THE UNIVERSITY of York

NHS CENTRE FOR REVIEWS & DISSEMINATION

**HEALTH SERVICES RESEARCH UNIT,
DEPARTMENT OF PUBLIC HEALTH AND PRIMARY CARE, UNIVERSITY OF OXFORD**

Preschool Vision Screening: Results of a Systematic Review

CRD REPORT 9

PRESCHOOL VISION SCREENING: RESULTS OF A SYSTEMATIC REVIEW

SARAH K SNOWDON
SARAH L STEWART-BROWN

Health Services Research Unit
Department of Public Health and Primary Care
University of Oxford

April 1997

ISBN 1 900640 08 2

This report can be ordered from: Publications Office, NHS Centre for Reviews and Dissemination, University of York, York YO1 5DD. Telephone 01904 433648; Facsimile: 01904 433661: email: revdis@york.ac.uk

Price £9.50

The NHS Centre for Reviews and Dissemination is funded by the NHS Executive and the Health Departments of Scotland, Wales and Northern Ireland; a contribution to the Centre is also made by the University of York. The views expressed in this publication are those of the authors and not necessarily those of the NHS Executive or the Health Departments of Scotland, Wales or Northern Ireland.

Printed by York Publishing Services Ltd.

NHS CENTRE FOR REVIEWS AND DISSEMINATION

The NHS Centre for Reviews and Dissemination (CRD) is a facility commissioned by the NHS Research and Development Division. Its aim is to identify and review the results of good quality health research and to disseminate actively the findings to key decision makers in the NHS and to consumers of health care services. In this way health care professionals and managers can ensure their practice reflects the best available research evidence. The reviews will cover: the effectiveness of care for particular conditions; the effectiveness of health technologies; and evidence on efficient methods of organising and delivering particular types of health care.

Further Information

General Enquiries:	01904 433634
Information Service	01904 433707
Publications:	01904 433648
Fax:	01904 433661
Email:	revdis@york.ac.uk

Publications

CRD Reports

1.	Which Way Forward for the Care of Critically Ill Children? (1995)	£7.50
2.	Relationship Between Volume and Quality of Health Care: A Review of the Literature (1995)	£5.00
3.	Review of the Research on the Effectiveness of Health Service Interventions to Reduce Variations in Health (1995)	£12.50
4.	Undertaking Systematic Reviews of Research on Effectiveness. CRD Guidelines for those Carrying Out or Commissioning Reviews (1996)	£7.50
5.	Ethnicity and Health: Reviews of Literature and Guidance for Purchasers in the Areas of Cardiovascular Disease, Mental Health and Haemoglobinopathies (1996)	£12.50
6.	Making Cost-Effectiveness Information Accessible: The NHS Economic Evaluation Database Project. CRD Guidance for Reporting Critical Summaries of Economic Evaluations (1996)	£7.50
7.	A Pilot Study of 'Informed Choice' Leaflets on Positions in Labour and Routine Ultrasound	£7.50
8.	Concentration and Choice in the Provision of Hospital Services	
	Summary Report	£6.00
	Part I - Hospital Volume and Quality of Health Outcomes	£12.50
	Part II - Volume and the scope of activity and hospital costs	£9.50
	Part III - Concentration, patient accessibility and utilisation of services	£7.50
	Complete set of reports	£30.00

Effectiveness Matters

Vol.1 (1995)	(1)	Aspirin and Myocardial Infarction (1995)
	(2)	Helicobacter Pylori and Peptic Ulcer (1995)
Vol.2 (1996)	(1)	Influenza Vaccination and Older People (1996)
	(2)	Screening for Prostate Cancer (1997)

AUTHORS AND ACKNOWLEDGEMENTS

Sarah Snowdon is a Research Officer at the Health Services Research Unit. She is a graduate of the University of Oxford and has an MPhil from the University of Reading. She has also worked as a nurse in paediatrics and her main research interest is in child health.

Sarah Stewart-Brown graduated from the University of Oxford with a degree in physiology and qualified as a doctor in 1974. She spent a number of years working as a junior hospital doctor in medicine and paediatrics. She became the main researcher on one of the early surgical audit projects – the Large Bowel Cancer Project – before moving on to Bristol University to research a number of topics relating to community child health services. She was awarded a PhD from Bristol in 1989. During this period she completed her post graduate training in public health medicine. She worked as a consultant in community medicine in Bristol before moving with her family to be a consultant in public health medicine in Worcester. Her present interests cover the effectiveness and costs of screening programmes, the importance of emotional well-being for public health, child and adolescent health outcomes and the effectiveness of parenting programmes. She has also researched the impact of different models of primary care led commissioning. She joined the HSRU in 1994.

This review was commissioned by the NHS Centre for Reviews and Dissemination (NHS CRD), University of York on behalf of the NHS Health Technology Assessment Programme. We would like to thank Trevor Sheldon, Julie Glanville, Sally Baker and all those at the NHS CRD who gave their help and support.

With grateful thanks to those who responded to our request for data or gave their assistance and advice:

Dr D Altman & M J Deeks, ICRF Medical Statistics Group, IHS, Oxford
Professor J Atkinson, Department of Psychology, University College London
Dr M J Bannon, Consultant Paediatrician, South Warwickshire NHS Trust
Dr J Barlow, Research Fellow, Health Services Research Unit, Oxford
Mrs M R Beardsell, Head Orthoptist, Hinchingbrooke Hospital
Mr L Benjamin, Consultant Ophthalmic Surgeon, Stoke Mandeville
Mrs J Berriman, Head Orthoptist, Essex County Hospital
Professor C Blakemore, Department of Physiology, University of Oxford
Mr M P Clarke, Consultant Ophthalmologist, Royal Victoria Infirmary, Newcastle
Mr M D Cole, Consultant Ophthalmologist, Torbay Hospital
Dr M Conway, Senior Registrar (Public Health Medicine), Suffolk Health
Mrs Z Diamond, Head Orthoptist, The Whittington Hospital, London

Mrs C. Dodridge, Mrs S Czypionka & colleagues, Orthoptic Department, Oxford Eye Hospital

Mr J Elston, Consultant Ophthalmologist, Oxford Eye Hospital

Ms J Evans, Glaxo Department of Epidemiology, Moorfields Eye Hospital

Ms C Fernandez, Community Orthoptist, Coventry & Warwickshire Hospital

Mrs R Gallagher, Senior Orthoptist, High Wycombe

Mrs S J Garner, Head Orthoptist, Salisbury District Hospital

Professor D.M.B. Hall, Department of Paediatrics, University of Sheffield

Mr R Ingram, Consultant Ophthalmic Surgeon (retired).

Mrs J M James, Head Orthoptist, Princess Margaret Hospital, Swindon

Mrs E James, Eye Service Manager, Liverpool Road Health Centre, Luton

Miss A Lusher, Enquiry Services Manager, Cairns Library, Oxford

Mr P McCance, Head Orthoptist, Altnagevin Hospital, Londonderry

Dr D McCulloch, Lecturer in Vision Sciences, Glasgow Caledonian University

Mr R McNamara, Orthoptic Advisor, Frimley Children's Centre

Mr A Moore, Consultant Ophthalmic Surgeon, Addenbrookes Hospital

Dr D Munro, Consultant Paediatrician, Harrogate General Hospital

Mrs D Oliver, Head Orthoptist, Leicester Royal Infirmary

Mrs J Nolan, Head Orthoptist, Birmingham Children's Hospital

Ms V Peto, Research Officer, Health Services Research Unit, Oxford

Dr J Rahi, MRC Clinical Training Fellow, Great Ormond Street Hospital/Institute of Child Health

Ms R Scherer , Ms K Dickersin & Ms K Robinson, Baltimore Cochrane Centre

Miss H Stanforth, Assistant Secretary (Professional), The College of Optometrists

