Rotterdam AMblyopia Screening Effectiveness Study: Detection and Causes of Amblyopia in a Large Birth Cohort

Johanna H. Groenevoud, Angela M. Tjiam, V. Kathleen Lantau, W. Christina Hoogeveen, Jan Tjeerd H. N. de Faber, Rikard E. Juttmann, Harry J. de Koning, and Huibert J. Simonsz

PURPOSE. The Dutch population-based child health monitoring program includes regular preverbal (age range, 1–24 months) and preschool (age range, 36–72 months) vision screening. This study is on the contribution of an organized vision screening program to the detection of amblyopia.

METHODS. A 7-year birth cohort study of 4624 children was started in 1996/1997 in Rotterdam. Vision screening data were obtained from the child screening centers. Treating ophthalmists working at the regional ophthalmology departments provided information about diagnosis and treatment. The diagnosis was reviewed by two experts. The parents provided additional information on their child’s eye history through written questionnaires and telephone interviews. At age 7 years, the children underwent a final examination by the study ophthalmists.

RESULTS. Of the 3897 children still living in Rotterdam by 2004, 2964 (76.1%) underwent the final examination. Amblyopia was diagnosed in 100 (3.4%) of these. At age 7, 23% had visual acuity >0.3 logMAR. Amblyopia was caused by refractive error (n = 42), strabismus (n = 19), combined-mechanism (n = 30), deprivation (n = 7), or unknown (n = 2). Eighty-three amblyopia cases had been detected before age 7. Amblyopia detection followed positive results in vision screening in 56 children, either preverbal (n = 15) or preschool (n = 41). Twenty-six other amblyopes were self-referred (n = 12, before a first positive screening test), especially strabismic or combined-mechanism amblyopia; data were uncertain for one other positively screened amblyopic child. Strabismic amblyopia remained undetected until age 7 due to unsuccessful referral (n = 4, three with visual acuity >0.3 logMAR at age 7) or false-negative screening (n = 13).

CONCLUSIONS. Most cases of amblyopia were detected by vision screening with visual acuity measurement. Preverbal screening contributed little to the detection of refractive amblyopia. Amblyopia affects approximately 3% of the adult population. It is commonly defined as a unilateral or bilateral vision reduction due to a dysfunction of the processing of visual information in the first years of life. Most cases can be treated effectively by occlusion therapy before age six. The purpose of child vision screening is to prevent bilateral visual impairment in adult life by the early detection and treatment of amblyopia and other disorders of vision. If treatment fails, adult eye conditions, such as eye trauma, glaucoma, macular degeneration, or cataract, may cause loss of visual function in the better eye in later life, resulting in bilateral visual impairment. In some countries, including Canada and The Netherlands, screening of visual function in infants and young children is also applied (preverbal screening). There is, however, inconclusive evidence of the overall and cost effectiveness of child vision screening.

In The Netherlands, a health screening program for mother and child was initiated in the early 1900s. Regular child vision screening has been part of this Dutch child health screening program since the 1960s. Initially, vision screening consisted of inspection, testing of monocular visual acuity, ocular alignment, and stereo acuity in children 3 years of age or older (preschool/school screening). In the 1980s, an additional method of screening visual function in infants and toddlers (preverbal screening) was implemented: the VOV method (Vroegtijdige Onderkening Visuele stoornissen, or Early Detection of Visual Disorders). The VOV examination includes the corneal light reflex, cover–uncover test, observation of ocular pursuits movements, inspection of the cornea and pupil, and a pupillary light reflex test.

In 1996, we started a follow-up study of a birth cohort of 4624 children in actual screening practice in the city of Rotterdam: the Rotterdam AMblyopia Screening Effectiveness Study (RAMSES). The purpose of this study was to determine the sensitivity, specificity, and effectiveness of the Dutch child vision screening program up to age 7. The baseline characteristics of vision screening activities in children aged 0 to 2 years have been published. In the present study, we analyzed clinical and screening data to describe amblyopia detection in children between 0 and 7 years of age and the contribution of...
preverbal and preschool vision screening to the detection of amblyopia.

**METHODS**

**Design**

Our study was a population-based, prospective, birth-cohort study. It was an observational study, our main objective being to evaluate the current practice of vision screening, referral, and follow-up.

