health governance and availability of specialized care services.

For instance, Pacífico Region had a higher proportion of omitted cases even when Valle del Cauca – one of its departments, is considered a country reference centre for cancer care. However, this Region has an intricated geography (Nariño), and a thick tropical forest territory over Chocó which limits its roads communication by far with Valle del Cauca. Such patients' exclusions among Regions could have altered the clusters' identification within most vulnerable groups, and induce a biased measure either on travel burden as timeliness to diagnosis at most of the regions.

On its own, diagnostic facilities where the patients were diagnosed showed the following: Caribe 102 cases, Pacífico 245 cases, Amazonia 31 cases, Orinoquía 18 cases, Andina 373; for 20 cases the Region of the diagnostic unit could not be determined. These regional differences between analyzed and excluded cases can partially be explained by rurality distribution, the quality of clinical records, and awareness of health system agents about registries governance.

Of the excluded cases, 42,5 % were girls (n = 335); 393 had contributive insurance, 347 subsidized insurance, and 49 other types of insurance. The most frequently occurring cancers in this group were: 1. Leukaemias, myeloproliferative diseases, and myelodysplastic diseases (323 cases). 2. CNS and miscellaneous intracranial and intraspinal neoplasms (118 cases). 3. Lymphoma and reticuloendothelial neoplasms (78 cases). Patients with CNS cancers occupied the second position within the group of discarded cases, in contrast with the included cases. This could be related to the technical requirements needed to reach a diagnosis and provide adequate attention to these patients in the Colombian Health System.

In our country, there are several information sources for cancer; one of them is the surveillance registry of childhood cancers. Despite national coverage and mandatory notification, not all childhood cancer patients are reported to this system, and additionally, not all childhood cancers may be diagnosed. This underreporting is confirmed by the comparison between the 2017 annual notification report by the National Health Institute and other reports: The NHI reported incidence for cancer at ages under 18 of 11,3 per 100.000 person-years [30], versus the estimates provided by the Colombian National Cancer Institute for cancer occurring under the age of 15 of 11,4 per 100.000 person-years [6], and the rate of 15 per 100.000 for boys and 15,6 per 100.000 for girls under the age of 18 according to the 4 good-quality cancer registries [31].

Therefore, the childhood cancer cases reported to the registry represent a subset of all childhood cancers. As patients reported to the registry are followed to evaluate their access to care, it is likely that unreported cases are in worse circumstances because of lack of diagnosis or being treated in centres which do not routinely report the cases.

In spite of a special exercise to correct typos in the addresses of the place of residence and facilities, some addresses were discarded by the search algorithm of geopositioning, causing a loss of records available for analysis. The addresses' accuracy was worse for suburban or rural areas, so this problem probably also caused selection bias towards including proportionally more children from larger cities – which supposedly have shorter travel distances and more facilities at hand.

These two limitations make clear that our findings provide a rather optimistic view of the situation in the country, as those patients who were not reported and those excluded from our analyses are most likely in less optimal circumstances for getting a timely diagnosis.

6. Conclusions

Further investigations are necessary to reveal the current access to diagnosis, taking into account endpoints related to surveillance according to distance-travel and time-travel as well as inequity analysis. In that very fashion, it is required to explore those patients unable to localize for making accurate measures and get an improved geographic panorama.

Authorship contribution

Daniel Uribe Parra Background, methods, analysis and data interpretation, discussion, limitations, bibliography

Diana Pulido Martínez Background, methods, discussion, limitations

Esther de Vries Background, methods, data interpretation, discussion, limitations, bibliography

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.canep.2019.101645.

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