Mr C J Tallents, Consultant Ophthalmic Surgeon, Kidderminster General Hospital

Ms J Taylor, Librarian, British Optical Association

Dr D Thompson, Department of Optometry & Visual Science, City University

Miss S M Thompson, Consultant Ophthalmologist, Sandwell Healthcare NHS Trust

Mrs J Voller, Chair, British Orthoptic Society

Miss G Walker, Head Orthoptist, North Riding Infirmary

Mrs K J Walklate, Head Orthoptist, North Staffordshire Hospital

Professor B Winn, Head of Dept, & Dr P McGraw, Research Assistant, Department of Optometry, University of Bradford

Miss C Williams, Senior Registrar, Bristol Eye Hospital

Mr T Williamson, Consultant Ophthalmologist, St Thomas's Hospital

ADVISORY GROUP

Miss R Auld, Head Orthoptist, Birmingham & Midland Eye Centre

Mrs A Bruce, Head Orthoptist, Bradford Royal Infirmary

Mrs A Bishop, Optometrist, Bishop, Rumney & Bishop, Hereford

Mr M P Clarke, Consultant Ophthalmologist, The Royal Victoria Infirmary, Newcastle

Professor A Fielder, Kennerley Bankes Professor of Ophthalmology, Imperial College School of Medicine at St. Marys, Academic Unit of Opthalmology, The Western Eye Hospital

Dr J Garcia-Rodriguez, Consultant in Public Health Medicine, Suffolk Health

Dr A Harnden, GP, Morland House Surgery, Oxford

Dr M Moseley, Vision Scientist and Senior Lecturer, Imperial College School of Medicine at St. Marys, Academic Unit of Opthalmology The Western Eye Hospital

Dr Barnaby Reeves, R & D Support Unit, Bristol Royal Infirmary

Dr Clare Robertson, Consultant Community Paediatrician, The Ounsted Clinic, Oxford

Mrs D Stubberfield, Health Visitor, Croydon Community Health

Dr J Thompson, Senior Lecturer in Ophthalmic Epidemiology, University of Leicester

Mr R Wormald, Director, GLAXO Department of Ophthalmic Epidemiology, Moorfields Eye Hospital, London

CONTENTS

ABSTRACT

Objectives

- To undertake a systematic review of research on the effectiveness of preschool vision screening
- To provide evidence on which decisions about the future provision of this service can be made
- To indicate areas where further research is needed

Identification of literature

Study Selection

The NHS Centre for Reviews and Dissemination Guidelines for Systematic Reviews were used. The research questions were formulated using the Wilson & Jungner criteria for evaluating screening programmes. They concerned prevalence, natural history, disability, treatment and screening in relation to three target conditions: amblyopia, refractive errors and squints which are not cosmetically obvious.

Studies were considered for inclusion according to pre-determined criteria concerning the age group studied, outcomes measured and study design. The following types of study design were considered: cross-sectional studies of prevalence, cohort studies of natural history, any type of study (for example, cross-sectional surveys, case-series, qualitative studies) of disability attributable to a target condition, controlled trials, observational studies and audits of screening programmes, and prospective controlled trials of treatment.

Data Sources

The following electronic databases were searched: Biological Abstracts, Cinahl, Embase, ERIC, IAC Health Periodicals, IAPV, Medline, Psychlit, Science Citation Index, System for Information on Grey Literature in Europe, DHSS-Data, Faculty of Public Health Medicine Database of Dissertations, Index of Scientific and Technical Proceedings, Dissertation Abstracts, Index of Theses, NHS Research Register, Public Health Information Sharing Database. A limited amount of handsearching was undertaken. Reference lists were scanned to identify other relevant studies, and requests for unpublished data were made to people working in this field.

Data Extraction

Data was extracted by the first author and then checked by the second.

Data Synthesis

Quantitative analysis has been undertaken where possible. Qualitative analysis has been performed where studies were too heterogeneous for the data to be combined, or for those aspects of the research questions that are not suitable for quantitative synthesis.

Results

The electronic search yielded over 5000 references, and over 500 abstracts were downloaded from the databases for further scrutiny. 85 studies have been included in the main analysis.

Prevalence

No studies were found with the primary aim of establishing the prevalence of visual defects in preschool children. Data from studies of screening programmes report a range of yields for all the target conditions combined of 2.4-6.1%.

Natural History

No studies designed with the intention of documenting the natural history of the target conditions in three or four year olds were found. Other studies that provide some natural history data suggest that mild degrees of amblyopia may resolve spontaneously. In the absence of information about natural history it is impossible to estimate the effect of treatment from studies without a control group that was not treated.

Disability

21 studies exploring disability in relation to the target conditions were included. The literature provides a reasonable basis for generating plausible hypotheses about the ways in which the target conditions might disable people but is insufficient to draw any firm conclusions about their impact on quality of life. The research to date is not sufficient to determine appropriate outcomes for controlled trials of treatment.

Treatment

Five randomised controlled trials of treatment and six prospective controlled trials without randomisation were found. No studies compared treatment with no treatment. Most of the studies were methodologically flawed.

Screening programmes

One prospective controlled trial and 16 retrospective studies (observational studies and audits) of different screening programmes were found. They showed that orthoptic screening programmes perform better than health visitor (HV) or GP screening in terms of programme yield and positive predictive value. The mean uptake rate was 64.8%. The mean referral rate was 6.7% for primary orthoptic screening programmes and 3.9% for HV/GP screening. The positive predictive value ranged from 47.5%-95.9% for orthoptic screening and 14.4%-61.5% for HV/GP screening. Only two studies were found which reported numbers of false negative cases. The findings of the one prospective study do not support the belief that identifying children with amblyopia in the preschool period reduces the prevalence of this condition in children aged seven.

Conclusions

There is a lack of good quality research into the natural history of the target conditions, the disabilities associated with them, and the efficacy of available treatments. We believe that this evidence is essential to support a screening programme for a non-fatal condition for which there have been no rigorously controlled trials. An invitation to preschool vision screening carries with it the implicit assumption that screening is going to benefit the child. In the absence of sound evidence that the target conditions sought in these programmes are disabling and that the interventions available to correct them do more good than harm, the ethical basis for such interventions is very insecure.

Recommendations for research

There is a need to research the following areas:

1. The extent of disability attributable to the target conditions.
2. The prevalence of blindness or partial sight attributable to amblyopia in the UK.
3. The prognosis for vision in the amblyopic eye following loss of vision in the better eye.
4. The impact of orthoptic treatment on family life and the psychological wellbeing of the child.
5. The effectiveness of orthoptic treatment for amblyopia on vision and quality of life. This should be a randomised controlled trial in which the control group is not treated, using health outcome measures defined in studies of disability. This would also provide data on the natural history of amblyopia. Trials undertaken in groups of children aged three to four and five to seven would determine whether screening in the preschool years confers any benefit over screening at school entry.
6. The effectiveness of treatment of non cosmetically obvious squints and refractive errors in this age group.

BACKGROUND

Vision screening of children aged three to four years of age was developed in the context of the UK child health surveillance programmes during the 1960s and '70s in response to a need perceived by health professionals. In the 1980's a variety of different programmes were practiced in different parts of the country.[103]

Aim of vision screening

There is some uncertainty in the literature about the precise aims of programmes to screen children's vision at this age as they have the potential to identify a range of visual problems. This is in contrast to other screening programmes where the aim is to identify a single disease entity. The primary aim of vision screening at this age is the identification of the less severe common defects which we have called target conditions: - amblyopia, refractive errors and the non cosmetically obvious squints which cannot be detected without screening (latent and intermittent squints and microtropias)[1].

