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Pediatric cataracts: Epidemiological, etiological, and clinical profiles in Morocco

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ABSTRACT

Cataracts are a prevalent eye disease in children, particularly in the congenital form. Its occurrence is the primary cause of avoidable blindness and visual impairment. Our study aimed to assess the epidemiological characteristics and spatiotemporal distribution of infantile cataracts in children from the Marrakech-Safi region. A retrospective study was carried out in the Mohammed VI University Hospital. Data collection, carried out between March 25, 2024, and April 26, 2024, was based on a review of the medical records of sick children aged between 0 and 15 years and having undergone surgery between 2019 and 2023. The findings revealed a high rate of cataract in boys (64.7%), with congenital cataract predominating (57.6%), followed by traumatic cataract (41.1%). In 2021, 81 cases of cataracts were reported, with 51.5% of cases being bilateral. Cataract development (42.4%) was attributed to postnatal and infantile factors, with the remaining 42.7% having an unknown etiology. The study revealed a significant association between cataract type and factors such as gender, age, residence area, age at onset of cataract, consanguinity, and family history. Efficient, high-quality care can prevent cataract complications. This can be achieved by implementing health strategies targeting all levels of prevention.

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1. INTRODUCTION

Infantile cataract is the most widespread cause of blindness and visual impairment in children, particularly in low-income countries [1]. The preventable form of blindness is largely attributed to cataracts [2]–[4]. Depending on the pathology's genesis, the onset conditions, and the risk factors, cataracts can be unilateral or bilateral. The infant may experience opacification of the lens from birth or it may occur later [5]. Furthermore, cataracts can be acquired or congenital, and the worldwide prevalence ranges from one to 15 per 10,000 children [6]. Because of their lower level of life, developing nations have a higher prevalence of childhood cataracts [7]. A study done in the Marrakech-Safi region of Morocco [8] found that infantile cataract was the most frequent condition among children, with a rate of 34%.

Congenital cataracts are lenticular opacity due to abnormal lens development that occurred prior to birth and a significant percentage of congenital cataract cases are linked to genetics [9], [10]. On the other hand, opacities known as developmental cataracts can occur in the capsule, deep regions of the cortex, or the nucleus during childhood or adolescence [9]. The primary causes of infantile cataracts are chromosomal/ syndromic/

genetic (Down syndrome, Patau, Edward, or single-gene mutations), maternal infection with Rubella, Syphilis, Toxoplasmosis, Varicella, and Cytomegalovirus, or metabolic, which includes galactosemia, diabetes mellitus, Mannosidosis, or Fabry disease [5], [9]. The same authors [5], [9] list additional causes of infantile cataracts including traumatic, inflammatory, uveitis related to juvenile idiopathic arthritis, iatrogenic (previous intraocular surgery, steroid treatment, or radiation exposure), craniofacial syndromes (Hallermann-Streiff, Rubinstein-Taybi, Smith-Lemli-Opitz, and others), renal syndromes (Alport syndrome and Lowe syndrome), and ocular anomalies (persistent foetal vascularization, posterior lenticonus or lentiglobus posterior segment tumor, retinal detachment (regardless of cause), or coloboma). In addition, the idiopathic nature's causes [5], [9].

Children with cataracts, or opacification of the crystalline lens, require to be specialized, high-quality treatment to minimize the damage that could result in loss of vision. Adults have fully developed eyes and eyesight, and once cataract is removed, most cases of treatment are successful. In children, the eye and brain are still developing until the age of 8 or 10, so cataracts can cause irreversible effects on the child's vision as well as permanent problems with the brain-eye connection [11].

The majority of pediatric cataracts are difficult for anyone close to the child to detect, which might postpone diagnosis. Furthermore, linked to late presentation include sociodemographic, cultural, and health system issues [12]. In this regard, children from low-income families and backgrounds appear to be more likely to encounter obstacles when trying to access care and to stick with their treatment plan from an early age [13].