**Child Vision Screening in The Netherlands**

The Netherlands has a nationwide health screening program for mother and child. The Child Health Care System provides preventive health care to all children aged 0 to 19 years living in The Netherlands and includes immunization and monitoring of growth and development. Participation in this free program is high, since 1997 ranging from 99% to 100% for infants to 72% to 87% for school children.1 Child health screening is performed by nurses and screening physicians who specialize in preventive child health care, including child vision screening. Vision screening is performed according to national guidelines and consists of a series of consecutive screening examinations between the ages of 0 and 6. Until age 4, children are screened at one of the Child Health Centers (CHCs). From the age of 4, they are monitored by the municipal Public Health Service (PHS).

**Preverbal Screening.** At the CHCs, the VOV method is applied during regular visits at ages 1 to 2, 3 to 4, 6 to 9, 14, and 24 months. The VOV method consists of the corneal light reflex test and the cover–uncover test to detect the presence of strabismus; an examination of ocular pursuit movements for both monocular and binocular conditions to obtain a gross estimate of visual acuity; inspection of the eyelids and anterior segment of the eye, in particular the cornea; inspection of the color and shape of the pupil; and testing of the pupillary light reflex.

**Preschool/School Screening: Visual Acuity Measurements.** At age 36 months, monocular visual acuity is tested by means of the Amsterdam picture chart (Amsterdamse Plaatjeskaart; APK). The APK is not logarithmic and does not use standardized optotypes. The cooperation of 3-year-old children with the APK is very good, making the test popular with staff at CHCs. At age 45 months, monocular visual acuity is measured at a CHC by means of the Landolt-C chart. If the child does not seem to understand the Landolt-C testing, the APK is used instead. A final standard vision examination with the Landolt-C chart is performed between 5 and 6 years of age at the PHS.

**Referral Strategy.** In case of an abnormal, that is, positive screening test result, the child is referred to an ophthalmologist or orthoptist for further assessment (usually via the general practitioner; Fig. 1). The VOV test result is deemed positive if one or more items are abnormal. In case of doubt about the results—for instance, an uncooperative child—the test should be repeated within 6 weeks. The referral and recall criteria for visual acuity measurements are presented in the Appendix. In The Netherlands, nearly all orthoptists work in ophthalmology departments in hospitals.

**Setting**

We performed our study in Rotterdam, the second largest city in The Netherlands. The city itself has ~592,660 inhabitants (as of January 1, 2000) and is located in an urban area (Rijnmond) with >1.2 million inhabitants. Forty percent of inhabitants in Rotterdam have a non-Dutch ethnic background.12 In Rotterdam, child health screening is offered at 27 CHCs and 20 offices of the Rotterdam PHS.

**Cohort**

The cohort consisted of 4624 children living in Rotterdam who were born between September 16, 1996, and May 15, 1997. The children were enrolled at the 9-month visit to the CHC after the parents had given their oral informed consent. All children were offered the regular Dutch health screening program for mother and child, including vision screening. The study protocol complied with the tenets of the Declaration of Helsinki for research involving human subjects.

**Data Collection**

Vision screening data and clinical data were prospectively collected by child health care staff and treating orthoptists, respectively, and reported to the study center at Erasmus Medical Center (MC).

Screening data were provided by the CHCs (0–4 years) and the Rotterdam PHS (4 years or older). If a child had visited an orthoptist or ophthalmologist before the age of 9 months, the study center was informed as to whether the visit had been the result of previous vision screening examinations.

Treating orthoptists working at the eight ophthalmology departments in Rotterdam and its suburban areas, Capelle aan den IJssel and Spijkenisse, provided clinical orthoptic and ophthalmic data to the study center. They filled out a standard form for each visit of a child in the birth cohort with questions concerning the diagnostic tests and treatment. The treating orthoptists were also asked to indicate whether the child (possibly) had amblyopia or any other eye disorder, and, if amblyopia was suspected, whether it was due to strabismus, a refractive error, or any other ambyogenic factor. In the summer of 2002, the study center sent a list of all the children who had been referred after screening, but from whom no clinical data were received, to the orthoptists at the ophthalmology departments to obtain as complete a record of orthoptic and ophthalmic data as possible.

The study center sent additional questionnaires to all parents about their children’s eye history, including questions about vision screening and visits to an ophthalmology department in 2004. These questionnaires provided additional information on the follow-up of any positive screening results and revealed that some children visited other than the eight regional ophthalmology departments participating in our study, or that the general practitioner had decided that further referral to an ophthalmology department was not necessary. In 2006, after the final examination of the study, parents of children with positive vision screening tests, but without known orthoptic or orthoptic follow-up, were contacted by additional phone or home visits. These visits are described in an accompanying paper (Tijam AM, et al., manuscript submitted, February 2010).

