Causes of functional low vision in a Brazilian rehabilitation service

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There is limited information on functional low vision (FLV) in Latin America, especially in individuals under 50 years of age. In the present study, we retrospectively evaluated the medical records of 1393 consecutive subjects seen at a Brazilian tertiary rehabilitation service, from February 2009 to June 2016. We collected sociodemographic, clinical data, and information on optical aids and spectacle prescription. Subjects were divided into three age groups: 0 to 14 years old (children), 15 to 49 years old (young adults), and 50 years or older (older adults). The main etiologies leading to FLV in children were cerebral visual impairment (27.9%), ocular toxoplasmosis (8.2%), and retinopathy of prematurity (7.8%). In young adults, retinitis pigmentosa (7.4%) and cone/rod dystrophy (6.5%) were the most frequent, while in older adults, age-related macular degeneration (25.3%) and diabetic retinopathy (18.0%) were the leading causes. Our results indicate that preventable diseases are important causes of FLV in children in the area, and proper prenatal care could reduce their burden. The increasing life expectancy in Latin America and the diabetes epidemic are likely to increase the demand for affordable, people-centered rehabilitation centers, and their integration into health services should be planned accordingly.

It is estimated that in 2020 there were more than 596 million people with any type of visual impairment worldwide (functional presbyopia excluded), approximately 30.4 million of them living in Latin America and the Caribbean. Despite the global decrease in the prevalence of blindness over the last decades, the number of individuals presenting functional low vision (FLV), defined as visual acuity (VA) of < 6/18 to ≥ light perception (LP) due to any untreatable cause, is increasing, mostly due to population growth and aging. Treatable causes, such as uncorrected refractive errors and cataract, still contribute to the highest visual impairment burden globally and in Latin America. But those with functional low vision need perennial, multidisciplinary rehabilitation assistance, often with the need for expensive optical aids. Providing specialized care for those in need is a priority for the World Health Organization (WHO), and a challenging task in developing countries.

There is a shortage of low vision services globally, especially in Latin America, Africa, and Asia. Through its World Report on Vision, the WHO urged for the inclusion of rehabilitation services within eye care interventions. Among the main barriers, cost, geographical distance, and maldistribution of human resources can be cited. For example, in Latin America, it was estimated that the low vision population in most countries have no more than 10% coverage of low vision rehabilitation services. The region is also the one with the lowest number of low vision professionals per 10 million population.

The Rehabilitation Service at the Hospital das Clínicas in Ribeirão Preto, Southeast Brazil, was created in 2009 and, at that time, was the only institution in the region that provided free-of-charge functional low vision care in an area covering approximately 4 million inhabitants. In the Brazilian Public Health System, a general practitioner refers those with visual complains to ophthalmologists at the secondary level, and when needed, subjects are referred to tertiary and rehabilitation services. In our Rehabilitation Service, patients are evaluated by a multidisciplinary team comprising of an ophthalmologist, occupational therapist, physical educator, orthoptist, pedagogue, social worker, and psychologist. When indicated, spectacles, optical aids, and walking sticks are prescribed.

Understanding the causes of functional low vision, the demographic profile of service users, and the optical devices prescribed is crucial for service planning. Also, since there is scarce population data on prevalence and causes of childhood blindness due to its difficulties in technical aspects, such as assessment and examination of children in the community, the description of the causes of childhood functional low vision and its frequencies in a tertiary service could serve as a proxy estimate of the leading blinding diseases in this age group in a given population.
area, since approximately 70% of the population use the public health service, and our Rehabilitation Center is the only service in the region. In the present retrospective study, we describe the demographic profile, the causes of functional low vision and its frequencies, and the prescribed optical devices in a Brazilian rehabilitation service during its first 89 months of existence.