Early diagnosis, excellent surgical intervention, and postoperative rehabilitation are the most relevant management processes for stabilizing cases. In order to offer tertiary level ophthalmological care, child cataract treatment clinics should have a well-established specialist team of clinicians with experience, optometrists, and orthoptists [14]. When multiple pieces of information and symptoms indicating the development an infantile cataract are found, the diagnosis is more likely to be accurate. Generally, leukocoria, strabismus, aberrant eye movements, poor vision or delayed visual milestones are the atypical issues that parents find most often in their children [15]. Therefore, further information must be collected, covering the age at which symptoms first appear, how long they last, prenatal, perinatal, and postnatal history, disorders linked to cataracts, family history of cataracts, and consanguinity [15]. Indeed, surgery and postoperative care are not the only treatment for this type of case. Treatment of amblyopia and refractive correction is equally crucial, and may continue for months or even years after cataract removal.

Morocco has received little research on childhood cataracts over the past few decades, making the efforts of health policies less effective. To this end, we conducted a study in the Marrakech-Safi region (central Morocco) specifically focusing on infantile cataracts, as a response to the high rate of these pathologies found in the study by Soukaina *et al.* [8]. This allowed us to further analyze the epidemiological, pathological, and sociodemographic data contributing to the onset of this eye disease in children. This study allowed for the analysis of spatiotemporal trends and notable movements of increase, decrease, or constancy of childhood cataracts over the past 5 years. The purpose of this study is to assess the epidemiological characteristics and spatiotemporal distribution features of infantile cataract in children residing in the Marrakech-Safi region of Morocco.

2. METHOD

2.1. Population and study area

This retrospective study took place in the ophthalmology department of the Errazi hospital attached to the Mohammed VI University Hospital Centre (UHC) in Marrakech. The center serves the entire Marrakech-Safi region, which is located in central Morocco, as shown in Figure 1. This region comprises seven provinces and one prefecture (regional capital), covering an area of 41,404 km² (i.e., 6% of the Moroccan territory) [8].

2.2. Instruments

The data was collected using a pre-established questionnaire based on the WHO standardized questionnaire named WHO/PBL eye examination record for children with blindness and low vision [16], [17]. Our adapted questionnaire consisted of a section on the patient's sociodemographic data, as well as the age of onset of the problem and the variables of consanguinity and family history. A second section on the assessment of visual acuity, where we have incorporated a metric for the group of sighted people. Next, based on the type of cataract and its laterality at this point, the eye examination precisely pinpoints the lesion's location. The patient's etiology for this pathology is then discussed. In order to do a spatiotemporal analysis, we included the variable of the year of child care in our questionnaire.

2.3. Data collection and analysis

Data collection was carried out between March 25, 2024, and April 26, 2024, in the ophthalmology department. We adopted an exhaustive method due to a limited number of cases. The data were collected by consulting the medical files of children with cataracts who underwent an operation for this reason between

the year 2019 and the year 2023. All children under 15 years of age who had undergone treatment at the Mohammed VI HUC living in the Marrakech-Safi region were included in the study. All children living outside the study region or over the age of 15 were excluded from the study to minimize confounding factors in the present study. The sample consists of 309 children of whom we have recruited all the children meeting the inclusion criteria and who underwent cataract removal surgery over a 5-year period, between the years 2019 and 2023 so that a spatiotemporal-trend analysis could be performed. Sociodemographic characteristics such as gender, age, and origin, as well as epidemiological and clinical characteristics such as age or year of cataract onset, type of cataract, consanguinity in parents, family history, visual acuity (VA), eye affected by opacification, and causes, were analyzed statistically by using SPSS 16.0 software. The association between cataract types and sociodemographic and pathological variables was analysed using the Chi-square (χ^2) test. The significance level of tests was $p<0.05$.

2.4. Ethical considerations

The study was carried out with respect for confidentiality and anonymity and adhered to the tenets of the Declaration of Helsinki. Authorization for data collection was obtained from the central administration of the Mohammed VI University Hospital center (N°: 7838) and was granted by the director of the Errazi hospital.

