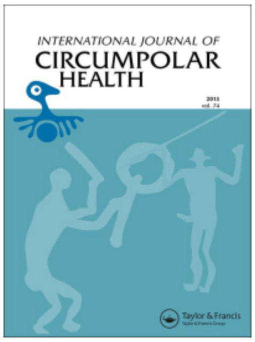

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Vision screening of school children in greenland 2017-2022: coverage and low vision prevalence

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ABSTRACT
Vision screening during childhood is vital for the early detection and treatment of visual impairment that may significantly impact a child's development and quality of life. This nationwide cross-sectional study used data from Greenland's national electronic medical records, including 2,493 six-year-old children from July 2017 to July 2023, to evaluate the coverage rate of vision screening and the prevalence of low vision in Greenlandic schoolchildren. The participation rate in vision screening increased from 43% in 2017 to 61% in 2022, while referral rates to ophthalmologists decreased from 14% to 5%, despite a consistent prevalence of low vision. The mean prevalence of impaired vision (0.3 logMAR / ≤0.50 Snellen decimal) in the better-seeing eye at the vision screening throughout the study period was 3%. At the same time, it was 8% for the worse-seeing eyes, indicating a continuous need for ophthalmological evaluation of the Greenlandic children. This study highlights healthcare delivery challenges in Greenland's sparsely populated areas and emphasises the need for new national guidelines to optimise referral processes. Utilising other healthcare professionals, such as optometrists, for vision screenings and ensuring follow-ups are critical for improving the visual health outcomes of Greenlandic children.

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KEYWORDS
Arctic; Greenland; school children; vision screening; visual acuity

Introduction

Early detection and treatment of visual impairment is essential to avoid negative impacts on children's development and quality of life. The World Health Organization (WHO) strongly recommends routine vision screenings to prevent and reduce the global burden of eye diseases, which may lead to severe vision loss or blindness if left untreated [1]. Early detection of reduced visual acuity in children vastly improves educational outcomes, social engagement, and overall well-being [2–4].

Greenland has adapted its healthcare system to its vast and sparsely populated areas by dividing them into five health regions. A regional hospital centres each region, while the capital hosts the national hospital, providing specialised care for all regions. However, there is no permanent ophthalmologist based in Greenland. Instead, visiting consultants from Denmark deliver annual examinations to each town. Between these visits, most ophthalmological assessments are conducted via telemedicine in nine of the sixteen towns, emphasising the reliance on remote healthcare solutions.

Greenland has implemented multiple screening programs targeting various health issues, such as hearing ability in children, gestational diabetes, diabetic eye disease, mammography, and cervical cancer. Despite these efforts, coverage rates for many of these programs are notably low, reflecting the logistical and infrastructural challenges of the healthcare system [5–7]. The diabetic eye disease screening program is among the most successful screening programs [8].

The vision screening program, conducted by school nurses, is critical to supporting children with developmental needs. In the current vision screening program, school nurses advise children to consult their local doctor or an optometrist if the visual acuity in their worse-seeing eye measures 0.2 Logarithm of the Minimum Angle of Resolution (logMAR) (0.63 Snellen decimal) or worse. However, the absence of permanent

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school nurses in some regions further reduces the effectiveness of these screenings.

In Greenland, ophthalmologists are the only eye care professionals authorised to prescribe glasses for children under the age of ten. Optometrists play a supportive role and may refer children directly to an ophthalmologist if they suspect that glasses are required.

Hence, the present study aims to evaluate the coverage rate of vision screening in schoolchildren in Greenland, identify the prevalence of low vision within this population, and assess the subsequent follow-up actions for those with visual impairments.

Methods

Design

A nationwide register study was conducted using data from Greenland's national electronic medical records (EMR).

Study population and data extraction

All residents of Greenland have a unique personal registration number (CPR), with the first six digits representing the date of birth. Using this, we extracted data from the EMR of all six-year-old children from July 2017 to July 2023. The data extraction took place in December 2023. The study extracted only medical records with a specific entry of a general health examination from the school nurse in the first grade of primary school. From these entries, we recorded visual acuity (VA) measurements of each eye, place and time of screening, and birthdate. If the VA was ≥ 0.2 logMAR (≤ 0.63 Snellen decimal) in either eye, we recorded information about any ophthalmological examinations, treatments, and future vision screenings.