Methods
The study protocol adhered to the Declaration of Helsinki’s tenets and was approved by the Ethics Committee in Human Research at Ribeirão Preto General Hospital (approval number 58577316.8.0000.5440). In this retrospective study, data regarding scheduling and attendance from February 1st, 2009, through June 30th, 2016, were obtained from the hospital’s electronic scheduling system and medical records. Subjects’ demographics included age at the first appointment, sex, city of residence, and distance from the Rehabilitation Service. Medical history was obtained by the review of physical (n = 1382; 99.2%) and electronic medical charts (n = 11; 0.8%). Medical data obtained from physical or electronic medical records cannot be altered or deleted after medical care. All of the patients were assisted by either MMF or RA-F. All data of interest for this study was collected manually to an Excel sheet and then transferred to a software package. The data included distance best-corrected visual acuity (BCVA), ophthalmological diagnosis of the better-seeing eye, anatomical site of the main diagnosis, types of prescription (spectacles and optical devices), and its acquisition (out-of-pocket or donated by the institution). Optical devices were divided into magnifying loupes, telescopes, and spectacles with an addition equal to or greater than +4.00 D and filtering lenses. For donated optical devices, the time elapsed from prescription to delivery was also analyzed.

Inclusion criteria were subjects with distance BCVA <6/18 to ≥LP on the better-seeing eye due to untreatable causes (FLV) associated with a known etiology; and complete ophthalmological evaluation included VA, refractometry, slit-lamp examination, and fundoscopy. Children unable to inform VA were also included in the study. Children unable to inform VA, but with visual behavior compatible with low vision and any irreversible diagnosis were also included.

Exclusion criteria were subjects with incomplete or no ophthalmological evaluation, or when their BCVA was equal or better to 6/18, or no light perception in both eyes. Only one cause of FLV per subject was assigned (the primary diagnosis that led to FLV in the better-seeing eye). When there was a concomitant diagnosis of cerebral palsy and an ocular diagnosis that led to FLV (e.g., retinopathy of prematurity or optic nerve atrophy), the ocular diagnosis was chosen.

The subjects were divided into three age groups, according to Resnikoff et al.: 0 to 14 years old (children), 15 to 49 years old (young adults), and subjects aged 50 years and older (older adults). Older adults were also subdivided into 50–59 years old, 60–69 years old, and 70 years or more. BCVA was measured using the Early Treatment Diabetic Retinopathy Study Chart (Lighthouse, Long Island, NY) and classified according to the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10), World Health Organization, as follows: moderate visual impairment (BCVA <6/18 to 6/60); severe visual impairment (BCVA <6/60 to 3/60); blindness (BCVA <3/60 to 1/60); and blindness (BCVA <1/60 to light perception). The anatomical site of the leading cause of functional low vision of the better-seeing eye was recorded for each included subject. A category “retrobulbar” was created to accommodate central nervous system involvement cases, such as cerebral vision impairment, due to many etiologies, such as anoxia, malformations, and tumors.

Statistical analyses were performed using the statistical analysis system R: Core Team, Vienna, Austria. Continuous variables were analyzed using the Mann–Whitney test. A p-value of less than 0.05 was considered to be statistically significant. Frequency tables were used for descriptive analysis.

Ethical approval. Due to the retrospective nature of this study, informed consent was not obtained from participants and legal guardians. The Ethics Committee in Human Research at Ribeirão Preto General Hospital approved the waiver for the consent (approval number 58577316.8.0000.5440).

Results
We identified scheduled appointments for 2168 subjects in our rehabilitation service during the study period. Among them, 252 (11.6%) did not attend the appointment, 442 were excluded due to BCVA equal or better to 6/18, 47 with no light perception in both eyes, and 34 were excluded due to incomplete ophthalmological evaluation, leaving 1393 subjects included for analysis (Fig. 1). Most of the included subjects were men (n = 727; 52.2%), and older adults corresponded to the most numerous group (n = 541; 38.8%), followed by children (n = 512; 36.7%; 236 of them younger than 5 years old). There was no sex predilection in all studied groups. Retina was the most frequent anatomical affected site (n = 655; 47.0%), followed by retrobulbar causes (n = 248; 17.8%), which included cerebral visual impairment as the main etiology (n = 143; 10.2% of the total) (Table 1). Regarding the anatomical site of the main diagnosis, in subjects under 15 years of age (n = 512) most cases were identified as retrobulbar (n = 184; 35.9%), followed by retina (n = 154; 30.1%) and whole globe (n = 60; 11.7%). In the group 15–49 years (n = 340), retina was the most affected site (n = 154; 45.3%), followed by retrobulbar (n = 45; 13.2%) and optic nerve (n = 44; 12.9%). For the subjects with 50 years and more (n = 541), retina was also the most frequently affected site (n = 378; 69.9%), followed by the whole globe (n = 64; 11.8%) and the optic nerve (n = 37; 6.8%). Approximately one out of three examined subjects were from Ribeirão Preto (n = 424), and 62.4% (n = 869) were residents from cities within a range of 150 km from Ribeirão Preto. There were no differences in the distances from the city where they lived and the rehabilitation service between the subjects who attended and those who missed their first appointments (p = 0.09).