In 2004, children underwent the final examination of the study. They were approached through their schools. A team of seven independent study orthoptists recruited from outside Rotterdam visited 174 schools to assess visual acuity with the Landolt-C test; to assess ocular alignment, eye motility, and stereopsis with the TNO random-dot stereotest; to check eye convergence; and to inspect the outer aspects of the eye. Children with visual acuity of 0.2 logMAR or less in one eye, a difference of 2 logMAR lines or more, manifest strabismus, or decreased stereopsis (≥240 sec/arc) were invited for an extensive orthoptic evaluation by a team of study orthoptists and an ophthalmol-
ogist (HJS). This additional eye examination consisted of stereo testing, examination of eye position and eye movements, visual acuity measurement with a Snellen chart, retinoscopy (under cycloplegia if deemed necessary), and examination of the anterior chamber and fundus of the eye.

Main Outcome Measures

The diagnosis of interest was amblyopia and its underlying cause—that is, strabismus, refractive errors (anisometropia, isometropia, or astigmatism), combined mechanism (a combination of strabismus and anisometropia), or deprivation (organic eye disorder). Amblyopia was defined as an interocular acuity difference of 2 logMAR lines or more or a bilateral visual acuity >0.2 logMAR in the presence of an amblyogenic factor—that is, strabismus without alternating fixation, anisometropia, astigmatism, severe myopia, or stimulus deprivation.

The following diagnostic sources were used:

1. The diagnostic information provided by the treating orthoptists. Two experts (VKL and HJS) reviewed the diagnosis proposed by the orthoptists in hindsight, with the aid of the additional data obtained later in the study. Both experts were blinded to the screening results. The diagnosis of (possible) amblyopia was upheld on expert review if it was likely that the difference in interocular visual acuity had been 2 logMAR lines or more from the start of treatment, if no alternating fixation was present, and if amblyogenic factors were identified. In cases of insufficient clinical data due to noncompliance with follow-up appointments or due to missing visual acuity measurements or cycloplegic refraction data, an expert diagnosis was made based on the results of the final examination.

2. The vision data collected in the final study examination.

Children without amblyopia were classified according to the primary disorder diagnosed by the treating orthoptists: manifest or latent strabismus; refractive errors, including (bilateral) hypermetropia, (bilateral) astigmatism, and myopia; other eye disorders, including conjunctivitis, ptosis, lacrimal disorders, and retina or optic nerve disorder; or no eye disorder.

We set the threshold for insufficiently treated or residual amblyopia at a visual acuity in the amblyopic eye worse than 0.3 logMAR at age 7 years.

Statistical Analysis

All data were entered into a database (Access; Microsoft, Redmond, WA). Relevant data were converted to a statistical analysis file (SPSS ver. 15.0 for Windows; SPSS, Chicago, IL) to enable calculation of frequencies, means, and standard deviations.

RESULTS

By January 2004, 3897 (84.3%) of 4624 children were still registered at the Rotterdam PHS. Seven hundred twenty-four children were outside the Rotterdam region (n = 242); their schools were outside the Rotterdam region (n = 263); their schools did not cooperate (n = 242); seemed to have moved out of Rotterdam (n = 225); or was absent at the day of the examination (n = 179); or their parents did not give permission for their child to take part (n = 14). Another ten children who were mentally retarded were excluded from the final analysis, because it was not possible to assess their visual acuity using the Landolt-C test.

For the present analysis, we used the results of 2964 children (76.1%) of 3897 children who underwent the final examination at age 7. The CHCs and the PHS had reported any positive vision screening test at least once for 561 (18.9%) of the 2964 children (95% CI, 17.5–20.3) before age 6.5 years (Fig. 2): 126 children had their first positive vision screening at the preschool screening and 435 at the preschoo. The proportion of children with positive screening results did not differ between those who underwent the final examination and those who did not (χ² test; P = 0.9).

Six hundred sixty (22.3%) of the 2964 children (95% CI, 20.8–23.8), whether or not they had a vision screening test with a positive result, had visited a general practitioner or an orthoptist or ophthalmologist at least once, as reported by the ophthalmology departments (384 children) or the parents (276 children) (Table 1).