Screening results were divided into school years from July 2 to July 1 of the following year. The towns and settlements were grouped into Greenland's five regions (Figure 1).

This study followed the Declaration of Helsinki and was approved by the Greenland Science Ethics Committee (ID-number 2023–20891) and the Greenlandic Health Service.

Definitions

The referral cut-off for vision impairment in Greenland is a VA of 0.2 logMAR (≤ 0.63 Snellen decimal) in the worse-seeing eye. In this paper, varying cut-offs of vision impairment in both the worse- and better-seeing eyes, including VA as low as ≥ 0.6 logMAR (0.25 Snellen decimal), are used to provide a basis for comparing our findings with international data. Notably, a VA of ≥ 0.5 logMAR (<0.3 Snellen decimal) is considered significant vision impairment in the Scandinavian countries and Greenland [9–11].

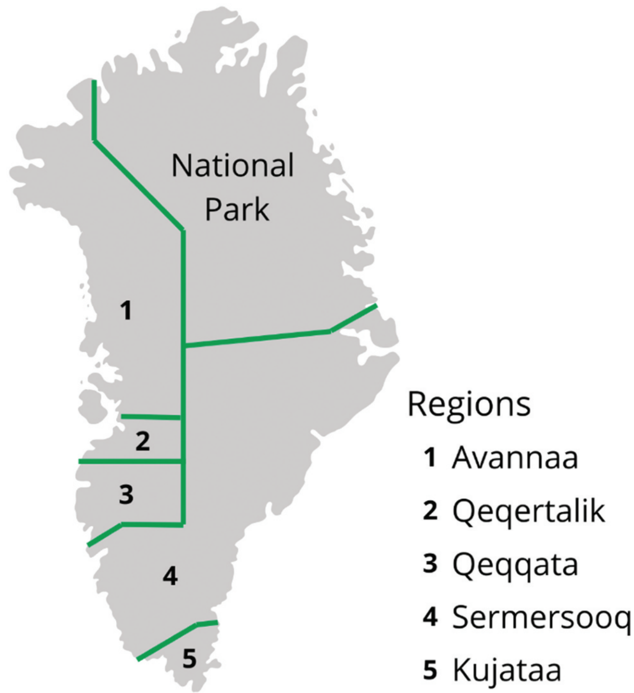

Figure 1. Map of Greenland illustrating the five regions.

Statistics

The measurements were presented as VA of the right and left eye and as the worse- and better-seeing eye.

Data were collected using a logMAR visual acuity chart and recorded as logMAR values. The mean and standard deviation (SD) of these values were calculated and then converted to Snellen decimals using the formula: Snellen decimal = $10^{-\text{logMAR}}$. The range for Snellen decimals was calculated by converting the mean logMAR +/− the SD to Snellen decimals.

The normally distributed measurements were presented as means with range. The participation rates, visual acuity, and interocular differences in VA were calculated and presented as percentages with 95% confidence intervals (CI), computed using the normal approximation (Table 1).

Data from Statistics Greenland was used to calculate annual participation rates [12].

Results

We included 2493 children with a mean age of 6.44 years (SD: 0.36 years, range 5.01 – 7.76 years).

The participation rate showed an upward trend, starting at 43% [95% CI: 42%, 43%] in 2017 and increasing to 61% [95% CI: 61%, 62%] in 2022 (Table 1).

Table 1. Characteristics of participating Greenlandic children at the vision screening at the Age of six years Between 2017 and 2022.