Target conditions

Amblyopia has been defined as a unilateral or bilateral decrease of vision, for which no cause can be found on physical examination of the eye.[118] It can be present at varying levels of severity and usually affects one eye only. Refractive errors describe the situation in which light rays cannot be focused on the retina and a blurred image is formed. The image can almost always be focused with the help of spectacles. Squint (strabismus) is a condition in which the two eyes are not aligned. In cosmetically obvious squint one eye is obviously looking in a different direction from the other. In small angle or micro-squint the deviation is not obvious and is revealed with the cover test. Latent and intermittent squints are only present under certain circumstances and can be revealed with the uncover test. These may develop into cosmetically obvious squints. None of the target conditions (amblyopia, refractive error and non cosmetically obvious squint) are clinically obvious. These three conditions are associated with one another but the relationship is complex and its precise nature is uncertain.[89, 94] Refractive errors (particularly anisometropia and hypermetropia) may strain ocular muscle balance and cause squints. Squints may also arise independently of refractive errors. Both are thought to predispose to childhood amblyopia because vision in one eye may be suppressed (the eye may become amblyopic) to prevent diplopia (double vision) when the ocular muscles cannot keep both eyes focused on a single image. Experimental evidence from animal studies and clinical experience in humans suggests that there is a sensitive period in the human child up to the age of about eight years when this process may occur and may be reversible. It would appear that vision is important for normal growth and development of the eye. Loss of vision in one eye may result in loss of oculomusclar balance and squint.

[1] Both the ophthalmological and epidemiological terms used in this report are defined in the glossary (see appendix A)

Conditions other than the target conditions which may be detected by screening

Cosmetically obvious squints should, by definition, be identifiable by parents or health professionals without a screening programme and most children with squints present by this route.[1, 79, 95] From time to time, a child with a cosmetically obvious squint will present through screening who has "slipped through the net" of child health surveillance. Although the frequency of this problem is unlikely to be sufficient to justify a screening programme in its own right, the identification of these children is an added benefit of the programme. Clinicians sometimes justify these programmes on the basis of identifying the rare childhood conditions that cause partial sight or blindness. Visual impairments are often detected in the first weeks of life by simple inspection,[86] and these children present spontaneously because their parents notice that they cannot see.[92] Very occasionally however a child will turn up for screening with a serious problem, such as retinoblastoma or a cataract, which has not been noticed by the parents. Such instances are too rare to be used to justify the screening programmes but, as for cosmetically obvious squints, their detection in this way is an added benefit. A true cost-benefit analysis of screening should take both into account.

The effect of target conditions on visual function and quality of life

Amblyopia

Visual acuity

The human eye is a very complex organ performing many different types of visual function. Traditionally visual acuity (the limit of spatial visual discrimination, commonly measured using letters or other geometrical forms) has been the most clinically valued characteristic in describing quality of vision.[109] In adults it is usually tested with a letter chart at six metres. In young children, the method of testing must be appropriate to the age of the child and for preschool children there are a variety of visual acuity tests. Visual acuity testing is the main screening method used to identify the target conditions, and reduced visual acuity not justified by other organic defects defines amblyopia.[110] If visual acuity screening is carried out accurately all children failing could, according to this measure, be regarded as disabled. However, children with amblyopia may have very good acuity in the unaffected eye. They may only have a visual acuity deficit with one eye closed.

Stereopsis

Children with amblyopia may suffer another type of visual disability - lack of binocular function. Two eyes focusing on an object from a slightly different angle allow the perception of depth (stereopsis). If one eye cannot see at all this cannot happen. Stereopsis is not an all or none phenomenon; people may have partial stereoscopic function measured in seconds of arc. The extent to which amblyopia affects stereopsis is therefore important in assessing visual disability from amblyopia.[89, 102]

Other Visual Functions

Complete lack of vision in one eye would cause visual disability by reducing the visual field (the area which an individual can see without moving their head). Complete lack of vision is, however, unusual

in amblyopia. Other aspects of visual function include perception of both colour and movement. These are not generally thought to be influenced by the target conditions.

Refractive errors

Refractive errors create a blurred image on the retina and thus also reduce visual acuity. A degree of hypermetropia (long sight) is normal in young children[94] and because most children have strong powers of accommodation, visual acuity may not be affected. However, the effort of accommodation in the presence of hypermetropia is thought to predispose to the development of squint. Hypermetropia and other refractive errors (myopia or short sight, anisometropia or unequal refraction in the two eyes and astigmatism) should be correctable with spectacles with no residual disability other than the need to wear spectacles.

Impact of amblyopia and refractive error on everyday life

It has been suggested that amblyopia and uncorrected refractive error may interfere with a child's development, educational performance and sporting ability. As a consequence of educational failure they may also have a long term disabling effect on adults. Adults suffering from amblyopia might have a problem with a number of activities: - racquet sports, driving, or jobs requiring fine motor coordination. Imperfect vision may be a reason for refusing entry into the armed forces and or to pilot training programmes. People with amblyopia are more at risk of blindness than those with two good eyes as a result of injury or disease in the non-amblyopic eye.

Squint

Non cosmetically obvious squints may progress to become obvious and unsightly and may, as a consequence, cause psychological problems. If these squints cause amblyopia they may be associated with poor stereoscopic function. They are thought to cause eyestrain (pain brought on by ocular muscle spasm) and headaches.

Treatment of target conditions

Traditionally, amblyopia has been treated by occlusion of the non-amblyopic eye by covering it with a patch, and this is the only method currently in use in the UK. Patching deprives the child of vision in the good eye and encourages use of the amblyopic eye to prevent loss of vision. Regimes for patching vary from one orthoptic department to another. In recent decades, alternative treatments have been tried. Penalization, or selective fogging of one eye using spectacles or cycloplegic drugs, is one such method. Systems designed to stimulate the amblyopic eye - pleoptics (dazzling light flashes) and CAM stimulation (high contrast grating patterns) - are another. Children in whom amblyopia is identified are treated with intermittent patching of the good eye to force continued use of the amblyopic eye and thus prevent loss of vision.

A refractive error may be treated to effect an immediate improvement in visual acuity or because it is thought to be contributing to the development of amblyopia or a squint. In the latter case, a refractive error may be treated at a level of severity that would not be considered to warrant treatment in its own

right. Squints that progress to become clinically obvious may be treated with surgery to the extra-ocular muscles to restore binocular single vision by realigning the visual axis or to improve cosmesis in the absence of binocular single vision.

Types of preschool vision screening programmes

In the past, UK child health surveillance programmes have incorporated a great variety of preschool vision screening tests undertaken at various ages.[103] Traditionally health visitors or clinical medical officers carried out these tests as part of a child health surveillance contact. The commonest tests at three to four years of age are inspection of the eyes for cosmetically obvious squint and other visual or ocular abnormalities, the cover-uncover test for squint, and a test of visual acuity, most commonly the Sheridan Gardiner test. In the last two decades programmes have been established by orthoptists in which children are invited to attend specifically to have their vision screened using a battery of orthoptic tests, including visual acuity, cover-uncover test, further tests of ocular muscle balance and tests of stereopsis. In some districts in which there is no primary orthoptic screening, orthoptists have set up community clinics or secondary screening clinics to which health visitors (HVs), general practitioners (GPs) and clinical medical officers (CMOs) can refer children about whom there is any concern either as a result of a primary screen or as a result of a clinical consultation. In other districts, referrals are made directly by HVs and CMOs, and in some places the referral has to be made via the GP. Orthoptists may also aim to invite and screen all high-risk children (those with a family history of visual problems or those with congenital defects).[97] The range of possible programmes therefore extends from no screening by anyone and referral to an ophthalmologist for children who present clinically through surveillance by HVs, GPs or CMOs, to screening with the cover-uncover test with or without visual acuity by HVs, GPs or CMOs, a limited orthoptic screen of high risk children, and a full population primary orthoptic screen. All but the last of these models may be provided with or without a community orthoptic clinic.

Previous reviews of preschool vision screening programmes

In 1989 a UK national working party undertook a review of the effectiveness of these programmes as part of an overall review of preschool child health surveillance. The working party concluded that there was no evidence to support screening at any age other than three to four years and that the efficacy of this screen was questionable.[91] The report identified a number of research issues that needed to be answered before a national screening programme could be recommended. In contrast both in the USA and Canada reviews of the evidence relating to preschool vision screening have led national bodies to conclude that screening at three to four years of age is effective and efficient and should be available to all children.[111, 112]

The need for evidence of effectiveness

In a recent Executive Letter, the Department of Health stated that shifts in investment are expected, away from ineffective and less effective interventions towards those that have been shown to be

effective.[87] The need for evidence of effectiveness is again underlined in the NHS Executive's programme 'Promoting Clinical Effectiveness'.[99] This review has addressed the fundamental questions that remain about the efficacy of preschool vision screening.