Clinical Follow-up

Clinical data were available for 384 of the 2964 children, for whom the participating ophthalmology departments confirmed the visits to an orthoptist or ophthalmologist (see Table 1). The mean presenting age was 42.3 months (SD 23.0). Fifty-three of the 384 children had visited the ophthalmology department without having a positive result in the vision screening test (mean presenting age: 28.5 months, SD 27.1). The remaining 331 children had had a positive test result at least once, of whom 44 had visited the ophthalmology department before the positive screening (mean presenting age: 23.4 months, SD 16.3) and 274 after the positive screening (47.8 months, SD 20.2). The relation with the first positive screening test was unclear in the remaining 13 of the 331 children.

The most frequent diagnosis was a refractive error without amblyopia (86 [22.4%] of the children). The error was mostly hypermetropia, whereas myopia was relatively rare in children aged 0 to 7 years. The diagnosis of amblyopia was the second most frequent primary diagnosis (75 [19.5%] children). Seventy-one (18.5%) of the 384 children had no eye disorder. Figure 3 provides a more detailed overview of the primary diagnoses and how they are related to screening.

Occlusion therapy had been prescribed to 86 (22.4%) of the 384 children; 22 children received occlusion therapy only, and 64 had been prescribed glasses as well. A diagnosis of amblyopia was upheld on expert review for 61 (85%) of the 86 children who underwent occlusion therapy. One hundred three (26.8%) of the 384 children had been prescribed glasses only. Ten (2.6%) children received treatment other than occlusion therapy or glasses, whereas no treatment had yet been prescribed or it had not been initiated at that point for 140 (36.5%) children (treatment data unknown for 45 children).

Amblyopia Prevalence

On expert review of all data, a diagnosis of amblyopia was made in 100 of the 2964 children (see also Fig. 1), resulting in a cumulative incidence of amblyopia of 3.4% (95% CI, 2.7–4.0) in children aged 0 to 7.

Refractive amblyopia was most frequent (n = 42 children), followed by combined-mechanism amblyopia (n = 30), strabismic amblyopia (n = 19), and deprivation amblyopia (n = 7) (unknown type [n = 2]). Of these 100 amblyopic children, 83 had visited an orthoptist or ophthalmologist according to the ophthalmology departments (n = 75) or the parents (n = 8) before age 7. Sixty-nine of these had a positive screening test. The other 17 amblyopic children had no (known) visit to an ophthalmology department, although 4 of them had had a positive vision screening at least once. The mean presenting age was 27.2 months (SD 19.2) for strabismic amblyopia, 29.8 months (SD 19.4) for combined-mechanism amblyopia, 36.3 months (SD 29.5) for deprivation amblyopia or unknown type, and 54.1 months (SD 11.0) for refractive amblyopia.
FIGURE 2. Screening result, orthoptic, or ophthalmic follow-up and amblyopia prevalence in a cohort of 4624 children between ages 0 and 7. By January 2004, 3897 of the 4624 children were still living in Rotterdam. Of these, 2964 underwent the final study examination at age 7 (the first branch of the diagram), whereas 933 other children were not examined at age 7 (the second branch). *On expert review of all data, a diagnosis of amblyopia was made in 100 of the 2964 children examined at age 7. †Of 2964 children, 660, with or without a positive vision screening test, had visited a general practitioner or an orthoptist or ophthalmologist at least once, as reported by the ophthalmology departments (384 children; for these children, clinical data were available) or by the parents (276 children).
Figure 4 shows the distribution of the detection of the different amblyopia types in time and in relation to screening. The points under the diagonal represent the cases of amblyopia that were detected before any positive screening test—that is, were not identified by screening. Above the diagonal are the cases of amblyopia that were detected after a positive vision screening test.

Fifty-six (56%) of 100 cases with amblyopia were detected due to the vision screening program; this proportion did not differ significantly between amblyopia caused by strabismus (12/19 cases) and refractive amblyopia (21/42 cases; \( \chi^2 \) test, \( P = 0.4 \)). For one other child with a positive vision screening test, it was unclear whether the visit to an ophthalmology department followed the positive test.

Twenty-six other cases were detected at the parents’ own initiative, although 12 of these had a first positive result in a vision screening test later on.