Characteristic	2017 $n = 341$	2018 $n = 330$	2019 $n = 430$	2020 $n = 466$	2021 $n = 435$	2022 $n = 491$	All Years $n = 2493$
Age at Screening (years)[1]	6.45 ± 0.33	6.54 ± 0.32	6.41 ± 0.30	6.48 ± 0.31	6.41 ± 0.41	6.37 ± 0.41	6.44 ± 0.36*
VA Right Eye (logMAR)[1]	0.05 ± 0.12	0.04 ± 0.12	0.03 ± 0.11	0.04 ± 0.12	0.05 ± 0.12	0.06 ± 0.12	0.04 ± 0.12
VA Right Eye (Snellen decimal)[2]	0.89 (0.67 – 1.18)	0.91 (0.69 – 1.20)	0.93 (0.72 – 1.20)	0.91 (0.69 – 1.20)	0.89 (0.68 – 1.17)	0.87 (0.66 – 1.15)	0.91 (0.69 – 1.20)
VA Left Eye (logMAR)[1]	0.06 ± 0.15	0.04 ± 0.13	0.03 ± 0.10	0.03 ± 0.12	0.04 ± 0.12	0.05 ± 0.13	0.04 ± 0.12
VA Left Eye (Snellen decimal)[2]	0.87 (0.62 – 1.23)	0.91 (0.68 – 1.23)	0.93 (0.74 – 1.17)	0.93 (0.71 – 1.23)	0.91 (0.69 – 1.20)	0.89 (0.66 – 1.20)	0.91 (0.69 – 1.20)
Worse-seeing Eye (logMAR)[1]	0.08 ± 0.16	0.06 ± 0.16	0.04 ± 0.12	0.05 ± 0.14	0.06 ± 0.13	0.07 ± 0.14	0.06 ± 0.14
Worse-seeing Eye (Snellen decimal)[2]	0.83 (0.58 – 1.20)	0.87 (0.60 – 1.26)	0.91 (0.69 – 1.20)	0.89 (0.65 – 1.23)	0.87 (0.65 – 1.17)	0.85 (0.62 – 1.17)	0.87 (0.63 – 1.20)
Better-seeing Eye (logMAR)[1]	0.03 ± 0.10	0.02 ± 0.08	0.02 ± 0.09	0.02 ± 0.10	0.03 ± 0.11	0.04 ± 0.10	0.03 ± 0.10
Better-seeing Eye (Snellen decimal)[2]	0.93 (0.74 – 1.17)	0.95 (0.79 – 1.15)	0.95 (0.78 – 1.17)	0.95 (0.76 – 1.20)	0.93 (0.72 – 1.20)	0.91 (0.72 – 1.15)	0.93 (0.74 – 1.17)
Participation rate (%)[¥]	43 [42,43]	43 [43,44]	59 [58,59]	60 [59,60]	57 [56,57]	61 [61,62]	54 [53.5,53.8]
Prop. VA ≥ 0.2 (≤0.63)[†] Better-seeing eye (%)	9 [6,12]	10 [7,13]	5 [3,7]	6 [4,9]	12 [9,15]	11 [8,14]	9 [8,10]
Prop. VA ≥ 0.2 (0.63)[†] Worse-seeing eye (%)	20 [15,24]	17 [13,21]	10 [7,13]	14 [10,17]	17 [14,21]	18 [14,21]	16 [14,17]
Prop. VA ≥ 0.3 (≤0.50)[†] Better-seeing eye (%)	5 [2,7]	2 [0,3]	2 [1,]	3 [2,5]	3 [1,5]	4 [2,6]	3 [2,4]
Prop. VA ≥ 0.3 (≤0.50)[†] Worse-seeing eye (%)	12 [9,16]	5 [3,8]	6 [3,8]	8 [5,10]	8 [5,10]	8 [6,11]	8 [7,9]
Prop. VA ≥ 0.4 (≤0.40)[†] Better-seeing eye (%)	1 [0,2]	1 [0,1]	2 [1,3]	2 [1,3]	1 [0,3]	2 [1,3]	2 [1,2]
Prop. VA ≥ 0.4 (≤0.40)[†] Worse-seeing eye (%)	8 [5,10]	4 [2,6]	3 [1,5]	4 [2,6]	4 [2,5]	5 [3,7]	4 [4,5]
Prop. VA ≥ 0.5 (≤0.32)[†] Better-seeing eye (%)	0 [0,0]	1 [0,1]	1 [0,3]	2 [0,3]	1 [0,2]	1 [0,2]	1 [0,1]
Prop. VA ≥ 0.5 (≤0.32)[†] Worse-seeing eye (%)	3 [1,5]	4 [2,6]	3 [1,4]	3 [2,5]	2 [1,3]	4 [2,5]	3 [3,4]
Prop. VA ≥ 0.6 (≤0.25)[†] Better-seeing eye (%)	0	0 [0,1]	1 [0,1]	1 [0,1]	1 [0,2]	1 [0,2]	1 [0,1]
Prop. VA ≥ 0.6 (≤0.25)[†] Worse-seeing eye (%)	1 [0,3]	2 [1,4]	1 [0,3]	2 [1,3]	1 [0,2]	2 [1,4]	2 [1,3]
Prop. ≥2 interoc. diff.[‡] (%)	8 [5,10]	7 [4,9]	4 [2,6]	6 [4,8]	5 [3,8]	5 [3,7]	6 [5,7]

