Prevalence, management strategies, and visual outcomes of amblyopia among paediatric patients at Kenyatta National Hospital, Kenya

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ABSTRACT

Amblyopia is a major cause of preventable visual impairment among paediatric population. Global prevalence was estimated at 1.44% by Fu et al., 2020, with the burden projected to rise to 175 million in 2030. Management strategies include optical correction, patching, atropine, and dichoptic therapy. This study aimed to determine the prevalence, management strategies, and visual outcome of amblyopia among paediatric patients at Kenyatta National Hospital. A retrospective clinical case series study design was adopted. The study population included all paediatric patients aged neonate to 18 years who were diagnosed with amblyopia and seen at Kenyatta National Hospital between August 2023 and September 2025, as identified through record books. Data were analyzed using SPSS 26.0, descriptive statistics, Pearson's chi-square test for associations between categorical variables, and regression modelling to identify predictors of clinically meaningful visual improvement. Prevalence is the proportion of the paediatric population with amblyopia within the study period. A total of 7,041 paediatric patients visited the facility within the study period; 106 were diagnosed with amblyopia and met the study criteria, giving a hospital-based prevalence of 1.51%. The cohort received combined management strategies; optical correction was the most commonly adopted strategy and was found to be statistically significant at $p < 0.001$ (71.7%); patching was applied (n=61, 57.5%); surgical intervention (n=38, 35.8%); and atropine penalization (n=4, 3.8%). Baseline index eye visual acuity was poorer than final visual acuity, indicating overall improvement. Shapiro-Wilk $p<0.001$ was used to analyze baseline VA, final VA, and VA improvement. The baseline mean visual acuity index (Log MAR) was 0.792, and the final mean was 0.554; 48 patients (45.3%) achieved clinically significant vision improvement of≥ 0.2 lines. Mean age at diagnosis was 7.55 years; older age at diagnosis and bilateral presentation remained associated with lower odds of ≥0.2-line improvement, and worse baseline VA remained strongly associated with higher odds of improvement. Pre-school visual screening and management of refractive errors are recommended for early diagnosis and management of amblyopia.

Keywords: Amblyopia, Atropine, Eyeglasses, Eye Occlusion, Prevalence, Visual Acuity, Vision Screening

I. INTRODUCTION

Amblyopia is a visual developmental disorder affecting one or both eyes, with no apparent organic cause, commonly presenting in the paediatric population as a monocular cause of visual impairment (Challa, 2022). Untreated amblyopia in the paediatric population is linked to long-term consequences, such as decreased motor skills, academic underperformance, socioeconomic challenges, and an increased chance of legal blindness if the non- amblyopic eye is diseased or injured; therefore, prompt diagnosis and management are necessary. Fu et al.'s systematic review reported a pooled prevalence of 1.44%: 2.90% in Europe, 2.41% in North America, 0.90% in Asia, and 0.72% in Africa(Fu et al., 2020). With the global burden of amblyopia postulated to increase to 175.2 million by 2030 and 221.9 million by 2040, this exponential growth rate warrants effective screening, diagnosis, and management. Among paediatric populations, management of amblyopia demands extended therapeutic intervention with consistent follow-up through reviews to account for prolonged visual recovery trajectory. Prevalence studies on amblyopia in Kenya are scarce. Muma, in his study of vision impairment, found amblyopia accounted for 24% of the 2.41% prevalence of visual impairment (Muma & Obonyo, 2020). In contrast, a study conducted in western Kenya found a prevalence of 0.66% (Signes-Soler.,2024). Kenya, as a region, lacks adequate clinical case series amblyopia data specific to the paediatric population, which play a role in informing policies for preferred patterns of practice unique to our health systems, planning, and financial allocation to screening processes that have often proved important in early diagnosis.

The current international standards of preferred practices for managing amblyopia are patching, optical correction, and dichoptic digital therapy, which covers the binocular aspect and is currently gaining momentum(Cruz et al., 2023). Prognostic characteristics that often influence the visual outcome for amblyopia are age at diagnosis, age at initiation of therapy, severity of amblyopia, and compliance with the management strategy administered. Optical

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correction modalities include Bangerter filters, optical penalization, and corrective lenses. (Agervi, 2011) Seong Kim, in a cohort prospective study administering Bangerter filters, found that there was a log MAR improvement of 0.1 in 30% of the sample size when the cohort was followed up for 10.4 months(Lee & Kim, 2021). Patching therapy has been the preferred monocular approach to amblyopia, with various studies crediting its effectiveness(Kadhum et al., 2024). However, it is faced with compliance issues; hence, clinically, some practitioners prefer extended optical treatment, lessening patch duration for better prognosis(Zhou & Zhou, 2024)The visual outcome of amblyopia from a compiled PEDIG studies 2002-2021 showed various outcomes, in a study of randomized trials comparing occlusion vs. pharmacologic therapy for moderate amblyopia found a VA improvement of 3.16 lines in the occlusion group and a 2.84 line improvement in the atropine group when the study population was followed for six months (Cruz et al., 2023)

Paediatric eye care services in Kenya are sparse, with limited epidemiological data on the prevalence, management strategies, and visual outcomes of amblyopia despite amblyopia being pathology of silent impairment during the critical and sensitive period. Kenyatta National Hospital, being the largest referral Hospital in Kenya, serves as a critical hub for paediatric eye care services. Yet, no comprehensive study has assessed the burden of amblyopia or the effectiveness of the current management strategies in its patient population, from neonates to 18-year-olds. This study aimed to assess the prevalence, management strategies, and visual outcomes of amblyopia among the paediatric population at KNH, from neonates to 18 years, between August 2023 and September 2025. This study sought to generate critical insights into the burden of amblyopia, clinical practices, and therapeutic efficacy within Kenya's unique healthcare context

1.1 Statement of the Problem

Children up to 7 years of age are generally not aware of the difference between good and poor vision; therefore, they often do not report it. In severe presentations of poor vision, guardians or parents often pick up non-verbal cues from toddlers such as bumping into surfaces while walking, assuming abnormal head posture when needing to see things, or squinting. Amblyopia disrupts early visual pathway development during the critical and sensitive period, particularly between the neonatal period and about 6 years of age. During this period, the visual circuitry is most active, and any form of disruption in the form of blurred images to the visual cortex or opacities along the visual axis can lead to amblyopia. Amblyopia, being a disease of childhood, is important to diagnose early to prevent consequences that ensue in children who are unable to read and write well early on in life.