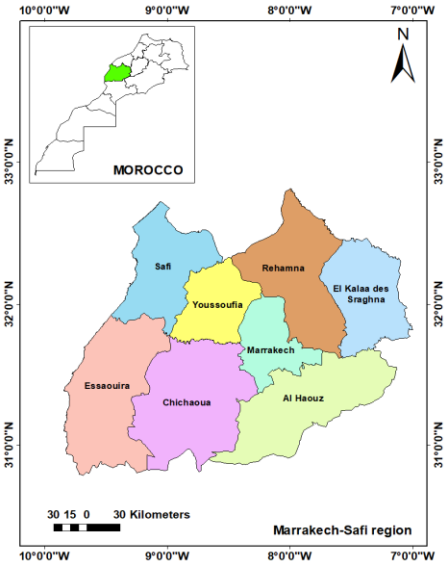

Figure 1. Regional and local Marrakech-Safi region map

3. RESULTS AND DISCUSSION

3.1. Results

According to the study's data, 309 children were the total of cases who underwent cataract removal surgery over a 5-year period, between the years 2019 and 2023 as shown in Table 1. The average age was 6.8 years, and the most common age group was 0-3 years (28.5%), followed by 4-7 years (28.2%). Boys made up 64.7% of the total, and the sex ratio was 1.83. Children from urban areas represent 52.4% of the total. More than half of the children with cataracts were from the Marrakech prefecture (54%), followed by the province of Elkalaa des Sraghna (16.2%) and Elhaouz (9.7%), with the province of Safi coming in last (2.6%) as shown in Table 1.

For the years 2019, 2022, and 2023, the frequency of children undergoing cataract removal as observed in this study is comparatively stable as shown in Table 2. Nevertheless, in 2020, there were a very low number of 44 children, and in 2021 there were 81 cases—the majority. In all 5 years, the spatiotemporal distribution also indicated a predominance of patients from Marrakech. Elkalaa des Sraghna experienced the same situation in 2019, 2021, 2022, and 2023. There was a discernible decrease in Safi cases during 2019, 2020, and 2023, as well as in Chichaoua and Rhamna in 2021 and 2022, respectively as shown in Figure 2.

The percentage of cases varies based on the residence's location and the year of first medical consultation. The rate of cases was high in urban areas in 2019 and 2021, and it was high in rural areas in 2022 and 2023 as shown in Figure 3. More than half of children are born with cataracts (53.1% of cases), followed by the 4-7 age group (15.9%), while only 6.8% of children develop cataracts in the months after birth until they are 3 years old as shown in Table 3. Six children out of 10 (57.6%) had congenital cataracts, while 41.1% had cataracts as a result of ocular trauma. Four children (1.3% of all cases) had developmental

cataracts of which three had corticosteroid cataracts and one had uveitic cataracts. In contrast to 48.5% for unilateral cataracts, a laterality analysis showed a rate of 51.5% for bilateral cataracts. It is because of carers' challenges in measuring young children's visual acuity that 36.6% of cases lack a VA assessment. Nonetheless, no light perception is present in 22.7% of children in the right eye and 24.3% in the left, and no vision loss is present in 23.6% of children in the right eye and 20.3% in the left. In 1.6% of cases the VA in both eyes was less than 6/12-6/18.

Table 1. Sociodemographic data

Variable	Categories	N	%	Variable	Categories	N	%
Age (year)	0 to 3	88	28.5	Locality of residence	Marrakech	167	54
	4 to 7	87	28.2		Rhamna	12	3.9
	8 to 11	77	24.9		El haouz	30	9.7
	12 to 15	57	18.4		Essaouira	21	6.8
Gender	Girl	109	35.3		Chichaoua	11	3.6
	Boy	200	64.7		Youssoufia	10	3.2
					Elkalaa des Sraghna	50	16.2
					Safi	8	2.6