VA = Visual Acuity (in logMAR and Snellen decimal) as a presenting visual acuity (PVA).
[1]Mean ± Standard Deviation (SD).
[2]Mean with range (lower – upper limit, based on SD of logMAR values).
*Age range: 5.01–7.76 years
[¥]Participation rate with [95% Confidence Interval].
[†]Proportion with specific VA's in logMAR (Snellen decimal) in percent with [95% Confidence Interval].
[‡]Proportion with an interocular difference of ≥ 2 lines in percent with [95% Confidence Interval].

The mean VA for the right and the left eye across all years was 0.04 logMAR (0.91 Snellen decimal, SD ±0.12); for the worse-seeing eye, the mean VA was 0.06 logMAR (0.87 Snellen decimal, SD ±0.14); and for the better-seeing eye, it was 0.03 logMAR (0.93 Snellen decimal, SD ±0.10), as shown in Table 1.

Overall, 9% [95% CI: 8%, 10%] of the participants had a VA of ≥ 0.2 logMAR (≤ 0.63 Snellen decimal) in the better-seeing eye, and 16% [95% CI: 14%, 17%] in the worse-seeing eye. These proportions decreased with stricter VA thresholds, down to 1% [95% CI: 0%, 1%] for VA ≥ 0.6 logMAR (≤ 0.25 Snellen decimal) in the better-seeing eye and 2% [95% CI: 1%, 3%] in the worse-seeing eye. The interocular difference of ≥ 2 lines of VA remained stable at an average of 6% [95% CI: 5%, 7%] (Table 1).

Overall, the proportion of children with poor visual acuity decreased with the severity of vision loss in the study period (Figure 2).

The annual proportion of children seen by an ophthalmologist decreased throughout the study period, from 14% [95% CI: 10%, 17%] in 2017 to 5% [95% CI: 3%, 7%] in 2022. This trend paralleled the proportion of children having prescribed glasses, which was 8% [95% CI: 5%, 11%] in 2017 and reduced to 4% [95% CI: 2%, 5%] in 2022 (Figure 3).

The participation rate has increased over the years, reflecting greater inclusion of children across various regions. The participation rate was consistently low in the regions of Avanna, Qeqertalik, and Sermersooq (Figure 4).

Of the 389 children with impaired VA of ≥ 0.2 logMAR (≤0.63 Snellen decimal), 57% ($n = 221$) were not referred to an ophthalmologist. Among these, 78% ($n = 172$) lacked records of further vision screening. Out of the 168 children who were referred to an ophthalmologist, 114 were prescribed glasses. Among the 54 children who were not prescribed glasses, 12 had a Best Corrected Visual Acuity (BCVA) of ≥ 0.3 logMAR (≤0.50 Snellen decimal) on one or