Amblyopia accounts for about 24% of causes of visual impairment in Kenya(Muma & Obonyo, 2020), and is the leading cause of monocular visual impairment among paediatric populations. Refractive errors, a major and leading risk factor for amblyopia, have been estimated to cause a loss of about 671 million to 10.4 billion in gross domestic product (Muma et al., 2024). This productivity loss is why the amblyopia burden is important. Current gaps include insufficient data on amblyopia prevalence, the adopted management strategies, and visual outcomes. Moreover, socio-economic complexities such as compliance and follow-up may exacerbate poor visual outcomes.

Despite the availability of evidence-based and gold-standard management guidelines for Amblyopia by the Paediatric Disease Investigator Group and American Academy of Ophthalmologists, these guidelines do not account for the unique regional differences in Kenya. PEDIG AAO guidelines were adopted following clinical trials in high-income resource countries where there are a higher proportion of paediatric ophthalmologists, readily available pharmacological intervention, and specific pre-school screening guidelines for the paediatric population. Paediatric eye care services in Kenya are disproportionately distributed, with the majority of the specialized eye care services being concentrated in urban areas, particularly the capital city of Kenya. Amblyopia, being a disease of childhood, lacks standardized treatment protocols unique to the regional setting, coupled with a lack of standardized eye screening programs for the paediatric population within the country. Kenya being a low-income country, provision of paediatric eye screening is frequently sporadic, with efforts typically supported by programs and non-governmental initiatives. Moreover, there is limited epidemiological data on the prevalence, management strategies, and visual outcomes of amblyopia specific to Kenya, factoring in the manpower and resource constraints. Kenyatta National Hospital, being the largest referral Hospital in Kenya with the majority of employed paediatric ophthalmologists, serves as a critical hub for paediatric eye care services. Yet, no comprehensive study has characterized the clinical profile and assessed the burden of amblyopia and the effectiveness of the current management strategies in its patient population, from neonates to 18-year-olds

1.2 Research Objective

i. To determine the prevalence of amblyopia among paediatric patients at Kenyatta National Hospital.
ii. To identify the management strategies adopted for amblyopic paediatric patients at Kenyatta National Hospital
iii. To determine the visual outcomes of the paediatric population being managed for amblyopia at Kenyatta National Hospital

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II. LITERATURE REVIEW

2.1 Theoretical Review

Several clinical definitions exist for amblyopia, including definitions based on visual acuity, multifactorial definitions, and definitions based on behavioral and neurophysiological measures. According to the widely accepted definition based on visual acuity, amblyopia is defined as an intraocular difference of two lines on the Snellen chart with best-corrected visual acuity and normal visual pathway findings (Blair et al .2024). Although this definition is widely used, it frequently misclassifies mild amblyopia, understates its prevalence, and may overestimate the success rate of management strategies for mild amblyopia.

The study was guided by three main theoretical frameworks: the Epidemiological Model (Hethcote, 1989), the Health Belief Model (HBM) (Rosenstock, 1974), and the Neuroplasticity Theory (Hubel & Wiesel, 1970). Collectively, these theories provided a foundation for understanding the prevalence of amblyopia, factors influencing treatment-seeking behaviour, management strategies, and visual outcomes among paediatric patients managed for amblyopia at Kenyatta National Hospital between August 2023 and September 2025.

The epidemiological model provided a basis for understanding the distribution and determinants of eye conditions within the study period, providing a foundation for understanding the prevalence of the condition. According to this model, the key concepts for this study specifically were the risk factors, which are demographic factors i.e., age, gender, prenatal factors, and genetic factors like Down syndrome that predispose the paediatric population to strabismus and contribute to the prevalence of amblyopia among the neonate to 18-year-old paediatric population at KNH.

Descriptive epidemiology, according to the model, characterized the pattern of amblyopia by looking at patients' age and gender, and also elucidating whether there are trends over the study period. Epidemiological analysis of the above factors aided in addressing the prevalence component of this study. It provided the baseline data needed to understand the scope of the problem. The model also emphasizes the importance of early detection and screening through public health initiatives, which are essential for lowering the prevalence of amblyopia in the paediatric population.

The Health Belief Model was adopted as a theoretical lens to elucidate patterns in the quantitative amblyopia management findings, such as low atropine uptake and variations in the changes of management strategies from one to another rather than a construct measured directly, as the study design did not support collection of the caregiver report perception data that underpins the constructs of the model. Key constructs in the Health Belief Model are perceived susceptibility, perceived severity, perceived benefits, cues to action, and self-efficacy. Perceived susceptibility describes how likely parents or guardians of children with ocular pathway obstruction conditions at the sensitive and critical period believed their child was likely to develop amblyopia. Perceived severity is how serious they perceived the consequences of not addressing the causative factors that predisposed their children to amblyopia. Furthermore, perceived benefits were linked to the research in that it addressed the perceived advantages of seeking treatment for amblyopia and adherence upon diagnosis. Perceived barriers in this study were the challenges guardians and parents faced throughout the management process, like the cost of spectacles, the cost of travelling to the hospital for the appointments, and the cost of time they missed working due to the multiple visits needed. Cues to action as a construct motivated the decision to seek management for amblyopia in their children, which stems from parents noting the child struggling to read, squinting, or crying when the good eye is obstructed in pre-verbal children. Finally, self-efficacy showed how parents adhered to patching because of improved vision in their child.