Two hundred and seventy subjects (19.4% of the total, 266 of them children) did not inform VA. Among those who informed VA in the first appointment (n = 1123), moderate visual impairment was the most frequent
2168 subjects scheduled

252 did not attend

34 incomplete ophthalmological evaluation

442 presented BCVA ≥ 6/18 in any eye

47 presented no light perception OU

1393 subjects included

Figure 1. Flowchart of the subjects included in the study. BCVA best-corrected visual acuity, OU both eyes.

| n = 1393 | n | % |
|----------|---|---|
| Sex      |   |   |
| Female   | 666 | 47.8 |
| Male     | 727 | 52.2 |
| Age (years) |   |   |
| 0–14     | 512 | 36.8 |
| 15–49    | 340 | 24.4 |
| 50 or more | 541 | 38.8 |
| Main anatomical site |   |   |
| Retina   | 655 | 47 |
| Retrobulbar | 248 | 17.8 |
| Whole Globe | 157 | 11.3 |
| Optic Nerve | 113 | 8.1 |
| Uvea     | 101 | 7.2 |
| Lens     | 68  | 4.9 |
| Cornea   | 51  | 3.7 |

Table 1. Demographic and clinical characteristics of the subjects studied (n = 1393). n number of subjects.

| BCVA classification | 0–14 years | 15–49 years | 50 years or more |
|---------------------|------------|-------------|------------------|
| n                   | n (%)      | n (%)       | n (%)            |
| BCVA < 6/18 to 6/60 | 132        | 25.8        | 131              | 38.5 | 184 | 34.0 |
| BCVA < 6/60 to 3/60 | 65         | 12.7        | 95               | 27.9 | 195 | 36.0 |
| BCVA < 3/60 to 1/60 | 19         | 3.7         | 51               | 15.0 | 85  | 15.8 |
| BCVA < 1/60 to light perception | 30 | 5.9 | 59 | 17.4 | 77 | 14.2 |
| Unable to inform BCVA | 266 | 51.9 | 4 | 1.2 | 0 | 0 |

Table 2. Frequency of best-corrected visual acuity per age group studied (n = 1393). n number of subjects, BCVA best-corrected visual acuity.
BCV A found (n = 447; 39.8%), followed by severe visual impairment (n = 355; 31.6%) (Table 2). Figure 2 displays the frequency of subjects with FLV per age group.

The most frequent diagnosis in children was cerebral visual impairment (n = 143; 27.9%), followed by ocular toxoplasmosis (n = 42; 8.2%), retinopathy of prematurity (ROP) (n = 40; 7.8%) and congenital cataract (n = 37; 7.2%). For the group aged 15–49 years, the leading diagnosis was retinitis pigmentosa (n = 25; 7.4%), followed by cone/rod dystrophy (n = 22; 6.5%), congenital glaucoma/other glaucoma (n = 21; 6.2%), degenerative myopia (n = 21; 6.2%) and ocular toxoplasmosis (n = 21; 6.2%). The main diagnosis for the last group was age-related macular degeneration (AMD) (n = 141; 26.1%), followed by diabetic retinopathy (n = 98; 18.1%), glaucoma (n = 60; 11.1%) and degenerative myopia (n = 31; 5.6%) (Table 3). The analysis of the subgroups showed that in both 50–59 and 60–69 age groups, diabetic retinopathy was the main etiology, accounting for 36 (22.0%) and 36 (25.5%) cases, respectively, followed by AMD, with 13 (8.2%) and 22 (15.6%) cases, respectively. In individuals aged 70 years or older, AMD was the most frequent diagnosis (n = 105; 43.5%), followed by glaucoma (n = 34; 14.1%) and diabetic retinopathy (n = 26; 10.1%).