CRITERIA FOR EVALUATING SCREENING PROGRAMMES

The basic principles of screening and the criteria by which the effectiveness of screening programmes may be judged were defined by Wilson and Jungner in 1968.[106] The criteria can be summarised as follows: -

The condition

- is common and disabling
- the natural history is known
- there is a recognisable latent or pre-symptomatic phase

The screening test

- is reliable, valid and repeatable
- is acceptable, safe and easy to perform
- has a high positive predictive value
- is sensitive and specific
- has a cost which is commensurate with the benefits of early detection

Treatment

- is effective and available
- service provision is adequate to treat the children identified by the screening programme
- there is an agreed policy on who will be treated

Failure to fulfill any one of these criteria calls into question the validity of the screening programme. All of the criteria can in theory be evaluated in a single study if the study starts by allocating children to be screened or not screened, and the entire population is followed up for several years to identify false negative cases and to measure the benefits in children who have been screened. In the absence of such studies it is useful to evaluate the extent to which each of the criteria is fulfilled. Although the criteria are usually presented in the above order, it is more logical to address questions relating to treatment before those relating to the efficacy of screening. If there is no effective treatment for the condition the questions about the efficacy of the screening programme become superfluous. The research questions for this review have been formulated using the Wilson and Jungner criteria but in this more logical order.

RESEARCH QUESTIONS

The conditions

Prevalence

What is the prevalence of the target conditions (amblyopia, refractive errors and non cosmetically obvious squints) in three to four year old children? What proportion of children with cosmetically obvious squints and partial sight and blindness fail to present spontaneously?

Natural history

What is the natural history of the three target conditions?

Disability

What are the consequences of the primary target conditions in terms of disability at that time or later, as measured by various outcomes such as visual acuity, stereopsis, educational achievement and the performance of everyday activities?

Treatment

What is the effect of treatment of the primary target conditions in three to four year olds on visual function and current and future disability?

Is there evidence that this is more effective than treating the same conditions in five to seven year olds? If treatment is as effective at five to seven years, screening could be carried out at school entry.

Screening

What is the uptake of screening following invitation? Is there evidence that these screening programmes can identify the target conditions efficiently?

The parameters of a screening programme that predict its performance are the sensitivity, specificity, positive predictive value and yield.

Measuring the efficiency of screening

	Target condition present	Target condition absent
Test +ve	a	b
Test -ve	c	d

a= true positive cases b= false positive cases
c= false negative cases d= true negative cases

$$\text{Yield} = \frac{a}{a+b+c+d}$$

$$\text{Positive predictive value} = \frac{a}{a+b}$$

$$\text{Negative predictive value} = \frac{d}{c+d}$$

$$\text{Sensitivity} = \frac{a}{a+c} \qquad \text{Specificity} = \frac{d}{b+d}$$

Potential research questions not included in this review

We have not attempted to identify and critically appraise all the literature pertaining to the performance of the numerous vision tests that could be used in this age group. We have restricted the search to tests that have been used in population screening programmes. This is necessary before a test can be recommended for use in a screening programme, as the results of testing in experimental conditions are not always replicable in practice. The reliability, validity and repeatability of a test determine the sensitivity, specificity and positive predictive value of the test's performance in a screening programme, and tests which have been shown to score highly on the latter must therefore perform reasonably on the former. Visual acuity charts in which the lines are scaled in a logarithmic fashion (LogMAR charts), and which can be scored by letter rather than by whole lines, seem to have advantages over the Snellen scale, including greater accuracy and better test-retest reliability[40, 98] but, in the UK, they are at present used only in research.

We have not looked for studies of the safety of these tests. All are non-invasive and have been in use for decades. It seems reasonable to assume that they are safe. Nor have we looked for studies of their acceptability. To some extent a high uptake rate can be regarded as a proxy measure of acceptability by a community.

We have not attempted to assess the adequacy of current service provision. This would need to be undertaken before a screening programme such as this was implemented.

This review has not attempted to assess the effectiveness of screening at three to four years of age relative to alternative strategies for the identification and treatment of visual defects in children. These include the identification and treatment of risk factors for amblyopia and squint in infants by various methods of refraction, and screening at school entry.

REVIEW METHODS

The NHS CRD Guidelines on Undertaking Systematic Reviews of Research on Effectiveness[126] were consulted. Trevor Sheldon, Director of the NHS Centre for Reviews and Dissemination, offered advice and support on all aspects of the review.

Advisory Group

A multi-disciplinary group of researchers and practitioners with diverse opinions were invited to help identify literature, comment on the protocol, check our interpretation of the literature, and offer peer review of a draft report and advice on implications. One meeting of the group to discuss an early version of the report was held. The group did not determine the contents of the review.

Search Strategy

Studies in any language were considered for inclusion. Medline was searched from its start date of 1966 and other databases from 1975.

Studies that focused on children with severe disabilities who also had visual defects were excluded.

Electronic searching

The electronic search strategies were devised with the help of Anne Lusher at the Cairns Library, Oxford, and Julie Glanville at the NHS Centre for Reviews and Dissemination.

The search strategy was modified to meet the requirements of each database. For those which code the research designs, separate searches were undertaken to identify a) RCTs b) CCTs and c) other study designs. The search strategies are included in Appendix B.

The following databases were identified by a CROS search (Appendix C) as those with the greatest number of references relating to the broad topics with which the review is concerned:

Biological Abstracts
Medline
Embase
SciSearch
Psychlit
IAC Health Periodicals
Cinahl

In addition, ERIC, an educational database, and IAPV (Incidence and Prevalence) databases were searched.

Handsearching

The results of the handsearching undertaken by Jennifer Evans and Richard Wormald at Moorfields Eye Hospital for the Cochrane Collaboration were made available for the purpose of the study. RCTs and CCTs of screening and treatment were looked for in the following journals:

British Journal of Ophthalmology 1948-1995

Ophthalmic and Physiologic Optics/Br J Optometry and Physiologic Optics 1948-1995

British Orthoptic Journal 1985-1995

Clinical Vision Sciences 1986-1995

European Journal of Implant and Refractive Surgery 1989-1995

Experimental Eye Research 1985-1995 (some issues missing 1994/5)

Journal of the British Contact Lens Association 1985-1992

Progress in Retinal Research 1985-1995 (1 issue missing 1994)

Vision Research 1961-1970,1975,1980,1985,1990,1992,1995

Visual Neurosciences 1988-1995

Journal of Paediatric Ophthalmology/Strabismus 1964-1994 (except 1978 & 1980 and some numbers missing in 1994)

We were notified of potentially relevant RCTs and CCTs identified at the Baltimore Cochrane Centre for inclusion in the Vision Trials Register.

The British Orthoptic Journal 1976-1996 was handsearched for any studies relating to the research questions.

Other sources

A request for unpublished data was sent to departments of ophthalmology, vision sciences and orthoptics and to researchers in this field. Notification of the review and a similar request was made in the following publications: British Orthoptic Society newsletter, Optician, and Optometry Today.

Reference lists of retrieved articles were scanned to identify other relevant studies.

The following databases of grey literature were searched: SIGLE (System for Information on Grey Literature in Europe), DHSS-Data, Faculty of Public Health Medicine Database of Dissertations, Index of Scientific and Technical Proceedings, Dissertation Abstracts, Index of Theses, NHS Research Register, PHISH, MSc theses from university departments of Community Paediatrics.

Inclusion Criteria

Studies were considered for inclusion on the grounds of relevance (subjects), outcome and design. For some of the research questions the range of study designs included is far greater than those usually included in systematic reviews. These are often confined to controlled or randomised controlled trials. Our inclusion criteria for studies on disability were particularly wide. It was deemed important to identify the literature on which clinicians base their views on disability and to appraise the extent to which it supports those views.

Studies that meet the inclusion criteria are tabulated. Those that were rejected on one or more of the criteria are identified in Appendix D. Some did not meet the inclusion criteria but provided useful contributory information, which is referred to in the text.