Health Belief Model explained the relationship between management strategies and visual outcome. Understanding the long-term effects of amblyopia frequently influences parents' decisions to adhere to recommended interventions, such as patching. The neuroplasticity model describes how the brain's capacity for visual correction changes with age. Neuroplasticity Theory and the Critical Period Hypothesis shed light on visual outcomes. According to neuroplasticity theory, younger children's visual cortex is more malleable; early intervention results in better visual prognosis. The degree of neural adaptation and the timing of intervention are related to the efficacy of various treatment modalities, such as patching and vision therapy. To optimize favorable visual results, this theory thus supports the necessity of prompt diagnosis and efficient management techniques. The Neuroplasticity model provides the biological rationale for the relationship between management strategy and visual outcome.

Together, epidemiological trends define the disease burden, while the Health Belief Model explains parental health-seeking behaviors and treatment adherence to the management strategies, and neuroplasticity models elucidate the critical window for visual pathway development, which directly determines final treatment success as recorded as visual outcome. Recognizing these connections will help close early detection gaps, improve treatment regimens, and enhance paediatric patients' long-term visual prognosis.

2.2 Empirical Review

The empirical literature on amblyopia is organized below around the objectives of this study, which are the prevalence, management strategies, and visual outcome. The review seeks to appraise what is currently known, highlight

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areas where the literature agrees and contradicts, and therefore establish gaps this study addressed. Amblyopia prevalence globally and regionally has predominantly been estimated using data from population- or school-based screenings. A systematic review by Fu et al. (2020) estimated global prevalence at 1.44%, with variations among continents as follows: Europe 2.9%, North America 2.41%, Asia 0.90%, and Africa accounting for the lowest percentage of 0.72%; the review estimated a rise in the burden of amblyopia to 175.2 million by 2030. Moreover, pooled data from 97 studies by Hu et al. (2020), with the meta-analysis accounting for more than 4.6 million children, reported a community-based prevalence of 1.36% that is comparable worldwide. In Denmark, similarly, community- and school-based screening studies (Hansen et al., 2019) and in Korea, in studies involving unselected sample child populations(Yoon & Kim, 2020), reported prevalence below 1.5%, with Korean surveys reporting a decline in amblyopia prevalence owing to the screening programs, from 10% to 1% at 5 years and 8 years, respectively.

In marked contrast, clinic- and hospital-based case series have consistently reported higher prevalence. In an Ethiopian study by Woldeyes and Girma (2008), which screened 2,020, children, 183 had amblyopia, from a paediatric ophthalmology unit , reported a prevalence of 9.1, moreover an equivalent tertiary institution in Nigeria reported a prevalence of 12.9%(Alarape et al., 2017).In Kenya, specifically, amblyopia data among the paediatric population remain inconsistent and scarce; a review profile of amblyopia at Sabatia Eye Hospital by Fu et al. (2020) restricted their study population to 7-8 years, which excluded the younger population at their sensitive and critical period and the adolescents in whom emmetropization is still ongoing. On the other hand, a Kenya Eye Study by Muma and Obonyo (2020) reported that amblyopia accounted for 24% of the 2.4% prevalence of visual impairment among children nationwide, whereas Signes-Solar et al., (2024), by contrast, reported a lower prevalence of 0.66%% in school screening studies in Western Kenya.

Compiled together, these studies elucidate a consistent pattern rather than a genuine contradiction: low prevalence is generally reported in community-based studies, while a higher prevalence has consistently been reported in tertiary hospital institutions and clinics. Moreover, the institutions report five to ten times higher prevalence, which can be accounted for by complex, undiagnosed, treatment-resistant cases in the institutions. This distinction matters methodologically; hospital-based prevalence reports the caseload, case mix, and service demand faced by referral institutions such as Kenyatta National Hospital but cannot be generalized as a community burden. Yet no identified Kenyan study has generated Hospital-based prevalence data across the full paediatric age range, neonate to 18 years, at the national referral hospital; existing local evidence is either restricted to a narrow age band (Wanyonyi et al., 2020), drawn from school screening programs (Signes-Soler et al., 2024), or dated relative to current service delivery. This empirical and contextual gap directly justifies the first study's objective of prevalence.

The evidence base for amblyopia management strategies is predominantly anchored in systematic reviews and randomized controlled trials largely conducted in high-income settings, synthesized in the American Academy of Ophthalmology Amblyopia Preferred Pattern of Practice (AAO PPP) (Cruz et al., 2023; Wallace et al., 2018). AAO PPP recommends prescription of glasses as the first-line therapy for refractive amblyopia; for patching or occlusion therapy, they recommend dosage in line with severity, where moderate to severe cases require a regimen of 2- 6 hours of patching per day. Weekend atropine penalization as an evidence-equivalent alternative to the patching regimen for noncompliant cases. In agreement with this is a systematic review by Alrasheed and Aldakhil (2024), who reported that up to one-third of bilateral refractive amblyopia cases resolve through full-time spectacle wear. By contrast, differed from the former, placing emphasis on the timing of the initiation of management rather than the extended optical treatment duration alone. Adoption of atropine clinically in real world settings diverge from the AAO PPP guidelines, a study in a Scottish cohort and a study in Hong Kong the studies reported an approximate of 30-40% non-compliance samples being switched to atropine having subsequent a good prognosis (Jeganathan et al., 2016; Sit et al., 2023) yet findings from practices by optometrists in Ghana where atropine was markedly underused, reflecting probably resource and formulatory constraints rather than a lack of evidence for atropine effectiveness(Acheampong, 2022).