The remaining 17 children received a diagnosis only at the final study examination. Reasons for this late detection were unsuccessful follow-up after a positive vision screening test (\( n = 4 \) children) or false-negative screening (\( n = 13 \)). The 13 children with false-negative screening results had different screening histories. The false-negative results were due to parental noncompliance with early recall or with successive screening appointments.

TABLE 1. The Diagnosis in 2964 Children, According to Their Screening History and Visit to an Ophthalmology Department between Ages 0 and 7 Years

<table>
<thead>
<tr>
<th>Diagnosis*</th>
<th>Amblyopia (Successfully Treated or Residual)</th>
<th>No Amblyopia</th>
<th>Unknown</th>
<th>Total† (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( n (%) )</td>
<td>( n (%) )</td>
<td>( n(%) )</td>
<td>( n(%) )</td>
</tr>
<tr>
<td>Without a positive vision screening test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No visit to ophthalmology department</td>
<td>13† (0.8)</td>
<td>1553 (99)</td>
<td>3 (0.2)</td>
<td>1569</td>
</tr>
<tr>
<td>Any visit to ophthalmology department</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(according to the department)</td>
<td>9 (17)</td>
<td>44 (83)</td>
<td>—</td>
<td>53</td>
</tr>
<tr>
<td>Any visit to ophthalmology department</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(according to parents)</td>
<td>5 (2.6)</td>
<td>182 (94)</td>
<td>7 (3.6)</td>
<td>194</td>
</tr>
<tr>
<td>Unknown visit to ophthalmology department</td>
<td>—</td>
<td>565 (96)</td>
<td>22 (3.7)</td>
<td>587</td>
</tr>
<tr>
<td>With a positive vision screening test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No visit to ophthalmology department</td>
<td>4 (3.3)</td>
<td>115 (94)</td>
<td>3 (2.5)</td>
<td>122</td>
</tr>
<tr>
<td>Any visit to ophthalmology department</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(according to the department)</td>
<td>66 (20)</td>
<td>261 (79)</td>
<td>4 (1.2)</td>
<td>331</td>
</tr>
<tr>
<td>Any visit to ophthalmology department</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(according to parents)</td>
<td>3 (3.7)</td>
<td>75 (91)</td>
<td>4 (4.9)</td>
<td>82</td>
</tr>
<tr>
<td>Unknown visit to ophthalmology department</td>
<td>—</td>
<td>20 (77)</td>
<td>6 (23)</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>100 (3.4)</td>
<td>2815 (95)</td>
<td>49 (1.7)</td>
<td>2964</td>
</tr>
</tbody>
</table>

* Diagnosis upon expert review of clinical information provided by the treating orthoptists working at eight regional ophthalmology departments. If clinical data were not available or were insufficient, data from the final examination were reviewed to assess whether the child had had amblyopia at the time of the visits to the ophthalmology department.

† These 13 cases included 6 of noncompliance with recall or successive screening appointments and 7 of false-negative screening. The diagnosis of amblyopia was made when the children were age 7, at the final examination of the study.

Figure 3. The primary diagnosis and relation to vision screening in 384 children who visited an ophthalmology department between ages 0 and 7. *Diagnosis on expert review of clinical information provided by the treating orthoptists. If clinical data were not available or were insufficient, data from the final examination were reviewed to assess whether the child had amblyopia at the time of the visits to the ophthalmology department. Orthoptists provided clinical data for 384 children in our screening cohort who had visited an ophthalmology department between ages 0 and 7 years. For 276 other children, no clinical data were received, although they had visited an orthoptist or ophthalmologist at least once, as reported by their parents (Table 1).
screening examinations (n = 6) or to false-negative visual acuity measurements at preschool screening (n = 7).

Treatment data were available for 74 of the 83 children with amblyopia who had visited an ophthalmology center at least once before age 7. Sixty-four of them received occlusion therapy (mean age at initiation: 45.1 months, SD 22.9), and 64 received glasses (mean age at initiation: 48.3 months, SD 20.1). Fifty-five of these children received both glasses and occlusion therapy, of whom 24 were prescribed occlusion therapy first (mean interval: 11.1 months), 16 children were prescribed glasses first (mean interval: 19.5 months), and 3 were prescribed occlusion therapy and glasses at the same time (data available for 43/55 children receiving both glasses and occlusion therapy).