Prevalence studies

Subjects: a representative population of children aged 3-4 years.

Outcome: prevalence of the primary target conditions.

Design: cross-sectional studies.

Natural history studies

Subjects: a representative population of children in whom any of the primary target conditions were identified at age 3-4 years and whose visual defects were not treated.

Outcome: any visual changes observed over time in children who had not been treated.

Design: cohort studies of 20 or more subjects.

Disability studies

Subjects: any aged 3 years or more.

Outcomes: any type of disability attributable to any of the primary target conditions.

Design: any (cross-sectional, comparative, case control, cohort, trials of treatment, qualitative, systematic and non-systematic reviews) studies that investigated whether disabilities were associated with the target conditions. In particular, we hoped to find studies that aimed to establish whether there was a causal relationship between visual defects and disability.

The epidemiological criteria for establishing a causal relationship were described by Bradford Hill in 1971.[113] They are: -

- strong and consistent, statistically significant association not accounted for by confounding factors
- a dose-response relationship
- evidence that the visual defect preceded the disability
- evidence that the disability could be reversed by correction of the visual defect

Treatment studies

Subjects: children aged 3-7 years who were treated for any of the primary target conditions.

Outcomes: visual outcomes, visual complications associated with surgery, spectacle use, disability, patient perceived outcomes, other side effects.

Design: prospective controlled trials, with or without randomisation.

Screening programme studies

Subjects: children aged 3-4 years.

Outcomes: uptake rates, referral rates, diagnostic yield, positive predictive value, negative predictive value, sensitivity, specificity, costs, visual outcomes, and patient perceived health outcomes.

Design: prospective controlled trials, observational studies and audits.

Critical Appraisal

The studies have been critically appraised independently by the two authors. The methodological shortcomings of each study are identified in the tables. Those of the different study designs are discussed in the text.

Data Extraction

Data was extracted from studies meeting the basic inclusion criteria by the first author and checked by the second. Any disagreements were discussed and resolved. Where possible, the authors of the studies concerned were contacted if data was unclear or appeared to be incomplete.

Data Synthesis

Results from studies that provide comparable numerical data on aspects of screening programmes have been gathered together in one table. Where possible these data have been pooled. Where secondary calculations have been made in order to produce comparable data this has been indicated in the tables. Some studies, particularly those on screening programmes, have addressed more than one of the research questions and so appear more than once in the results tables. A qualitative approach has been used to explore aspects of the research hypotheses that are not suitable for quantitative synthesis.

RESULTS: PREVALENCE

No studies were found which were conducted with the primary aim of establishing the prevalence of amblyopia, refractive errors and squints at three to four years of age. Our search strategy and inclusion criteria were specific and should have been sensitive. It seems unlikely that we have missed studies that are retrievable electronically at present.

We identified two types of study which could contribute to this research question: retrospective analyses of hospital records in communities where hospitals serve a defined catchment population and observational studies of the yield of screening programmes for this age group (these are presented in Tables 5a and 5b in the section on screening).

Prevalence rates depend on the definition of the condition. All three target conditions can be present at varying degrees of severity. Comparing the yield from screening programmes, that is the proportion of children in the screened population found to have a target condition, is complicated by the absence of precise definitions of the conditions in the studies (see Tables 5a and 5b). Only one study gave a yield for micro-squints,[80] and the other studies failed to distinguish between different types of squint when reporting yield. The level of acuity at which amblyopia is considered significant may not be defined, and the type and degree of refractive error included in the prevalence estimates of refractive errors is not always identified. One study of screening programme yield included all children of the relevant age referred to eye hospitals[9] and one recorded separately referrals made through screening and by other routes,[20] while the rest included only those referred from the programme. The latter studies will underestimate the prevalence of the conditions because they may exclude children who have presented spontaneously and do not turn up for screening because they are already under the care of an eye hospital.

The studies of primary orthoptic screening programmes presented in Table 5a provide an estimate of total yield of 2.4-6.1%. The study with a yield of 2.4%[9] excluded isolated refractive errors from the target conditions. The studies with yields of 5.9%[20] and 6.1%[80] both identified 4.3% of children as having refractive errors (including anisometropia), but the severity of hypermetropia and myopia were not defined and may have included mild cases. The second of these studies stated that glasses were prescribed if the refraction was more than +4 D but there is no indication that only children with refractive errors at this level were included in the yield. If these two studies are excluded the range of yields reported in these programmes runs from 2.7 to 4.4%.

We found one survey of ocular and/or vision defects detected in a cohort of children born in 1984 and followed up to the age of five, in one health district.[67] In this district during this period a secondary orthoptic screening service was provided. 5.1% of the children were found to have an ocular or vision defect requiring treatment or surveillance between the ages of two and five years. Heterotropia was the primary defect in 2.3% of children and heterophoria in 0.5%, while refractive error only was found in 2.1% and other pathologies (non target conditions) in 0.2%. These figures include children who also

had amblyopia, which was classified according to the putative cause (squint, refractive error or cataract).

One study[74] analysed in detail all referrals to all hospitals in Leicester to identify the age specific and cumulative incidence of amblyopia. There was no primary orthoptic screening in place in this city. The cumulative incidence of amblyopia up to age three years was 1.25% and up to four years 1.69%. Three percent of the population of Leicester were diagnosed as having had amblyopia of 6/12 or worse by the time they reached eight years of age. In theory, if pre-school vision screening is effective in identifying children with amblyopia earlier than they would otherwise present, these figures from Leicester should underestimate the prevalence of amblyopia at age three and four years.

No comparable studies of squint or refractive error prevalence in this country have been found. The lack of information on the prevalence of non cosmetically obvious squints (intermittent squints, latent squints and micro-squints) is notable. One study[84] suggests that the figure may be very high. Seventy-seven per cent of a group of 86 children selected as controls for a study of dyslexic children from a whole population of second grade children in one Swedish county, were shown to have a tropia or phoria at near and 25.4% at distance. This contrasts with the much smaller number of children found to have a tropia or phoria in the birth cohort study discussed above.[67] That study was based on a population of children referred to the Eye Hospital and would not have included children in whom there was no reason to suspect an abnormality. The control group in the Swedish study approximates to a normal population and is more likely to give an indication of the true prevalence.

No studies were found which addressed the question of how many children with cosmetically obvious squints and partial sight and blindness fail to present spontaneously. The few studies that touched on the issue of spontaneous presentation of children with visual defects are discussed in the section on screening.

Summary

Despite the methodological limitations of the studies included in this section, and excepting the difference between the two studies mentioned above,[67, 84] the prevalence estimates are consistent. There can be no doubt that the target conditions are sufficiently common to justify screening programmes

RESULTS: NATURAL HISTORY

We found no studies designed with the intention of documenting the natural history of squint, amblyopia or refractive error in three to four year olds. This was a focused search strategy and it is unlikely that correctly coded studies were missed.

We found some studies that, although they do not fill our inclusion criteria for natural history studies and are methodologically limited, provide useful background data.

One of these[14] was set up to evaluate the effectiveness of a primary orthoptic screening programme for children aged three to four in Newcastle. The prevalence of amblyopia associated with non cosmetically obvious squints or refractive error (straight- eyed amblyopia) was significantly higher in the group who underwent orthoptic screening than it was in the other groups of children and more of these children received treatment. This was attributed to the efficiency of orthoptic screening in finding children with amblyopia. When the children were followed up to the age of seven it was expected that the prevalence of amblyopia would be higher in the group which had not been screened by orthoptists because fewer of the amblyopic children in this group would have been identified and treated. The prevalence of amblyopia was found to be the same in all groups. The implication of this result is that some of the amblyopia identified and treated in the orthoptic screening group would have resolved spontaneously if left untreated. This study was a CCT not an RCT and the sample sizes small, so conclusions must be drawn with caution. (A fuller appraisal of this important study is to be found in the section on screening).