Binocular and surgical approaches: studies concluding randomized controlled trials cite that dichoptic therapy, which is a binocular approach to managing amblyopia contrasted with former monocular regimens, is gaining favorable momentum(Kadhum et al., 2024). Surgical intervention from a Cochrane review of strabismic amblyopia management favors visual acuity changes when an optical regimen is administered as opposed to recession-resection surgical intervention(Taylor & Elliott, 2014). These syntheses are synchronized from digitally resourced and high-income health systems.

Lastly, two patterns emerge from the synthesis of these studies: first, combined individualized adoption of the management strategies (optical, patching, surgical, atropine penalization) outperforms adoption of one strategy, but disagreement person on the sequencing , dosing and duration of administration of the regimen(Li et al., 2020) versus(Zhou & Zhou, 2024). Secondly, the African empirical source looked into the providers, optometrists, and patterns rather than the hospital records, which reflects the sequences in the management and outcomes provided in an African tertiary referral setting. This is a contextual and methodological gap between real-world documented practice and trial-derived recommendations that the present retrospective clinical case series addresses through the management strategies adopted for management of amblyopia, objective two.

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Literature on visual outcomes of amblyopia is reasonably well standardized using visual acuity definition, according to Park and Paediatric Disease Investigator Group randomized controlled trials derived definition converge of a clinically significant improvement in visual acuity as a threshold of ≥0.2 Log MAR that is equivalent to a two improvement in Snellen acuity chart (Park, 2019). However, Repka (2020) argued that there is more room for appraisal of visual acuity in how findings from trials are adopted into clinical and practice management of amblyopia, taking into consideration the confounding factors that are factored in controlled trials, such as age of the patient, age at diagnosis, severity of amblyopia, and compliance with treatment.

Literature consistently converges on visual outcome predictors. Studies from cohorts covering samples with ages within the sensitive and critical visual development period, below 8 years, have reported better prognostic findings(Cotter et al., 2006), with similar findings reported in observational hospital cohort studies. A Nepalese and a Thai clinical cohort reported that among compliant samples there was a ≥ 2-line gain in the Snellen chart within a period of mean time of 13.69, while compliance with treatment increased the odds of successful outcomes by 43-fold (Kalti et al., 2021; Montriwet, 2022). Age, age at diagnosis, and severity of amblyopia emerge as dominant predictors of visual outcomes (Kalti et al., 2021) across different study designs and settings, strengthening the confidence in these generalizable predictors rather than artefacts of a particular study design.

African empirical evidence is fairly descriptive of the visual outcomes. Studies conducted in Nigeria and Ethiopia have generally reported the profile and clinical characteristics of amblyopia patients, but fell short of modelling the aforementioned predictors of visual outcomes (Gebru et al., 2022; Woldeyes & Girma, 2008). A comparable tertiary institution in the Philippines does not extend the analysis of the data to multivariable analysis but only reports the profile of amblyopia. Western paediatric disease investigator groups apply multivariable regression to quantify the independent contribution of age, laterality, baseline severity, and management approaches to visual outcomes, whereas comparable studies in Africa and low- and middle-income countries have rarely applied regression analysis.

In conclusion, a methodological and geographic divide exists within the empirical literature review. High-income countries adopt their approaches predominantly from evidence drawn from randomized clinical trials that have culminated in preferred patterns of practice whose applicability to resource-constrained African clinical practices is uncertain, while studies in Africa are mainly descriptive, sampling a narrow age band and not integrating the objectives of this study within one study. There is scarce evidence that has jointly examined prevalence, management strategies, and visual outcomes within one study across an age gap of neonates- eighteen years at an African national referral hospital. Therefore, it is this combined empirical, methodological, and contextual gap that prompted the retrospective cohort study at Kenyatta National Hospital.

III. METHODOLOGY

3.1 Research Design

This study adopted a retrospective clinical case series undertaken at Kenyatta National Hospital. The study design was adopted as it permitted specific condition description, which in this study was amblyopia, through medical records without requiring comparison against a control group. Case files of the paediatric population within the study period, August 2023 to September 2025, were retrieved and reviewed. Data abstraction was done entirely from the clinicians' notes, including data on age, age at diagnosis, entry visual acuity, type and severity of amblyopia, and final visual acuity. The study period was chosen in order to aid in the quantification of visual outcomes of amblyopia. The paediatric sample summary statistics were provided as a whole to capture the age, age at diagnosis, the type and severity of amblyopia, mean durations of different management strategies adopted, and also changes observed between the final and initial visual acuity to quantify visual outcome. The study design therefore presented the clinical characteristics of the sample, management strategies adopted, together with the statistical modelling of predictors of visual outcomes consistent with the objectives of the study.

3.2 Study Area

The study was conducted at the Ophthalmology Department of Kenyatta National Hospital, Nairobi, Kenya. The facility was chosen because it is the largest public tertiary institution with affiliations to the University of Nairobi and is important, serving as a critical hub for specialized paediatric eye services, receiving referrals from primary and secondary health facilities across the Country. This referral status makes the facility an appropriate setting for characterizing the clinical burden and management of paediatric amblyopia, as the hospital's paediatric clinic concentrates cases requiring specialist diagnosis and management that would not typically be captured in primary eye-care or community-screening settings.

3.3 Target Population

The target population comprised all paediatric patients, as defined by the Modified Munich age classification system, which categorizes the paediatric population from neonate to 18 years old (Asaduzzaman, 2024). The sample

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population was drawn from the sample frame of the paediatric population who visited KNH between August 2023 and September 2025. The accessible paediatric population from which the sample population was drawn consisted of a subset of these paediatric attendees who were diagnosed with amblyopia, using the institution's amblyopia diagnostic criteria, and who had corresponding records in the clinic's record book. Patients with amblyopia present with poor vision despite best-corrected visual acuity and with no structural ocular anomalies.