Figure 5 presents the visual acuity at age 7 of the 100 children with amblyopia. Twenty-three of the 100 children with amblyopia who had visited an ophthalmology center at least once before age 7. Sixty-four of them received occlusion therapy (mean age at initiation: 45.1 months, SD 22.9), and 64 received glasses (mean age at initiation: 48.3 months, SD 20.1). Fifty-five of these children received both glasses and occlusion therapy, of whom 24 were prescribed occlusion therapy first (mean interval: 11.1 months), 16 children were prescribed glasses first (mean interval: 19.5 months), and 3 were prescribed occlusion therapy and glasses at the same time (data available for 43/55 children receiving both glasses and occlusion therapy).

Figure 5 presents the visual acuity at age 7 of the 100 children with amblyopia. Twenty-three of the 100 children with amblyopia had visual acuity >0.3 logMAR in the worse eye at age 7. This group included 9 children with strabismic or combined-mechanism amblyopia (including 2 with untreated amblyopia), 3 with deprivation amblyopia, and 11 with refractive amblyopia (including 6 with untreated amblyopia).

DISCUSSION

We investigated the contribution of a child vision screening program to the detection of amblyopia in a large prospective birth-cohort study. We found that half of the cases of amblyopia in our cohort were detected as the result of a positive vision screening test. About one quarter of amblyopic children did not directly profit from a positive screening result because of earlier self-referral to an ophthalmology department, or because of unsuccessful referral. In the remaining quarter, the amblyopic child never had a positive result in vision screening, although half of these had received a diagnosis before age 7 after self-referral.

Preschool visual acuity measurements from age 3, in particular, played an important role in the detection of amblyopia, especially of refractive amblyopia. Cases of strabismic or combined-mechanism amblyopia were relatively more likely to be self-referred than were those of refractive amblyopia.

Ours is the first birth-cohort study of this size on amblyopia. We were able to observe almost 3000 children from birth until age 7. There are, however, several limitations to our study.

First, the provision of data was partly dependent on the attentiveness of the professionals working at the child screening centers or ophthalmology departments. We triangulated data from different sources to overcome any incomplete data. Screening and clinical data have been cross-checked and completed by parental information, and diagnostic decisions have been supported by expert review. We found that, according to parental reports, more children...
had visited an orthoptist or ophthalmologist than were reported by the ophthalmology departments. Part of this discrepancy can be explained by the fact that children had visited other than the participating ophthalmology departments. All children, however, were evaluated at the final study examination, and amblyopia, if present, was diagnosed at that stage.

A second weakness of our study may be that in the first phase of the final examination, involving 2964 children, clinical refraction was not measured. Measuring refraction with children under cycloplegia, however, was not feasible in a population-based study of this magnitude. In the secondary phase of our study, clinical refraction was measured with the children under cycloplegia if deemed necessary to diagnose amblyopia.

About three of four children with amblyopia attending one of the eight ophthalmology departments in our study had visited the ophthalmology department after a positive vision screening test. The visits to the outpatient ophthalmology department had not been initiated by a positive screening in the remaining quarter, although some of these children were screened positively at one of the subsequent screening examinations. The children who visited the orthoptist or ophthalmologist before or without any positive screening test were, in general, younger than 3 years of age at the first visit, and strabismic or combined-mechanism amblyopia was more common in this group than was refractive amblyopia.

We found that occlusion therapy, with or without glasses, had been prescribed to one of five children visiting the ophthalmology departments—mainly for those who had strabismic or combined-mechanism amblyopia. Orthoptists, however, had initiated occlusion therapy in some children with strabismus in whom, in hindsight, amblyopia could not be confirmed, considering all successive hospital visits. For instance, occlusion therapy could have been stopped shortly after its initiation in cases of alternating esotropia. In another Dutch study, the diagnosis of amblyopia could not be confirmed in hindsight in 7% of patients who had been prescribed occlusion therapy 30 to 35 years earlier. In our study, this percentage was 17%, but children in our study were, on average, more than 2 years younger at the start of amblyopia treatment.

To be on the safe side, orthoptists may initiate occlusion therapy in children with an uncertain diagnosis of amblyopia, because the course of treated amblyopia between termination of treatment around age 8 and adulthood varies. Visual acuity will increase slightly in most amblyopic patients, but may decrease in patients with combined-mechanism amblyopia or with increasing anisometropia. The cumulative incidence of cases of amblyopia in this study is estimated at 3.4%. This rate is in line with previous estimates of amblyopia prevalence, ranging from 0.02% to 5.3%. Because of the different definitions of amblyopia, results cannot be easily compared.