Table 2. City of residence * Year of first medical consultation cross-tabulation

Variables	Values	Year of first medical consultation										Total	
		2019		2020		2021		2022		2023			
		N	%	N	%	N	%	N	%	N	%	N	%
City of residence	Marrakech	36	57.1	23	52.3	48	59.2	30	47.6	30	51.7	167	54
	Rhamna	2	3.2	1	2.3	6	7.4	1	1.6	2	3.5	12	3.9
	Elhaouz	5	7.9	8	18.2	5	6.2	7	11.1	5	8.6	30	9.7
	Essaouira	2	3.2	2	4.5	6	7.4	8	12.7	3	5.2	21	6.8
	Chichaoua	2	3.2	2	4.5	1	1.2	4	6.3	2	3.5	11	3.6
	Youssoufia	4	6.3	1	2.3	2	2.5	2	3.2	1	1.7	10	3.2
	Elkalaa des Sraghna	10	15.9	6	13.6	11	13.6	9	14.3	14	24.1	50	16.2
	Safi	2	3.2	1	2.3	2	2.5	2	3.2	1	1.7	8	2.6
Total		63	100	44	100	81	100	63	100	58	100	309	100
Residence area	Urban	37	58.7	22	50	46	56.8	30	47.6	27	46.6	162	52.4
	Rural	26	41.3	22	50	35	43.2	33	52.4	31	53.4	147	47.6
Total		63	100	44	100	81	100	63	100	58	100	309	100

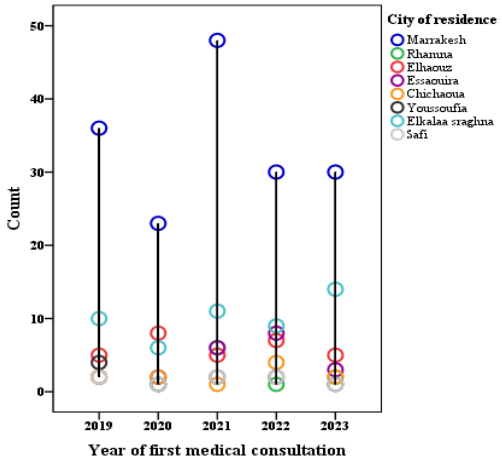

Figure 2. Spatiotemporal distribution by city of origin

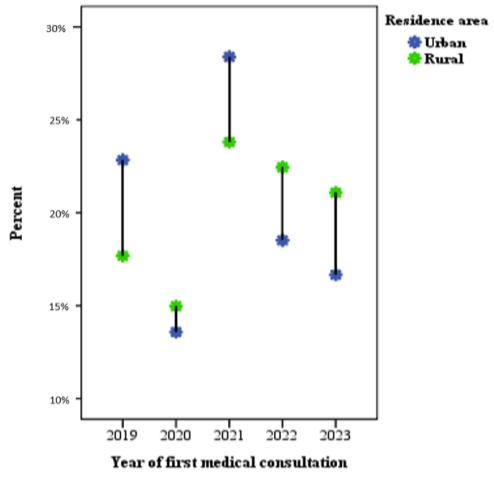

Figure 3. Spatiotemporal distribution by residence area

Regarding the etiology of cataracts, we discovered that in 42.7% of cases, the cause is unknown, and in 42.4% of cases, postnatal and infantile factors are involved. Hereditary factors were also indicated in 13.3% of children with cataracts, while perinatal/neonatal factors were cited in just 1.6% of cases as shown in Table 3. Consanguinity between parents was found in 11.7% of cases, and 6.8% of children had a family history of cataracts in at least one family member as shown in Table 3. Table 4 shows the association between the type of cataract and characteristics linked to sociodemography and pathology. The results revealed a significant association between cataract type (post- traumatic and congenital) and the following variables: gender, age,

residence area, age at onset of visual loss, consanguinity, and family history (p-value = 0.000 for each variable). However, no association was detected for the variable etiology of cataract (p-value = 0.875) as shown in Table 4.