3.4 Sampling and Sample Size

The study adopted a retrospective census sampling technique to recruit the sample population; all paediatric patients diagnosed with amblyopia during the study period were included, eliminating selection and sampling error. Power analysis and a formal sample size calculation were not required as a census design was adopted. This design ensured that, for KNH specifically, the data demonstrated a higher internal validity representing the paediatric population visiting the clinic; however, external validity was limited due to the single-center data abstraction as compared to a multi-center randomized sample.

3.5 Data collection Instruments and Procedures

The research team was composed of two research assistants (2 record officers) and a researcher. Before data collection, research assistants were trained on how to abstract the data by the principal investigator. Training included the inclusion and exclusion criteria of the study, with emphasis on distinguishing amblyopia diagnosis from other diagnoses among the paediatric group within the study period. Furthermore, the research assistants, being record officers from KNH, were acquainted with patient identification numbers and were trained to include the correct date of visit and the age of the patient on the designated data collection tool. The training aided in minimizing inter-observer variability and ensuring consistency prior to file retrieval at the Health Records Office on the eligibility criteria of the study.

The record officers aided in identifying the outpatient numbers of patients diagnosed with amblyopia by going through consultant register records at the ophthalmology clinic. They then presented the list of patients diagnosed with amblyopia to the Health Records and Information Management Clinic 19, which centrally manages patients' records and data, where the files were physically retrieved.106 patients who had been diagnosed with amblyopia met the eligibility criteria upon the perusal of the files. The research data were then fed into a data collection instrument that contained the study's variables of interest on Google Forms, which was used to collect the data by the researcher. The variables of interest in this study were the demographic data of the patient (age, gender), age at diagnosis of amblyopia, the entry visual acuity, the type of amblyopia diagnosed, the etiology of amblyopia diagnosed, laterality of amblyopia, severity, how soon therapy was initiated, the type of therapy initiated, duration of the therapy, and finally the final visual acuity.

The amblyopia types of interest were strabismus, which is amblyopia due to misalignment of the eyes; refractive (anisometropia and isometropia) due to uncorrected refractive error; and deprivation amblyopia, which is a result of lack of visual stimulation due to obstruction in the visual pathway, due to organic or nonorganic causes(Kadhum et al., 2024b).

3.6 Data Analysis

The data collected in the research were entered into Excel, cleaned, and coded. The data were analyzed using IBM SPSS software (version 26). Descriptive statistics and chi-square tests were used for secondary analysis of objective 1 to ascertain whether prevalence differs significantly across demographic groups and clinical subgroups, which were stratified in terms of age groups, gender, and type of amblyopia. Prevalence was calculated by dividing the total number of amblyopia cases within the study period by the total number of paediatric patients seen during the study period. Objective 2 employed a chi-square test of independence to determine whether there was a significant association between categorical variables, and a regression model was employed to compare the before-and-after changes in visual acuity in amblyopic patients following the employment of management strategies. The output expected following analysis: the prevalence of amblyopia and clinical characteristics within the study period, the management strategies of amblyopia, and the visual outcome

3.7 Ethical Consideration

The study commenced after permission was sought from the Hospital management and ethical approvals from the institutional ethical review committee at Masinde Muliro University of Science and Technology (MMUST/ISERC/188/2025) and Kenyatta National Hospital-University of Nairobi (KNH-UON ERC P805/10/2025). A research license to conduct data collection on human subjects was also obtained from the National Commission for Science, Technology and Innovation (NACOSTI/P/25/4182317). The Kenyan legal framework, specifically the Health Act of 2017, emphasizes the importance of informed consent for research involving human subjects, the act also emphasizes that for retrospective data, informed consent is waived through approvals made by ethical review board that oversights the specific study, in this study the research team did not interact directly with the sample owing to the

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retrospective nature of data collection; hence informed consent was waived, as seen by amblyopia retrospective study conducted by Stults et.al in Kenya(Stults et al., 2024).

IV. FINDINGS & DISCUSSION

4.1 Findings

One hundred and six paediatric patients were diagnosed with amblyopia (56 males, 48 females); the majority of the sample was aged 5-9, while the lowest proportion was 15-18; the mean age at diagnosis was 7.6 years. During the study period, 7,041 paediatric patients visited the clinic, with 106 diagnosed with amblyopia, giving a prevalence of 1.51%. The management strategies administered were: eyeglasses in 70,74 (66%, 69.8%)cases in the right and left eyes, respectively; eye occlusion administered to 61 cases (57.5%); surgical intervention in 38 cases (35.8%); and atropine penalization in 4 cases (3.8%). Eyeglass dispensing was further examined by eye. The dominant recorded pattern was eyeglasses dispensed with follow-up; prescription changes were observed in 62 right eyes (58.5%) and 61 left eyes (57.5%). Eyeglasses were not dispensed in 36 right eyes (34.0%) and 32 left eyes (30.2%). The most frequently prescribed initial eye occlusion regimen was 2 hours per day (50.8%), followed by 4 hours per day eye occlusion (19.7%) and 1 hour per day occlusion (16.4%). Among the 52 cases with complete numeric records for both eye occlusion intensity and treatment duration, the mean initial eye occlusion intensity was 2.35 hours per day (SD 1.14; median 2; range 1–6 hours). The mean initial treatment duration was 2.98 months (SD 1.71; median 2; range 1–9 months). Notably, the mean final treatment duration was considerably longer at 9.21 months (SD 5.28; median 8; range 1–24 months).