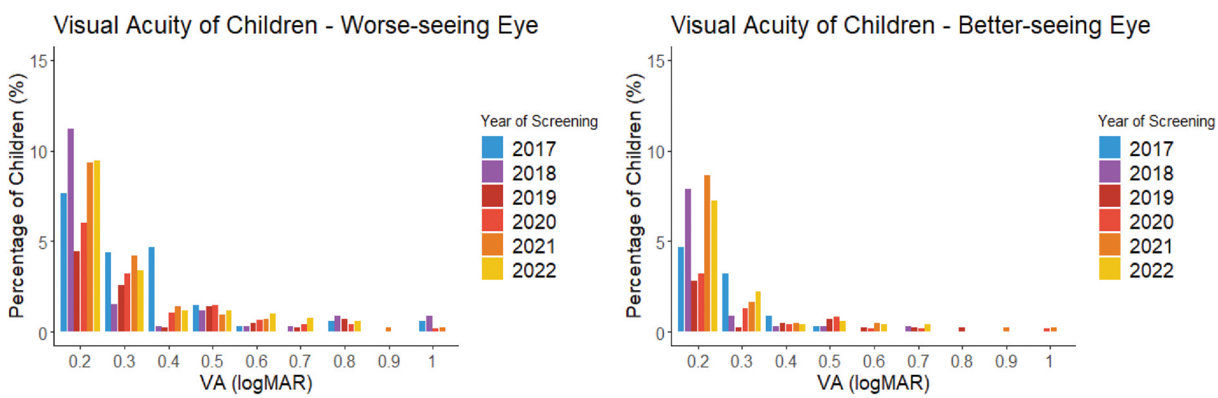

Figure 2. Proportion of children with visual acuity (VA) of 0.2 logMAR (0.63 snellen decimal) or worse for the years 2017-2022. A different colour represents each year. The figure on the left shows the worse-seeing eyes, and the figure on the right shows the better-seeing eyes.

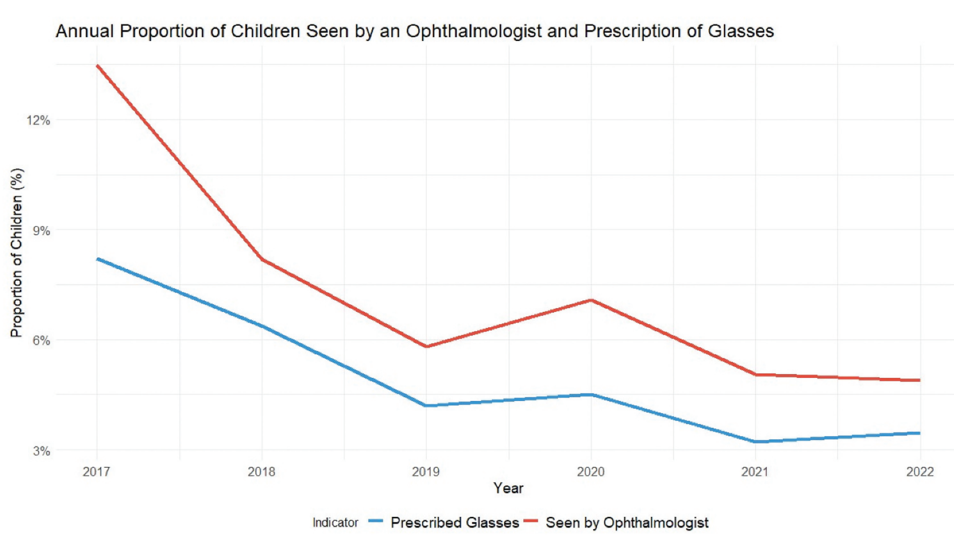

Figure 3. Proportion of children prescribed glasses (blue line) and seen by an ophthalmologist (red line) for the years 2017-2022. An ophthalmologist saw fever children in 2022 and prescribed fever glasses in 2022.

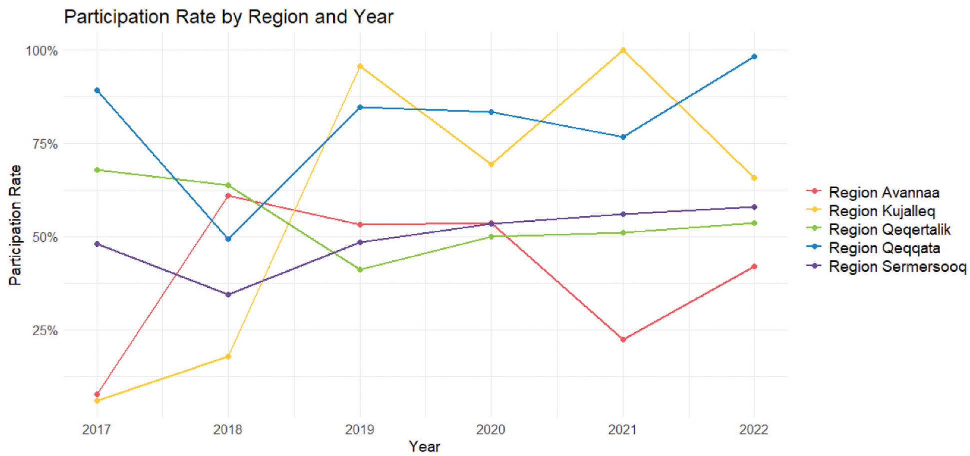

Figure 4. Participation rates for each region from 2017 to 2022, illustrating the fluctuating participation trends over the years.