Table 3. Clinical data

Variable	Categories	N	%	Variable	Categories	N	%
Age at onset of cataract	Since birth	164	53.1	Visual assessment of the left eye	More than 6/12-6/18	63	20.4
	A few months to 3 years	21	6.8		Less than 6/12-6/18	5	1.6
	4 to 7	49	15.9		Less than 6/18-6/60	14	4.5
	8 to 11	43	13.9		Less than 6/60-3/60	14	4.5
	12 to 15	32	10.4		Less than 3/60-PL	25	8.1
Cataract type	Post traumatic	127	41.1		No light perception	75	24.3
	Congenital	178	57.6		Difficult to measure	113	36.6
	Developmental	4	1.3	Etiology of Cataract	Hereditary factor	41	13.3
Laterality	Unilateral	150	48.5		Perinatal/neonatal factor	5	1.6
	Bilateral	159	51.5		Postnatal/infancy/childhood factor	131	42.4
Visual assessment of the right eye	More than 6/12-6/18	73	23.6		Unknown etiology	132	42.7
	Less than 6/12-6/18	5	1.6	Consanguinity among parents	Yes	36	11.7
	Less than 6/18-6/60	15	4.9		No	273	88.3
	Less than 6/60-3/60	15	4.9	Family history	Yes	21	6.8
	Less than 3/60-PL	18	5.8		No	288	93.2
	No light perception	70	22.7				
	Difficult to measure	113	36.6				

Table 4. Association between cataract type and sociodemographic and pathological factors

Variable	Categories	Traumatic		Congenital		p-value
		N	%	N	%	
Gender	Girl	28	22	81	45.5	0.000**
	Boy	99	78	97	54.5	
Age	0 to 3	11	8.7	76	42.7	0.000**
	4 to 7	45	35.4	41	23	
	8 to 11	36	28.3	39	22	
	12 to 15	35	27.6	22	12.3	
Residence area	Urban	51	40.2	110	61.8	0.000**
	Rural	76	59.8	68	38.2	
Age at onset of visual loss	Since birth	3	2.4	159	89.3	0.000**
	A few months to 3 years	12	9.4	8	4.5	
	4 to 7	44	34.6	4	2.2	
	8 to 11	40	31.5	3	1.7	
	12 to 15	28	22.1	4	2.2	
Consanguinity	Yes	2	1.6	34	19.1	0.000**
	No	125	98.4	144	80.9	
Family history	Yes	0	0	21	11.8	0.000**
	No	127	100	157	88.2	
Etiology of Cataract	Hereditary factor	0	0	41	23	0.875
	Intrauterine factor	0	0	0	0	
	Perinatal/Neonatal factor	0	0	5	2.8	
	Postnatal/Infancy/Childhood factor	124	97.6	4	2.2	
	Unknown etiology	3	2.4	128	72	

3.2. Discussion

In this current study, 309 children with cataracts who underwent surgery over a 5-year period were included. The mean age was 6.8 years, and the age group with the most dominance was 0 to 3 years, followed by 4 to 7 years. A highly significant association between cataract types and age with a p-value of 0.000 was detected following correlation analysis. These findings demonstrated that younger children are even more affected by cataract disease than older children. This discovery can therefore be explained by the fact that there are a considerable number of congenital cataracts, which often manifest at a very young age, and traumatic cataracts, which primarily affect children in their early years of life. Comparable findings were observed in Yaoundé where the mean age is 6.6 years, with 42.5% of the results being assigned to the 0-4 age group [3]. Other studies have also revealed age means that are similar to ours. These studies include Brazil [18] which found an average age of 48.9 months. The male gender had a notable predominance (64.7%) in contrast to the female gender, which recorded 35.3%. In Korea [19], the incidence rate among boys 1.69 (1.49–1.88), was higher than among girls 1.50 (1.31–1.69). In South India [20] , there is a little male predominance (57/109 boys, 52/109 girls). In relation to cataract type, male gender was highly dominant for

all cataract types (traumatic cataract (78%), developmental cataracts (uveitic cataract and corticosteroid cataract), and congenital cataract). It is essential to know that Multiple X-linked disorders demonstrate congenital cataracts. In this regard, congenital cataracts caused by X chromosome-linked genetic disorders are more common in boys [21]. All these results were linked to a significant association between cataract types and the gender variable (p-value = 0.000).