Table 1

The Initial and New Eye Occlusion Regimens for Paediatric Amblyopic Patients Seen at the Kenyatta National Hospital Ophthalmology Clinic

Initial Regimen category	N	Valid %	New regimen	N	Valid %
1 hour/day patching	10	16.4	1-hourly	6	46.2
2 hours/day patching	31	50.8	2-hourly	3	23.1
3 hours/day patching	3	4.9	30 minutes a day	2	15.4
4 hours/day patching	12	19.7	4-hourly	2	15.4
6 hours/day patching	1	1.6			
Atropine penalization	4	6.6			

Visual acuity data were available for all 106 participants, using an index eye approach; the worst baseline eye visual acuity (VA) ranged from 0.3 to 1.0 log MAR (mean 0.792, SD 0.242; median 0.900). Final VA ranged from 0.2 to 1.0 log MAR (mean 0.554, SD 0.273; median 0.400). The distribution shifted toward better acuity at final assessment. The mean improvement in index eye VA was 0.239 log MAR (SD 0.276; range −0.6 to 0.8), with a median improvement of 0.200. Overall, 73 cases (68.9%) demonstrated any improvement (va_improve>0), 26 (24.5%) showed no change, and 7 (6.6%) exhibited a decline (va_improve<0). Clinically meaningful visual outcome was recorded as Log MAR ≥0.2 in n=48 (45.3%), while 58 (54.7%) did not. Older age at diagnosis, unilateral case, and worse visual acuity at baseline were associated with lower odds of obtaining a clinically significant visual outcome. Bilateral cases demonstrated a comparatively greater mean improvement in visual acuity relative to unilateral cases. However, this observed difference did not attain statistical significance ($F(1,102) = 2.922$, $p = 0.090$).

Table 2

Baseline and Final Visual Acuity in the Paediatric Population Seen at the Kenyatta National Hospital Ophthalmology Clinic

Measure	N	Mean (SD)	Median (IQR)	Min–Max	95% CI for mean
Baseline VA (index eye)	106	0.792 (0.242)	0.900 (0.4)	0.3–1.0	0.746–0.839
Final VA (index eye)	106	0.554 (0.273)	0.400 (0.5)	0.2–1.0	0.501–0.606
VA improvement (baseline − final)	106	0.239 (0.276)	0.200 (0.4)	−0.6–0.8	0.185–0.292

A multivariable logistic regression model was constructed to identify independent predictors of clinically meaningful visual acuity improvement, defined as achieving a gain of two or more lines on visual acuity testing, as shown in Table 3. The analysis was conducted using complete case methodology, resulting in a final analytical sample of 100 participants, with 6 cases excluded owing to missing covariate data. The overall model demonstrated strong statistical significance (Omnibus χ^2 df=9 = 30.773, $p<0.001$), confirming that the included predictors collectively contributed meaningful explanatory value beyond chance. Model fit was further characterized by moderate explanatory power, as reflected by Cox & Snell R^2 of 0.265 and a Nagelkerke R^2 of 0.354, indicating that the model accounted for a reasonable proportion of the variance in treatment outcome.

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Table 3

Independent Predictors of Clinically Meaningful Visual Acuity Improvement, Defined as a Gain of Two or More Lines on Visual Acuity Testing

	Adjusted OR	**95% CI**	**p-value**	**Interpretation**
Age at diagnosis (years)	0.876	0.773–0.992	0.037*	Older age is associated with lower odds of ≥2-line improvement.
Baseline VA (index eye)	122.316	9.705–1541.635	<0.001*	Worse baseline VA associated with higher odds of improvement.
Sex	1.211	0.473–3.101	0.690	No evidence of association.
Laterality (Bilateral versus Unilateral)	0.785	0.179–3.438	0.749	No evidence of association.
Eye occlusion (any flag)	2.330	0.851–6.383	0.100	Borderline association; however, not significant at 0.05.
Atropine (atropine initial flag)	0.191	0.015–2.445	0.203	No evidence of association.
Surgery (surgery any flag)	1.493	0.493–4.518	0.478	No evidence of association.
Any eyeglasses correction (eyeglasses correction any flag)	3.209	0.873–11.794	0.079	Borderline association; however, not significant at 0.05.

4.2 Discussion

The demographic characteristics of the paediatric amblyopic sample population in the current study resonate with other regional countries, with minor variations. The mean age at diagnosis of 7.55 years (SD 3.803; range 1–17 years) is closely matched by the Ethiopian tertiary cohort studied by Woldeyes and Girma, which reported a mean age at presentation of 6.9 ± 3.0 years(Woldeyes & Girma, 2008) and by a 2022 Ethiopian study by Gebru et al. that found strabismus was most common in children aged 5–9 years, with emmetropization typically complete by age 6(Gebru et al., 2022). However, it is lower than the mean age of 9.4 ± 3.9 years reported in the Nigerian tertiary cohort (Alarape et al., 2017). The 2016 Korean National Health and Nutritional Examination Survey found that amblyopia prevalence peaks at 10% among 5-year-old children, declining to 5.6% at 6 years, 3.8% at 7 years, and about 0.9% at 8 years, reflecting the impact of universal early screening and treatment programs (Yoon & Kim, 2020).

The present study's most common age group at diagnosis was 6–9 years (44.3%), followed by 3–5 years (21.7%), indicating that a large proportion of Kenyan children with amblyopia are not diagnosed until after the critical period for visual development before age 7, when treatment outcomes are less favorable. This delay is consistent with findings of extremely low parental awareness of amblyopia in Kenya, where fewer than 10% of caregivers could correctly identify the condition or its risk factors (Muma & Obonyo, 2020), and with data from the Philippines where Tamayo et al. noted that their lower age cut-off of 6 years, near emmetropization onset, excluded many older amblyopia patients, suggesting that even in Asian low middle income country settings, diagnostic delay beyond early childhood remains a major challenge (Tamayo et al., 2022).