The second study[114] followed up 22 of 24 children referred to the eye department of a Swedish children's clinic following screening at four years of age with confirmed mildly reduced visual acuity of 0.65 (decimal equivalent of approximately 6/9) in both eyes, or 0.65 in one and 0.8 (approximately 6/7.5) in the other. Distance visual acuity was tested using the HVOT chart. Two of the children had hypermetropia of >+3.25D in both eyes. None of the 24 children were treated. At five years of age 18 of these children could see 0.8 or better with each eye. The visual acuity of the four whose vision had not self-corrected had not deteriorated. However, in two of these the refractive error had increased slightly. These children were treated with spectacles and patching at five years and both improved. This is a small study, but its findings are in agreement with[14] and call into question the need to refer or treat children with amblyopia of 6/9 at three to four years of age.

The third study was also Swedish.[115] This study followed up babies of parents who reported that they, or a sibling, had had a squint. These children had their vision tested at 3, 6, 12, 24 and 48 months. All the children who developed an esotropia (a convergent squint) by four years (17.6% of this group of 34 children) were hypermetropic >+4.0D at six months of age. Half of the group who were hypermetropic to this degree at six months did not develop squints, but in these children, in contrast to the former, the hypermetropia had decreased by four years. The study also documents the changes in refraction that occurred in this group of children over this period. Most babies were more

hypermetropic at six months than they were at three months and at this age the modal refractive index was +3.0-3.75D. Hypermetropia reduced in all children except those who ended up with squint; at four years of age the modal refractive index was +1-1.75D. The study was small and the statistical significance of the results was not tested.

In a study of 186 one year old children,[116] bilateral hypermetropia of +2.00D or more and/or anisometropia or astigmatism was significantly associated with a child eventually developing a squint and/or amblyopia. This finding also applied to a group of 215 preschool siblings of children presenting with squint and/or amblyopia, in whom the presence of +2.00D or more of bilateral hypermetropia, or +1.00D or more of anisometropia was significantly associated with a child being found to have squint and/or amblyopia two or more years later.[117]

The results lend support to the hypothesis that hypermetropia in early infancy that does not reduce with age results in cosmetically obvious squint. However treatment of hypermetropia following early detection will result in the correction of hypermetropia in many children in whom it would regress naturally.

We found one small study that provides some circumstantial evidence of the natural history of amblyopia in people with squints. This reported the prevalence of amblyopia in 20 immigrants to the United States from south east Asia (average age 20 years) with a history of untreated early onset esotropia, who were seeking an improvement in their cosmetic appearance.[29] These were compared with 20 people with the same condition who had received orthoptic and surgical treatment and for whom the follow-up period varied from one to eight years. Of the treated group, 20% had amblyopia prior to surgery and 80% afterwards. In the untreated group, only 15% had amblyopia. Although these two groups are not at all comparable, the findings in the untreated immigrant population are important as they suggest that, in this group at least, amblyopia was by no means an inevitable consequence of uncorrected cosmetically obvious squint.

Summary

The few studies which provide information about what would be expected to happen to the vision of children with any of the target conditions at three to four years in the absence of intervention do not support the need to treat these children, but there are many important gaps in the data. Lack of documentation of the natural history of the three target conditions means that it is impossible to estimate the effect of treatment from studies which have no control group. Any improvement observed during the course of treatment might be occurring in spite of, rather than because of, treatment.

RESULTS: DISABILITY

We found 21 studies which aimed to investigate whether a variety of disabilities were associated with any of the three target conditions The literature on the relationship between visual defects and reading difficulties is particularly extensive and diverse. The reviews we identified on this subject[31, 32, 63] cover studies dating back to 1932 conducted by a range of professionals (psychologists, optometrists, ophthalmologists, educationalists, and neurologists). We have not attempted to appraise all the studies in these reviews as they predate the rest of our search.

Five different types of study design were identified:

- Studies of representative cohorts of children in which the performance of the small number of children with a visual problem is compared to that of the remainder of the population
- Studies comparing a group of children or adults with a problem to a similar group without the problem. Most of these studies were comparative studies rather than true case control studies. This study design has been applied to groups of children with reading difficulties, groups of clumsy children and groups of children with learning difficulties; in these studies the outcome was visual defects. The same study design has been applied to a group of students with amblyopia; in this study the outcome was performance of everyday activities
- Studies in which the level of vision is correlated with the level of potential disability using both attributes as continuously distributed variables rather than categorical variables as in the designs above
- Experimental studies in which the vision of normal subjects is artificially impaired in the way that the vision of people with the target conditions might be impaired and performance at everyday activities measured
- Studies of the epidemiology of partial sight aiming to identify the proportion in which amblyopia is a contributory factor

The first two types of study are methodologically sufficient only to establish the first of the epidemiological criteria necessary to conclude that the target conditions cause disability. They should be able to identify a strong and consistent association if one exists. To fulfill these criteria such studies need to have tested whether potential confounding factors associated with both the problem and the outcome (for example social class) have been taken into account. The mathematics are complex and time consuming. Computer software which can " adjust" for confounding factors was only developed in the 1980s and these calculations were not commonly done before that time. Two of the later cohort studies[51, 68] and one of the studies comparing matched groups[35] did this.

The third type of study (correlating levels of defect with levels of disability) can go some way towards demonstrating that the disability gets worse as the target condition gets worse, a dose-response relationship. The problem with this design is that some measures of visual performance, such as visual acuity, are rank order rather than continuously distributed variables. The fourth is valuable in showing that a reduction in visual function could result in impaired performance, that is that the vision defect

precedes the disability. The findings from the latter type of study, however, need to be substantiated in people who have had the target conditions since childhood to demonstrate that the developing brain was not able to develop compensatory mechanisms. The fifth is important in defining the size of this particular and important outcome in later life. None of these studies designs is sufficient to demonstrate the last and most important criteria in establishing a causal relationship, that by reversing or treating the visual defect it is possible to prevent the development of disability.

The studies we identified and appraised are presented in Table 1 at the end of the section on disability, where they are organised by study design and topic.

Studies of representative cohorts of children in which the performance of the small number of children with a visual problem is compared to that of the remainder of the population

The strength of these studies is that the group of children with whom the 'abnormal' children were compared was truly representative of the general population. An additional advantage is that, in all but one study,[4] vision and educational tests were carried out independently of each other. Their disadvantage rests in the level of diagnostic accuracy, which is limited because many different people (school medical officers and nurses) carried out the testing and standardisation of testing and diagnosis is difficult.

We identified four studies of this kind.[2,4,51,68] The earliest[2] in children aged seven showed an association between squint and educational performance. Children with squints scored less well on tests of reading and copying, and were rated by teachers as fidgety and clumsy and having less intelligible speech. This association appeared to be due to a clustering of problems in some children who were labelled as having 'minimal cerebral dysfunction'. After excluding clumsy children, significant differences remained in the performance of children with squints in the reading and copying design tests. The results of the second study[4] in five year olds were consistent with the first. They showed an association between squint and poor performance in neuro-developmental tests. The third study[51] examined the motor abilities of children with reduced stereoscopic function likely to be due to amblyopia or squint, comparing those with other children. Children with poor stereoscopic vision at seven years had poorer motor ability at five years. In this study potentially confounding factors like socio-economic status, physical development and IQ were taken into account. The fourth study[68] was a large UK study using more complex analysis on children aged ten. The results of school visual acuity testing were used to group children with less than perfect vision according to the likely cause. The performance of these children was compared with those with perfect vision. The most dramatic finding in this study was the superior intelligence test performance of children who were likely to have myopia. This association has also been found in other studies.[90, 119, 120] The differences in the other groups were small. The only group who appeared to be reading at a level that was inconsistent with their intelligence were children who failed the near but not far vision tests. These children were likely to have been hypermetropic and to have had poor accommodative powers. This study also adjusted for confounding factors. Because of the very large size (15000 children) the statistically significant differences are small in absolute terms.