both eyes. The ophthalmological findings of these 12 children were as follows: Two had optic nerve anomalies, one was concluded to have a non-organic vision loss, and two children were prescribed glasses years later by an optometrist. Four children were discharged without treatment, maintaining a BCVA around 0.3–0.2 logMAR (0.5–0.63 Snellen decimal). Three children had permanent amblyopia in one or both eyes. In one case, reduced visual acuity was associated with corneal scarring in one eye, which may have caused the impairment either through deprivation amblyopia or direct media opacity. Only one of the three children with amblyopia underwent patch treatment, which was unsuccessful (Figures 5, 6).

Discussion

The present study provides a comprehensive overview of vision screening among children in Greenland. The participation rates have shown an upward trend from 43% in 2017 to 61% in 2022. The additional training received by school nurses in 2017, and more efficient utilisation of medical records may contribute to this increase. Greenland's neighbouring Inuit communities in Canada have no school-based vision screening programs for comparison [13]. However, the participation rates in Greenland are still lower than in the rest of Europe and the USA, which have more centralised healthcare systems [14–17]. Such differences underline the challenges Greenland's vast and sparsely populated rural areas pose, and how this complicates healthcare delivery. Nevertheless, the increasing trend in participation is a positive sign, indicating gradual improvements in health service outreach and engagement.

In our study, 3% of children showed impaired vision ≥ 0.3 logMAR ≤0.50 Snellen decimal) with presenting visual acuity (PVA) in the better-seeing eye. This finding was reasonably consistent throughout the study period, with the proportion of children with impaired vision ranging from 2% to 5%. This rate is similar to the

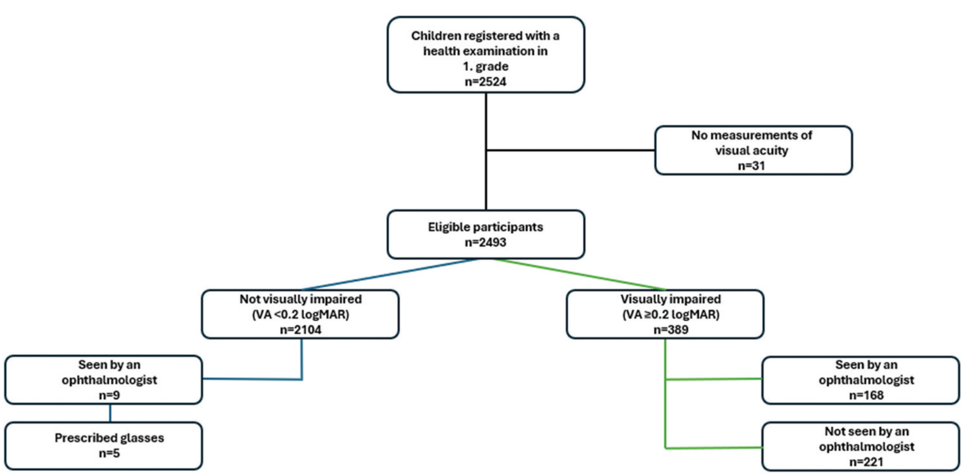

Figure 5. Flowchart of the participants. A visual acuity of 0.2 logMAR is equivalent to 0.63 in Snellen decimal.