The children lived in both rural (47.6%) and urban (52.4%) areas, which was a fairly equal distribution. Traumatic cataracts were dominant in rural areas (59.8%), while congenital cataracts were predominant in urban areas (61.8%). These findings draw attention to a significant problem in rural areas, namely the traumatization of children due to their extremely precarious lifestyle, which may expose them to sharp items or force them to engage in violent play. In this regard, the relationship analysis revealed a significant association (p-value = 0.000) between the three types of cataracts and place of residency. Next, the prefecture of Marrakech, the capital of Marrakech-Safi region, accounted for nearly half of the cases, while Elkalaa des Sraghna coming in second (16.2%), and Safi having the lowest rate (2.6%). Similarly, Amankwaa-Frempong *et al.* [22] discovered comparable findings for Ghana in a study carried out in 2022, with 52.5% of cases found in urban areas and 40.3% in rural areas (7.2% of cases did not specify the region).

2020 had a lower rate of infantile cataract surgery recipients than the other studied years, according to the spatiotemporal distribution of these patients. The COVID-19 pandemic occurred in 2020, which caused delays and obstacles in the surgical care of these children. Consequently, the frequency of surgery was reduced to exclusively treat urgent cases. The normal surgical activity resumed in 2021, and the rate rose from 44 cases in 2020 to 81 cases in 2021 — an almost 50% rise. The greatest rates in the rural area were in 2022 and 2023 (52.4% and 53.4%, respectively), whereas the highest rates in the urban area were in 2019 (58.7%) and 2021 (56.8%). In 2020, there were equal rates for the two environments.

Of all children, half (53.1%) had cataracts at birth, followed by the 4 to 7 age group (15.9%). A number of indicators, including vision impairment, which may serve as a starting point for a consultation and diagnosis to identify the underlying ocular anomaly, may play a role in the discovery of cataracts in children. These statistics also reflect the fact that most congenital cataract cases have an early beginning. In contrast, the correlation study showed that ocular trauma frequently happens in early infancy, with 34.6% of children in the 4–7 age group and 31.5% in the 8–11 age group reporting having experienced this trauma.

Indeed, the type of pathology and its age of onset are strongly correlated, which was reported as a significant association (p-value = 0.000). With a prevalence of 57.6%, congenital cataracts predominated in this regard, followed by cataracts that occurred as a result of ocular trauma (41.1%). In one infant in our investigation, uveitic cataract development was rigidly developed from birth. Children in the second and third age groups of cataract onset from the age of four had developmental cataract. Because continuous use of corticosteroids—whether through self-medication or a prescription drug frequently used to treat inflammations—causes cortisone cataract. According to Kramer & Tomkins-Netzer [23], the risk was 0.01/EY (95% confidence interval, 0.005-0.03/EY) for subjects receiving 3 drops per day, suggesting that corticosteroid dosages may also have an impact on the start of cataracts. Comparably, the rate of infantile congenital cataracts was 40.8% in Yaoundé [3], with traumatic cataracts coming in second at 27.6%. The same results were noted in Ghana, where the rate of congenital cataracts was 39.5%, followed by traumatic cataract (33.1%) [22]. Therefore, the least impacted by traumatic cataract were older children (2–12 years, OR = 12.59, $p<0.001$; >12 years, OR = 7.57, $p = 0.004$), as well as female children (OR = 0.58, $p = 0.038$) [22]. As the literature indicates, congenital diseases may not appear from birth [24]. For the four remaining age groups in order of ranking, a minority of children (4.5%, 2.2%, 1.7%, and 2.2%, respectively) exhibiting symptoms of congenital cataract in the years after birth were detected in our study.

With 51.5% of children discovered to have bilateral cataracts and 48.5% to have unilateral cataracts, laterality did not appear to be a significant factor. In our study, traumatic cataract was strongly associated with a high rate of unilateralism. Ghana [22] likewise exhibited rates of laterality that were comparatively identical (51.7% for unilateral cataract and 47.5% for bilateral cataract). In a similar vein, there found no variation in laterality among Brazilian infants ages 0 to 1 [18]. Differently from our results and those of Ghana, and Brazil, Korea [19] reported a unilateral cataract rate that was excessively higher than the bilateral cataract rate (82% and 18%, respectively).