Among the subjects included in the study, 828 (59.4%) received at least one spectacle or optical device prescription (Table 4). Children received most of the spectacles/optical devices donated (106 out of 157; 67.5%) The most frequent items that were donated by the institution were loupes (n = 235), spectacles (n = 152) and telescopes (n = 78). Most donated loupes (n = 182; 77.4%) varied from 10 to 20 diopters, while 4 × and 6X magnification telescopes represented 93.6% (n = 73) of the donated ones (Table 5). Most commonly donated spectacles were spheric-prismatic lenses (n = 30; 19.7%), aspheric diopters (monocular) (n = 30; 19.7%) and divergent lenses (n = 24; 15.8%). The median elapsed time from prescription to donation was 10.8 months (range = 0 to 47 months) for optical devices and 3.8 months (range = 1 to 17 months) for spectacles.

Discussion

In this study of a large series of 1393 subjects seen in a tertiary Brazilian rehabilitation service, we observed that most cases had diseases affecting the posterior segment (n = 768; 55.1%; retina and optic nerve combined, uveitis not included). Older adults received more optical devices prescription, while children received more spectacle prescriptions. The rate of optical device acquisition, either donated or purchased, was high in all groups, ranging from 73.4% in individuals aged 15–49 years old to 90.9% in older adults. Although the quality of life of the subjects included in the study was not assessed, our results suggest that young adults, subjects with moderate visual impairment, and subjects with cone/rod dystrophy and albinism benefited most from the rehabilitation center. Since the cost of the spectacles and optical devices can be a barrier for part of the population, especially in low-middle income countries like Brazil, identifying those who cannot afford the prescribed aid and providing affordable, low-cost spectacles and optical devices is paramount for proper rehabilitation.

Age-related macular degeneration, diabetic retinopathy, and glaucoma were the leading causes of FLV in individuals aged 50 years or older. This is in agreement with most Brazilian population-based studies, although interestingly, diabetic retinopathy does not seem to be a major blinding condition in the Brazilian Amazon region. Although diabetic retinopathy falls in second place as a cause of FLV in individuals aged 50 years or more, the disease is also present among the main causes in the 15–49 years group and was the leading cause of FLV in individuals 50–69 years old, reflecting an increased burden in economically-active individuals.

Retinopathy of prematurity, considered a leading cause of childhood blindness globally and in Latin America, was an important cause of FLV in children in the present study, but less frequent than CNS-associated disorders and ocular toxoplasmosis. Toxoplasmosis has a higher frequency and also a higher burden in Latin America than other regions of the world, and prophylactic measures related to water and food consumption and educational campaigns should target pregnant women in the region.
In other Brazilian studies, ocular toxoplasmosis and retinopathy of prematurity are also among the main diagnoses in children attending rehabilitation services.20,21 However, retinopathy of prematurity was the main diagnosis in a study conducted in children attending a Mexican low vision service.22 This reinforces the need for actions to preventable diseases.

We found an extensive time between prescription and donation of optical devices (median: 10.8 months). It is important to emphasize that this waiting time occurred in the first years of the Rehabilitation Center’s life, due to the difficulty in finding optical aid providers and combining the supply with the rules for releasing financial resources by the public health system. This is a time-consuming process initially and needs to be continuously improved, so that the waiting time is as little as possible and patients can be effectively rehabilitated.

We believe that the search for more suppliers and the reduction of bureaucracy for the use of public resources may substantially reduce this time interval.