The current study indicated the prevalence of amblyopia over the study period was 1.51%. A global meta-analysis, which pooled data from 97 studies including over 4.6 million children across all world regions, established a worldwide community-based prevalence of amblyopia of 1.36% (95% CI 1.27–1.46%), with the lowest regional rate recorded in Africa at only 0.38% (95% CI 0.25–0.67%) (B Hu et al., 2022). This contrast between community and tertiary care prevalence is well-documented and has been further identified in recent systematic reviews.

A synthesis of clinical trial and practice measurement data confirms that tertiary center case series consistently report 5–10-fold higher prevalence than population-based screening studies due to referral bias toward complex, undiagnosed, or treatment-resistant disease (Repka, 2020), which was not a finding in this setup. Another study at Menelik II Hospital, a comparable tertiary referral center in neighboring Ethiopia, reported a prevalence of 9.1% with 183 amblyopia cases among 2,020 children screened (Woldeyes & Girma, 2008), while a study at a paediatric hospital in Southwest Nigeria found an even higher rate of 12.9% with 57 cases among 441 children evaluated (Alarape et al., 2017). A Danish observational study found a prevalence of just 1.5% among children under 12 undergoing routine visual screening (Hansen et al., 2019), reflecting the impact of universal early detection programs that reduce the need for tertiary referral

Eyeglasses were dispensed to 66.0% of right eyes and 69.8% of left eyes with amblyopia, for an overall uptake rate of approximately 68%. This falls slightly below the 88.3% optical correction uptake reported among Ghanaian optometrists managing amblyopia in primary care settings (Acheampong, 2022), but is in line with data showing that spectacle correction alone resolves amblyopia in approximately one-third of refractive cases without need for additional treatment (Alrasheed & Aldakhil, 2024). Among cases with documented corrective power (76 total cases translating to 71.7% of the cohort), sphere-cylindrical correction combining spherical and astigmatic correction was by far the most common type, accounting for 88.2% of prescriptions, while spherical-only correction accounted for only 11.8%. This was comparable with the known epidemiology of paediatric amblyopia, where astigmatism is a leading contributor to refractive amblyopia, particularly in bilateral cases (Li et al., 2020).

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The strong association between bilateral amblyopia status and eyeglass uptake (88.1% of bilateral cases compared to 62.2% of unilateral cases) reflects the central role of refractive correction in bilateral amblyopia management. A systematic review found that full-time spectacle wear alone resolves amblyopia in up to one-third of bilateral refractive cases, with additional improvement seen over 16–22 weeks of adaptation before requiring occlusion therapy (Alrasheed & Aldakhil, 2024), a staged approach that appears to be followed given the high rate of optical correction with follow-up and prescription change in bilateral cases. For unilateral amblyopia, evidence confirms that refractive correction alone achieves meaningful visual gain in 25–30% of cases, but most required concurrent or subsequent occlusion therapy to reach maximal improvement (Li et al., 2020), explaining the lower but still substantial optical correction uptake in unilateral cases.

Eye occlusion or penalization therapy was documented in 57.5% of the cases, a rate nearly identical to the 58.5% patching uptake reported in the Ghanaian practice pattern study(Acheampong, 2022). This is lower than the 60% eye occlusion utilization rate observed in a Scottish cohort of children with moderate to severe amblyopia, where 40% of patients instead received weekend atropine penalization (Jeganathan et al., 2016), though more recent data from Hong Kong show growing adoption of atropine as first-line therapy in Asian settings (Sit et al., 2023). The difference in atropine use is quite notable. Atropine was prescribed to only 3.8% of all patients (4/106 cases), with use restricted exclusively to bilateral amblyopia cases (6.8% of bilateral cases, 0% of unilateral cases). In contrast, guidelines and updated practice patterns routinely offer atropine as a first-line alternative to patching, particularly for families with poor adherence to occlusion therapy, with the American Academy of Ophthalmology preferred practice pattern (AAA PPP) noting that weekend atropine and digital dichoptic therapies achieve equivalent visual acuity improvements to 2-hour daily patching while significantly improving adherence rates (Wallace et al., 2018). A review of amblyopia management in Hong Kong found that 30–40% of patching-nonresponsive cases are switched to atropine or combined atropine patching therapy, with significant additional visual acuity gains in 50–60% of these cases (Sit et al., 2023). The low atropine uptake is likely to reflect limited availability of 1% atropine drops in public sector formularies, as well as clinician preference for eye occlusion as a more familiar and monitorable intervention in resource-limited settings, though emerging evidence suggests that weekend atropine is well tolerated when available, with patients preferring it over complete dichoptic digital training due to lower cost and no need for therapist supervision (Acheampong, 2022; Blair et al., 2024).

Surgical intervention was recorded in 35.8% of KNH cases (38/106 total), with eye-specific strabismus surgery performed on 12 right eyes and 13 left eyes. This rate is consistent with tertiary facility cohorts where strabismic and sensory deprivation amblyopia account for a large proportion of cases. A systematic review found that surgical correction of strabismus or cataract, which are the underlying causes of deprivation amblyopia, is required in 30–40% of paediatric amblyopia cases presenting to referral centers, with combined recession-resection procedures achieving long-term alignment stability in 84–85% of paediatric cases (Alrasheed & Aldakhil, 2024). The predominance of combined recession-resection procedures among strabismus surgeries (83.3% of operated right eyes, 84.6% of operated left eyes) in this study resonated with standard practice for comitant strabismus correction in children, which prioritizes recession-resection to achieve long-term alignment stability (Taylor & Elliott, 2014).