Studies comparing a group of children or adults with a problem to a similar group without the problem

Reading

The literature suggests that the relationship between reading and vision has intrigued researchers for almost a century. We identified three reviews looking at the prevalence of visual defects in children with reading difficulties compared to children who had no reading difficulties.[63, 31, 32] These covered studies dating back to the 1930's. The first and most recent[63] was based on a systematic search for studies with quantitative outcome data. Thirty-four studies were included. The authors applied statistical tests of heterogeneity to the data and provide results for analyses with and without the outliers. It does not appear that the studies were critically appraised and that any were excluded on the grounds of methodological inadequacy. The results of this review are consistent with the studies showing that myopia is negatively associated with poor reading. The authors found a positive association with hypermetropia and anisometropia. Some types of squint (exotropia at near and vertical phorias) were positively associated with poor reading, and others (esophorias at both near and far) were negatively associated.

The authors of the second recent review[31] did not specify their search strategy. They aimed to identify studies with a control group, which looked at the prevalence of refractive error in children with reading difficulties. They did not specify methodological quality criteria and do not appear to have excluded studies on the grounds of methodological inadequacy. They presented a qualitative synthesis of the results of the studies and concluded that myopia was not associated with reading difficulty, but that hypermetropia and anisometropia were. None of these three conditions was defined in terms of the level of refraction and the ages of the children in the different studies were not specified. It is impossible to tell whether the visual assessment was carried out by an independent reviewer.

The third review[32] was another non-systematic review of studies of children with reading difficulties. It included "only studies which adhere to the rudiments of scientific investigation" but did not specify what these are. The findings are consistent with the above reviews with regard to refractive errors. Squints were found to be positively associated with poor reading.

Lack of information on the methodological quality of the studies included in these three reviews makes it impossible to place much weight on the findings. The one finding which would appear to be consistent in all these studies and is born out in the studies quoted above is that children with myopia perform better than their peers at reading. In contrast hypermetropia and anisometropia may be associated with poor reading. The studies on oculomotor function and squint have produced inconsistent findings.

The four primary studies we have included were undertaken more recently than those included in the reviews and two are methodologically superior. These studies have concentrated on the relationship of oculomotor abnormalities to reading difficulty. The largest study[84 & 85] was a case control study of the 86 dyslexic children in a cohort of children from one Swedish county each of whom were matched to a non-dyslexic child of the same age, sex, social class and intelligence. Visual assessments were

undertaken by an ophthalmologist and orthoptist blind to the child's reading ability. This study concluded that dyslexic children did not differ significantly from control children in terms of oculomotor function. A study of similar design and size in Finland,[44] but in which visual assessment was not blinded, concluded that the only oculomotor difficulty was a reduction in the ability of the eyes to converge on near objects (so preventing a double image). The two other studies[10, 21] had small sample sizes, matching was restricted to age, sex and, in the latter study, intelligence. Visual assessment was not blinded. These studies suggested that dyslexic children had an abnormal vergence response. It is likely to be important that the largest study, which was also the only one in which the possibility of bias in visual assessment was excluded by blinding, found no difference in oculomotor function between children with dyslexia and those without.

Clumsiness

One small study[35] compared the visual performance of children who were defined as clumsy on a test of motor competence with that of a group of children who were similar in terms of age, sex and IQ. Blind assessment was undertaken. The study found that clumsy children performed less well on tests of visuospatial discrimination but there was no dose-response relationship.

Learning difficulty

We found another small study[69] comparing the visual performance of children from classes classified as learning disabled with a group of children from a conventional class in the same school grade. The assessment was not carried out blind, no academic testing was carried out and no information on IQ was available. Vertical fixation disparity was said to be more common in the learning disabled children.

Amblyopia and perceptual skills

We found one non-systematic review[30] in which the authors brought together a number of studies that contribute to the debate on the importance of stereopsis in humans. They noted the lack of studies exploring the functional consequences of reduced stereopsis. Evidence relating to the importance of binocular vision seems to be conflicting. The authors concluded that even people who require a high level of visual skills, such as pilots, function well without stereopsis, but that it appears to be an advantage in certain tasks, such as those requiring complex hand-eye co-ordination.

We identified one unpublished study[38] that investigated the impact of amblyopia on contrast sensitivity, the ability to detect depth in stereopsis tests, and the judgment of spatial relationships. The performance of students with amblyopia in exercises designed to test these skills were compared with those of students who had the same level of visual acuity in their better eye and no amblyopia, but who had monocular acuity deficits due to under-corrected or uncorrected refractive errors. This study suggested that monocular amblyopia had little impact on perceptual skills and was unlikely to affect the performance of everyday tasks in 'most normal environments where spatial cues are abundant'. The author suggested that people with amblyopia might find it difficult to construct topographical

maps from aerial photographs or to detect counterfeit money, but did not investigate further the possible functional consequences of amblyopia in terms of 'real life' activities. The severity of amblyopia amongst these students was not specified and the sample sizes were small. The fact that those in the control group also had reduced vision in one eye, albeit due to refractive errors, may offer some explanation for the similarities in the test performance of the two groups.

Another study with several methodological weaknesses[43] attempted to assess the stereoscopic ability of office workers. The study used an outcome measure which was not validated and collected this data in a questionnaire. The results suggest that the majority of office workers do not make use of the stereoscopic function they do have. One hour's instruction produced a subjective improvement.

Studies in which the level of vision is correlated with the level of potential disability using both attributes as continuously distributed variables rather than categorical variables as in the designs above

Three studies of representative samples of children, one large[34] and two small[8, 33] all looked for a correlation between visual defects and reading ability and found none. In these studies, children's performance on various dimensions of visual function was graded, as were the outcomes (such as reading scores). The authors assessed the level of correlation between vision and outcomes.

Experimental studies in which the vision of normal subjects is artificially impaired in the way that the vision of people with the target conditions might be impaired and performance at everyday activities measured

We found two studies in which the vision of normal subjects was artificially impaired in order to assess the impact on specific tasks. The first[6] examined the performance of a small convenience sample of university staff in a tightly controlled experimental situation. This sample performed less well at almost all tasks with one eye closed and there was a significant interaction with dim light. The reduced performance was not entirely accounted for by lack of stereopsis. Another study[66] rendered primary school children myopic with spectacles. The children performed less well than would have been expected from their visual acuity in discriminating complex pictures.

Studies of the epidemiology of partial sight aiming to identify the proportion in which amblyopia is a contributory factor

Finally, one much-quoted study[75] attempted to calculate the contribution which amblyopia makes to blindness and suggested that the rate of 1.75/1000 amblyopes was higher than the risk of blindness in the general population. During the same period in Finland, the overall blindness rate in children was 0.11/1000 and in adults aged 15-64 years 0.66/1000. These calculations did not take account of changes in the birth rate or in the incidence of amblyopia over time, and are dependent upon the quality of the ascertainment and registration of blindness in Finland. Knowledge of the size of this problem is very important in assessing the potential impact of screening and treatment, and it is surprising that the Finnish study has not been repeated elsewhere. There are reports of improvement in vision in amblyopic eyes after functional loss in the good eye. One study[121] found that of 59 cases of unilateral amblyopia with the loss of the good eye taken from literature and 144 cases obtained from a questionnaire sent to ophthalmologists, in 47.5% and 28.5% respectively there was a reported

improvement in the acuity of the amblyopic eye. The authors took the latter group to constitute a more random selection and noted that 17.4% of that group improved without any treatment.

Summary

Although experimental studies suggest that people with good vision in only one eye might be expected to be disabled in a number of ways, this finding has not been born out in the one study of the performance of people with amblyopia. This may be because most people with amblyopia have some vision in their poor eye or because people with only one good eye since childhood develop compensatory visual mechanisms. The latter study did not carry out tests on all the areas demonstrated to be affected in the experimental study and the participants were not tested in the dark. Further more detailed studies of the performance of adults with amblyopia are urgently needed.

One strong and consistent relationship emerges from studies of visual defects and reading. Children with myopia perform better at tests of reading than their peers. Whether this is due to superior intelligence or to reading ability alone is not so clear. The relationship, although of academic interest, is of little consequence to the debate about the importance of preschool vision screening partly because myopia is rare in this age group and partly because there are no clear therapeutic implications. The possibility that hypermetropia might interfere with learning to read warrants testing in a well designed randomised controlled trial of spectacle correction but the evidence is not sufficient to warrant screening at this stage.