### Table 3. Causes of functional low vision divided per age group (n = 1393).

| Condition | 0–14 years (n = 512) | 15–49 years (n = 340) | 50 years or more (n = 541) |
|-----------|----------------------|-----------------------|----------------------------|
| Cerebral Visual Impairment | 143 (27.9) | Retinitis Pigmentosa 25 (7.4) | AMD 141 (26.1) |
| Ocular Toxoplasmosis | 42 (8.2) | Cone/Rod Dystrophy 22 (6.5) | Diabetic Retinopathy 98 (18.1) |
| ROP | 40 (7.8) | Cong. Glaucoma Other Glaucomas 21 (6.2) | Glaucome 60 (11.1) |
| Cong. Cataract | 37 (7.2) | Degenerative Myopia 21 (6.2) | Degenerative Myopia 31 (5.7) |
| Ocular Malformations | 30 (5.9) | Ocular Toxoplasmosis 21 (6.2) | Retinitis Pigmentosa 23 (4.2) |
| Cong. Glaucoma / Other Glaucomas | 30 (5.9) | Cong. Cataract 20 (5.9) | Retinal Detachment 21 (4.1) |
| Nystagmus / Strabismus | 29 (5.7) | Diabetic Retinopathy 18 (5.3) | Other Maculopathies 20 (3.9) |
| Albinism | 18 (3.5) | Other Maculopathies 16 (4.7) | Corneal Opacity 12 (2.2) |
| Cong. Infection (Toxoplasmosis excluded) | 15 (2.9) | Corneal Opacity 12 (3.5) | Macular Hole 10 (1.8) |
| Cone/Rod Dystrophy | 14 (2.7) | Retinal Detachment 12 (3.5) | Alcohol-Tobacco Neuropathy 9 (1.6) |
| Optic Nerve Hypoplasia | 12 (2.3) | Albinism 10 (2.9) | Anterior Ischemic Optic Neuropathy 9 (1.6) |
| Other Retina Diseases | 51(10.0) | Keraotonous 10 (2.9) | Ocular Toxoplasmosis 8 (1.4) |
| Other Optic Nerve Diseases | 20 (3.9) | Optic Nerve Compression 9 (2.7) | Other Retina/Choroid diseases 40 (7.4) |
| Other Segment Diseases | 18 (3.5) | Other Optic Nerve Diseases 44 (12.9) | Other Optic Nerve Diseases 21 (3.8) |
| Othera | 13 (2.6) | Other Retinal Diseases 27 (7.9) | Other Anterior Segment Diseases 10 (1.8) |
| Otherb | 58 (17.0) | Other Retinal Diseases 27 (7.9) | Other Segment Diseases 28 (5.2) |

### Table 4. Prescription and acquisition of spectacles and optical devices per age group (n = 1393). n number of subjects.

| Spectacles n = 397 | 0–14 years n = 512 | 15–49 years n = 340 | 50 years or more n = 541 |
|-------------------|------------------|------------------|------------------|
| Prescription | 154 30.1 | 108 31.8 | 135 24.9 |
| Acquired with own resources | 24 15.6 | 88 81.5 | 54 40.0 |
| Donation | 25 16.2 | 7 6.5 | 4 3.0 |
| Unacquired | 105 68.2 | 13 12.0 | 77 57.0 |

| Optical Devices n = 609 | Prescription | 157 30.6 | 188 55.3 | 264 48.8 |
| Acquired with own resources | 12 7.6 | 39 20.7 | 127 48.1 |
| Donation | 106 67.5 | 99 52.7 | 113 42.8 |
| Unacquired | 24 24.8 | 50 28.6 | 24 9.1 |

In other Brazilian studies, ocular toxoplasmosis and retinopathy of prematurity are also among the main diagnosis in children attending rehabilitation services, whereas retinopathy of prematurity was the main diagnosis in a study conducted in children attending a Mexican low vision service.22 This reinforces the need for actions to preventable diseases.

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Strengths of our study include the substantial number of enrolled subjects, the inclusion of all age groups, information on different VA categories, and also prescribed/donated spectacle correction and optical devices. Limitations of the work reflect its retrospective nature, including the inability to assess refractive error data and some ocular findings, for example disc pallor in children. Also, we were unable to assess the adherence to the use of donated spectacles and optical devices, and whether the subjects use any electronic devices, such as cell phone cameras as a magnifying glass and mobile apps for low vision. This study was conducted at a tertiary referral public hospital clinic, and the exact causes of functional low vision and their importance in the sample may not reflect the reality in the region, since there are many barriers in access to public health care and part of the population uses the private health system.

Future studies including longitudinal component and multidisciplinary approach in rehabilitation centers to provide holistic healthcare to people with visual impairment are needed.

Our results indicate that preventable diseases are important causes of functional low vision in children in the area, and proper prenatal care and educational campaigns could reduce their burden. The increasing life expectancy in Brazil and most Latin American countries and the diabetes epidemic are likely to increase the demand for affordable, people-centered rehabilitation centers, and their integration into health services should be planned accordingly.

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Author contributions
M.M.F, R.A.F and J.M.F wrote the manuscript; M.M.F collected data; R.A.F and J.M.F analyzed the data and supervised the study.

Competing interests
The authors declare no competing interests.

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