A significant percentage of the children diagnosed had blindness (visual acuity less than 3/60 to no light perception) in both eyes (28.5% for the left eye and 32.4% for the right eye). Normal vision was measured in 23.6% of left eyes and 20.4% of right eyes. In contrast, 36.6% of children were unable to have their visual acuity measured due to their young age. Ocular trauma was the most common type of cataract to cause blindness in the affected eye, and the congenital form of cataract caused blindness in most cases.

Analyzing the risk factors linked to cataracts was crucial. The majority of patients, especially those with congenital cataracts, had an unknown or undetected cause (42.7%). The predominance of postnatal and infantile factors (42.4%), suggests that traumatic cataracts, which damage the lens, are common and are often

caused by sharp objects or heat or chemical burns. Traumatic cataract in children was closely linked to environmental factors, notably play and household mishaps. According to Günaydın and Oral's study [25], which was conducted in an Istanbul ophthalmology referral center in 2022, children's traumatic cataracts are primarily caused by sharp items. One stakeholder to be examined in the current research was the hereditary factor. The findings showed that this factor contributed to 13.3% of children suffering from cataracts, and that this number only included children who had congenital cataracts. In 2023 [26], another study carried out on Turkish families with congenital cataracts revealed that 58% of families had autosomal dominant transmission and 42% had autosomal recessive transmission. These results highlight the importance of investigation and surveys conducted for the benefit of families whose members have congenital cataracts in order to guarantee early treatment for cases that are discovered. It is noteworthy that 6.8% of instances included a family member who had been affected by cataracts.

We also investigate the notion of consanguinity among the parents of children affected by cataracts because the etiology of this ocular pathology is genetic. In contrast to the 88.3% of children who had no consanguinity between their parents, the rate of parental consanguinity among these children was 11.7%. This variable also pertained to the congenital form, with the exception of two kids who had traumatic cataracts, whose consanguinity had no bearing on the accidental type. Likewise, infantile cataracts are one of the hereditary pathologies, according to a study on the epidemiology of blindness and visual impairment in infants conducted in the same region [8]. In this regard, children with eye problems that may have a genetic origin are more likely to be consanguineous [27]. Thus, in consanguineous populations, autosomal recessive congenital cataracts are highly common [28]. Jomaa *et al.* [29] also found that in children with congenital cataract, consanguinity is present in 85.71%, and family history was detected in 23.8%. Our study presented family history very minimally (6.8%). However, it has reached 20% in Kenya [30]. The variables of consanguinity and family history were associated with cataract types according to the results of the correlation analysis (p-value = 0.000, respectively). On the other hand, the relationship between etiology and cataract types did not demonstrate a significant association (p-value = 0.746).

4. CONCLUSION

Children still frequently suffer blindness and visual impairment as a result of infantile cataracts. The study revealed that this eye condition affects boys much more than girls. Congenital cataract had the highest rate, and the most common age of onset was at birth. Congenital cataracts were associated with a hereditary factor, while postnatal and infantile factors were highly prevalent and closely linked to traumatic cataracts. However, a significant number of cases lacked an established risk factor. Avoidable blindness is primarily caused by its congenital form. Irreversible retinal damage is also frequently caused by ocular trauma. Diagnosing and monitoring neonates with genetic factors and consanguinity is crucial to preventing any issues that may result from infantile cataracts. As well as prompt, effective surgical therapy for those that are found. Adopting health plans is the only way to accomplish effective and efficient therapy. These should emphasize primary prevention and medical-surgical care for secondary prevention through increasing tutors' knowledge. The significance of examining the disease's pathological and sociodemographic causes has also been shown by our research.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest regarding the publication of this article.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the ethics committee entitled Moroccan Association for Research and Ethics (7/REC/2023).

DATA AVAILABILITY

The data that support the findings of this study are available on request from the corresponding author, [SL], upon reasonable request. The data, which contain information that could compromise the privacy of research participants, are not publicly available due to certain restrictions.

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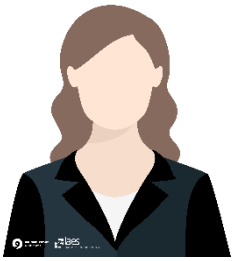

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