The eye occlusion regimen distribution in this study showed concordance with Randomized Controlled Trials (RCT) evidence supporting part-time occlusion therapy for moderate amblyopia; the AAO PPP further stratifies patching dose by amblyopia severity, recommending 2 hours daily for moderate amblyopia (0.30–0.70 Log MAR, 6/12–6/24 Snellen) and 6 hours daily for severe amblyopia (>0.80 Log MAR, 6/30–6/120 Snellen) (Wallace et al., 2018). In this study, only 1.6% of cases were prescribed 6 hours daily of eye occlusion, while over 85% received ≤4 hours daily, as most cases 77.8% presented with mild to moderate amblyopia. Recent evidence in a comparable Nepalese referral cohort supports this duration range, finding that mean time to meaningful improvement (≥2-line gain) was 13.61 months for patients with good compliance, confirming that follow-up duration at Kenyatta National Hospital is within expected bounds for successful treatment completion (Kalti et al., 2021).

The overall visual acuity trajectory of the paediatric amblyopia cohort demonstrated statistically significant improvement from baseline to final assessment, with mean index eye visual acuity improving from 0.792 log MAR (SD 0.242, median 0.900) at baseline to 0.554 log MAR (SD 0.273, median 0.400) at final follow-up. This mean improvement of 0.239 log MAR was equivalent to approximately 2.4 Snellen lines on a standard chart, and fell within the range reported in major international RCTs and clinical guidelines. The updated AAO Amblyopia PPP, which synthesizes evidence from over 20 landmark Paediatric Eye Disease Investigator Group Randomized Controlled Trials (PEDIG RCTs) and recent digital therapeutic trials, reports that 2 hours of daily patching, the most common regimen prescribed in this cohort used by 50.8% of patched cases, yields a mean visual acuity improvement of 2.3 Snellen lines over 16 weeks of treatment (Wallace et al., 2018), nearly identical to the 2.4-line mean gain observed in this cohort.

Crude analysis of visual acuity improvement by laterality showed that bilateral amblyopia cases had a numerically greater mean improvement (0.280 log MAR, SD 0.273) than unilateral cases (0.187 log MAR, SD 0.278), though this difference did not reach statistical significance (p=0.090). This adjusted finding of lower meaningful success odds for bilateral amblyopia is consistent with prior evidence on bilateral disease treatment challenges. A PEDIG RCT

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of anisometropic (unilateral) amblyopia found that refractive correction alone resolved amblyopia in at least one-third of children aged 3–7 years (Cotter et al., 2006), whereas bilateral refractive amblyopia typically requires longer treatment durations and more aggressive regimens to achieve equivalent gains.

Furthermore, none of the individual treatment modalities assessed at KNH including patching, atropine, surgery, or optical correction reached statistical significance as predictors of ≥2-line improvement at the α=0.05 level in the primary multivariable model, though patching (aOR 2.330, 95% CI 0.851–6.383, p=0.100) and optical correction (aOR 3.209, 95% CI 0.873–11.794, p=0.079) showed borderline positive associations. This lack of statistical significance for treatment factors likely reflects three key limitations of this retrospective cohort study. First, heterogeneous treatment delivery with variable dosing and adherence, with only 57.5% of patients receiving documented patching or penalization therapy, and a mean patching duration of only 2.98 months initially. Second, there is a small sample size for some treatment subgroups; for instance, only 4 patients received atropine penalization. Third, there is a lack of sufficient adherence data, which is known to be the single most important modifier of treatment outcome in amblyopia care. A study found that good treatment compliance increased the odds of a successful outcome by 43-fold (Montriwet, 2022), and a network meta-analysis concluded that adherence to prescribed patching or atropine regimens explains up to 60% of the variance in visual outcomes across studies (Li et al., 2020)

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

This assessment of pediatric amblyopia care at Kenyatta National Hospital reveals a substantial but modifiable burden of preventable childhood vision loss, with 106 confirmed cases presenting at a mean age of 7.55 years well beyond the optimal critical period for visual development. The case profile is closely in line with regional low- and middle-income country referral center cohorts, characterized by slight male predominance, high rates of bilateral presentation driven by uncorrected refractive error, and predominance of mild to moderate disease severity that still leaves nearly a quarter of affected eyes with severe residual impairment. Management practices demonstrate strong alignment with PEDIG guideline global evidence-based standards, prioritizing optical correction as first-line therapy followed by part-time patching regimens that match randomized controlled trial efficacy benchmarks, though significant gaps exist in access to alternative penalization therapies such as atropine and structured long-term follow-up to support regimen adaptation. Visual outcomes are favorable on average, with a mean gain of 0.239 log MAR equivalent to approximately 2.4 Snellen lines, yet only forty-five percent of the treated paediatric population achieved clinically meaningful improvement of two or more lines, which is vision in which the sample experienced real, noticeable, and functional change to their vision, a rate constrained primarily by late age at diagnosis, which reduces neuroplasticity potential, suboptimal treatment adherence in observational care settings, and unique challenges in treating bilateral amblyopia where both eyes require simultaneous rehabilitation.

5.2 Recommendations

Clinical practice should prioritize early detection through integration of universal preschool vision screening into existing maternal and child health outreach programs, given that every additional year of age at diagnosis reduces odds of successful treatment by over twelve percent per the current study cohort multivariable model, and community health worker training in basic amblyopia red flag identification could significantly lower the current mean age at presentation toward the under-five target associated with >80 percent success rates in other global cohorts.

Second, amblyopia treatment protocols at KNH should be adapted to expand access to 1% atropine penalization as a first-line alternative to patching, particularly for unilateral cases and families reporting poor occlusion therapy adherence, as global evidence shows equivalent efficacy with far better compliance profiles, and local formulary advocacy to secure reliable one percent atropine supply could immediately address the current near-zero utilization rate in unilateral disease. Third, structured outcome tracking and adherence support systems should be integrated into routine care, including scheduled 6-to-8-week review cycles with standardized visual acuity assessment and clear criteria for dose escalation or modality switching when improvement plateaus, as the current low rate of documented regimen changes suggests missed opportunities to optimize treatment response in the large subset of non-responding patients.

Declaration of Interest

The authors declare that they do not have any known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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