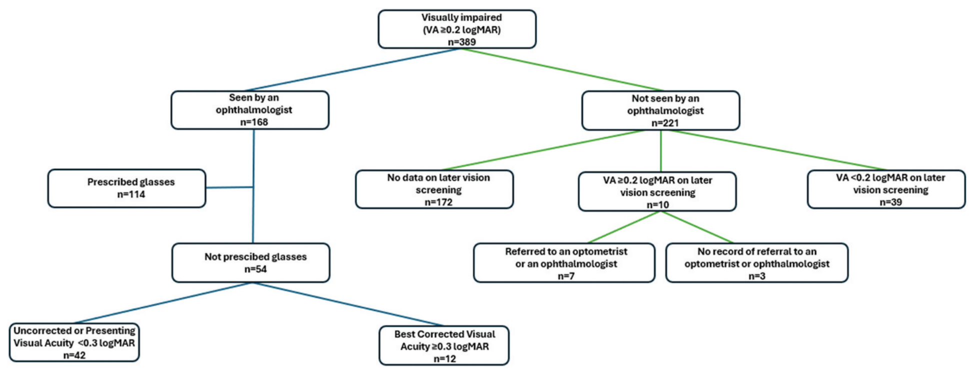

Figure 6. Flowchart showing children with impaired vision (0.2 logMAR, equivalent to ≤ 0.63 in Snellen decimal), divided by a visit to an ophthalmologist. The chart also details the outcome for referred children and additional available information obtained for those not referred. A visual acuity of 0.3 logMAR is equivalent to 0.50 in Snellen decimal.

Americas, yet lower than in Southeast Asia, Africa, and the Eastern Mediterranean [18]. These differences in the rates suggest regional differences in health outcomes, possibly due to variations in healthcare access and policies. A more conservative criterion of ≥ 0.5 logMAR (≤ 0.32 Snellen decimal) reduced the prevalence of impaired vision to 1% in the better-seeing eye. This lower prevalence is similar to the Eastern Mediterranean and lower than in European populations [18], indicating possibly less severe visual impairment in Greenlandic children despite healthcare delivery challenges.

Conversely, the prevalence of visual impairment (0.3 logMAR / ≤ 0.50 Snellen decimal) in the worse-seeing eye was 8%, and an interocular difference of ≥2 lines was 6%. These rates are significantly higher than the 3.1% and 4.7%, respectively, observed in Danish children [19], reflecting possible differences in healthcare access or the effectiveness of early intervention programs. Using WHO's criterion of 0.4 logMAR (≤ 0.40 Snellen decimal) in the better-seeing eye [20], our prevalence of visual impairment was 2%, allowing for direct comparison with global standards and underscoring the need for targeted vision health strategies in Greenland. However, using register data introduces a risk of missing or incomplete data, possibly leading to an underestimation of vision impairment.

A concerning trend from our study is the decreasing rate of children with poor VA seen by ophthalmologists, which dropped from 14% in 2017 to only 5% in 2022. Despite this decrease, the proportion of children with poor VA remains high, with 16% of children having a VA of 0.2 logMAR (≤ 0.63 Snellen decimal) in the worse-seeing eye and 8% a VA of 0.4 logMAR (≤ 0.50 Snellen decimal), indicating a substantial number of children needing ophthalmological care. This decline in visits to an ophthalmologist indicates inefficiencies in the referral process and could significantly impact child health due to the importance of early detection and intervention. Another possible explanation is that since 2017, no paediatric ophthalmologists have visited Greenland. The Greenlandic Healthcare System now relies solely on general ophthalmologists, rather than paediatric specialists.

In regions lacking school nurses, utilising other healthcare professionals, such as optometrists, may be beneficial in conducting vision screening. In addition, the consistently high proportion of children with low vision in their worse-seeing eyes indicates that preschool vision screening might be ineffective and needs evaluation.

New national guidelines outlining referral criteria for school nurses are required to optimise the referral process. Appointing regional personnel to ensure follow-ups for referred children will most likely minimise the shortfalls in consultations by ophthalmologists.

In conclusion, although the participation rate has increased from 2017 to 2022, the referral rate to an ophthalmologist has decreased in the same timeframe without a corresponding decrease in the proportion of low vision. Low vision in Greenlandic schoolchildren exists and remains a critical concern. Utilising other healthcare professionals, such as optometrists, for vision screening in regions without school nurses, along with streamlined referral processes, is essential for improving visual health outcomes for Greenlandic children.

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Author contribution

Research Design: ND, IN, IF, MEJ, SH, HJ.
Data Acquisition/Research Execution: ND.
Data Analysis/Interpretation: ND, IF, IN, HJ.
Manuscript Preparation: Original Draft: ND, IN, HJ Writing, Review & Editing: ND, IN, IF, MEJ, SH, HJ.

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