In our study, one quarter of amblyopic children—that is, 0.8% of the total population—had visual acuity in the worse eye of >0.3 logMAR at age 7. In a sample of 6-year-old Australian children, this percentage was 0.7%. Residual amblyopia (>0.3 LogMAR) was found in 1.1% of a screened population of 12- to 13-year-old children in Sweden. Residual amblyopia in our study included both cases of unsuccessfully treated combined-mechanism amblyopia and missed (and thus untreated) cases of refractive amblyopia. In general, children with combined-mechanism amblyopia may have a worse prognosis, even despite treatment.

Refractive amblyopia and combined-mechanism amblyopia occurred more frequently than strabismic amblyopia in our study. The distribution of amblyopia types differs from that in other studies, in which combined-mechanism amblyopia was present in 19% of amblyopic children only or refractive amblyopia accounted for 78%.

In our study, children with strabismic or combined amblyopia were 2 years younger than children with refractive amblyopia when they first visited the orthoptist or ophthalmologist (about the age of 2.5 years and 4.5 years, respectively). In the late 1960s, the various types of amblyopia were detected more than 2 years later, although with the same age sequence. In this historic cohort study, occlusion therapy was started at a mean age of 5.1 years for strabismic amblyopia, 5.7 years for combined-mechanism amblyopia, and 6.6 years for anisometropic amblyopia. In a retrospective Australian study of 127 children with amblyopia, a trend was also seen for earlier detection of deprivation amblyopia and later detection of anisometropic amblyopia.
**Table A1.** Referral and Recall Criteria for Preschool/School Vision Screening According to the 2002 Guidelines for the Detection of Visual Disorders in Children aged 0 to 19 Years

<table>
<thead>
<tr>
<th>Screening Test, Age</th>
<th>Referral Criteria</th>
<th>Recall† Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>APK, 36 mo</td>
<td>VA ≤ 5/15 in either eye; difference of ≥2 logMAR lines</td>
<td>VA of 5/10 or 5/6 in the worse eye, with an intraocular difference of no more than one logMAR line</td>
</tr>
<tr>
<td>Landolt-C, 45 mo</td>
<td>VA &gt; 0.3 logMAR in either eye; difference of more than 2 logMAR lines</td>
<td>Difference of 2 logMAR lines if VA is ≤ 0.3 logMAR in both eyes</td>
</tr>
<tr>
<td>Landolt-C, 60–72 mo</td>
<td>VA ≤ 5/6 in either eye; difference of ≥2 logMAR lines</td>
<td>VA of 5/5 in the worse eye, with an intraocular difference of no more than one logMAR line</td>
</tr>
</tbody>
</table>

* APK, Amsterdam Picture Chart. 5/5 was considered to be equivalent to 0 logMAR.
† The test should be repeated within 3 months. If the test result is the same or worse, the child still should be referred.

Although amblyopia type and age at the first outpatient visit were not significantly related. 17

We cannot give a definite assessment of how effective the Dutch child vision screening program is when there are regular vision measurements until age 6. In a British study, the prevalence of amblyopia in 7.5-year-old children was significantly smaller in children who underwent intensive orthoptics by age 8 compared to children seen between 37 months old. 18 Our results suggest that preschool screening from age 3 contributes most to amblyopia detection. Preverbal screening especially contributed to the earlier detection of strabismic and combined-mechanism amblyopia. Whether earlier detection and treatment of amblyopia is cost-effective, remains to be seen. 7

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**APPENDIX**

**Referral Criteria for Preschool/School Vision Screening in The Netherlands**

The referral and recall criteria are described in a special guideline for the detection of visual disorders to be used by the child health care staff (Table A1). 5 These guidelines are currently being revised.

**Rotterdam Amblyopia Screening Effectiveness Study (RAMSES) Steering Committee**

Harry J. de Koning, Rikard E. Juttmann, and Johanna H. Groeneveld, Department of Public Health, and Huibert J. Simonsz, Department of Ophthalmology, Erasmus MC, University Medical Center Rotterdam, Rotterdam.

V. Kathleen Lantu, Foundation Early Detection of Visual Disorders, Amsterdam.

Jan Tjeerd H. N. de Faber, The Rotterdam Eye Hospital.

W. Christina Hoogeveen, Rotterdam Municipal Health Department.

Els Hostmann, Rotterdam Homecare Foundation.

**References**