The quality of the literature on visual defects and disability is insufficient to offer any advice to parents about what might be expected to happen to children who have amblyopia, non cosmetically obvious squint or refractive error if they were left untreated.

Table 1. Disability Studies

Study	Study Type	Sample	Visual Defect or Function & Tests	Disability or Affected Activity & Methods of Assessment	Results	Comments
Alberman [2] (1971, UK)	Cross-sectional study of 7 year old children born in one week in 1958, comparing social function & educational performance in those with squints & those without.	The 478 children with a squint on medical exam by a school doctor were compared with the 12,904 children with no squint on medical exam and in whom parents reported no squint. Children whose parents reported a squint who were not found to have one on medical exam were excluded as were educationally subnormal children & those with cerebral palsy.	Squint	Clumsiness, speech intelligibility & reading ability assessed by teachers: Southgate group reading test, copying design test, arithmetic test, draw-a-man test. Social maladjustment (Bristol social adjustment guide). Educational & vision tests carried out independently of each other. All outcomes were analysed categorically. Cut-off points for abnormality not stated to be set prior to analysis.	Children with squints were poorer at reading & copying design tests, and were rated by teachers as being poorer readers, having less intelligible speech, and being more clumsy & fidgety. No significant differences in arithmetic performance. Significantly higher incidence of social maladjustment amongst children with squints. The authors investigated the hypothesis that the results were attributable to the children who had 'minimal cerebral dysfunction' (clumsiness & mild learning difficulty). After excluding clumsy children the only differences to remain significant were the reading and copying design tests.	Squints diagnosed by school doctor. Type not classified – might include latent as well as manifest squints. Other visual defects not reported (eg. refractive errors & amblyopia). Differences were small and those for reading in the analysis without clumsy children only just significant in this large sample. No justification presented for the cut-off points chosen to define abnormality.
Bax [4] (1973, UK)	Cohort study of a representative sample of children to investigate their neuro-developmental status	All 5 year olds entering ordinary schools on the Isle of Wight in one academic year. All the children were followed up aged 7 years (reading test and behavioural questionnaire), & referrals to psychologist by 9 years noted .	Squint	Neuro-developmental screen performed including tests for hearing, speech, facial symmetry, motor impersistence (tongue protrusion), tongue tremor, fine motor control (hand patting), drawing shapes, hopping	The presence of a squint was significantly correlated with poor performance overall in the neuro-developmental tests.	It is not clear whether the tests used had been validated on population samples. They are in standard clinical use. Medical officers assessed both squint & neuro-developmental status, so were not blinded. Total number of children examined not stated. Full data available on 602.

Study	Study Type	Sample	Visual Defect or Function & Tests	Disability or Affected Activity & Methods of Assessment	Results	Comments
McGee [51] (1987, New Zealand)	Cohort study of a representative sample of children examining the correlation between stereopsis & motor ability.	858 children Motor abilities at 5 years examined, and level of stereopsis at 7yrs.	Stereopsis (TNO plates)	Motor ability (Arnheim & Sinclair Basic Motor Ability Tests)	Children with poor stereoscopic vision also had poorer motor ability at age 5. Results suggest a significant relationship between stereoscopic vision & motor ability.	Authors considered potentially confounding factors: poor VA, socio-economic status, physical development, IQ. They conclude nature of relationship unclear. Assessment blinded.
Stewart-Brown[68] (1985, UK)	Cross-sectional study of children born in one week in 1970, when they were 10 years of age.	9500 of the 14,906 children for whom information on visual acuity and educational tests was complete None of the ESN-s and only 60% of the ESN-m children in the sample completed the educational tests.	Eligible children were classified into ten different groups on the basis of near and distant visual acuity tests without spectacles. The educational performance of these groups was compared with that of children with perfect visual acuity.	Educational performance assessed by the British Ability Scales (intelligence), the Edinburgh Reading Test & a specially designed maths test; parental assessment of sporting ability. All scores adjusted for sex & social class	Distant visual defects (presumptive myopia) associated with increased intelligence. Mixed distant and near defects (variety of types of defect including amblyopia) with slightly reduced intelligence. After adjusting for BAS score, near vision defects (presumptive hypermetropia) associated with below average reading scores and severe distant defects (myopia) with above reading scores. Mothers perceived children in 8 out of the 10 defect categories to be less able at sport. The performance of children who had been prescribed spectacles was no better than those who had not.	It is impossible to relate visual acuity test results to types of visual defect with precision. Differences in mean scores were small. Children who had not been prescribed spectacles cannot be regarded as true controls for those who had. Visual status would not have been known to those conducting educational tests.

Study	Study Type	Sample	Visual Defect or Function & Tests	Disability or Affected Activity & Methods of Assessment	Results	Comments
Simons [63] (1988.USA)	Systematic search from 1930-87 and review of studies comparing the prevalence of visual anomalies in poor readers and control groups of average or above readers	34 studies with quantitative outcome data permitting the calculation of effect size. No quality criteria applied in process of study selection.	Visual anomalies including refractive errors, strabismus, reduced visual acuity.	Reading performance	Hyperopia, exophoria at near, vertical phoria, anisometropia & anisekonia associated with below average reading performance. Myopia & espophoria at far negatively associated with poor reading. Reduced VA, astigmatism, esophoria at near, fusional convergence & divergence, strabismus, nearpoint of convergence & stereopsis not associated with reading performance.	Lack of critical appraisal is a problemin assessing validity of the findings. In the meta-analysis of results for reduced visual acuity of each eye was averaged so the prevalence of amblyopia cannot be assessed.
Grisham [31] (1986,USA)	Literature review of controlled studies. Search strategy not specified		Refractive errors	Reading performance (measures varied between studies)	Hyperopia & anisometropia appear to be related to poor reading & their correction seems to result in improved performance. Reduced distance VA & myopia not associated. Studies on astigmatism too poor to draw conclusions.	Few recent studies. Studies on hyperopia date from 1932-1969. Most studies on VA predate 1970. The two studies showing performance of children with refractive errors improved after spectacle correction are not true control studies.
Grosvenor [32] (1977, USA)	Review of results of studies which demonstrate a relationship between visual defects and reading	19 studies known to the author.	Visual anomalies including refractive errors, strabismus, colour vision defects	Reading performance (measures varied between studies)	Myopia consistently associated with good reading performance. Hypermetropia, astigmatism, lateral phorias, poor fusional vergence, strabismus & colour vision anomalies tend to be associated with below average reading performance. .	Selection of studies biased. Authors call for well designed well controlled studies to be carried out.

Study	Study Type	Sample	Visual Defect or Function & Tests	Disability or Affected Activity & Methods of Assessment	Results	Comments
Ygge [84,85] (1993, Sweden)	Study of visual defects & function in dyslexics compared to children without dyslexia. Groups matched for age, sex, class in school & IQ	86 dyslexics & 86 controls aged 9 years. Groups selected from whole school year tested. 'Dyslexic' group had a mean reading level at least 2 years below chronological age.	Strabismus, refractive errors, VA, contrast sensitivity (Vistech's test), accommodation, binocularity (Bagolini test) stereopsis (TNO test), vergence function, ocular dominance (Dunlop test), eye movements.	Reading performance (OS-400 test of decoding ability & 'word-chain test')	No significant difference in visual function between dyslexic & control groups.	Vision testing conducted blind.
Latvala [44] (1993, Finland)	Comparative study of visual defects in dyslexic & non dyslexic children matched for age, sex & social class	50 dyslexic & 50 matched controls aged 12-13 years Exclusions inc. IQ<80, neuro-logical disease.	VA, refraction, strabismus, stereopsis, contrast sensitivity, fusion, accommodation, convergence.	Reading difficulties grouped: general deficiency, general language, visuo-motor, naming, mixed, normal	No significant difference found in VA, refraction, amount of phorias & tropias, stereopsis, fusion, accommodation. Convergence nearpoint 8cm or more was more frequent in dyslexic group. Findings also suggest a low accommodative convergence/accommodation ratio in dyslexics.	Subgroups small. Assessment not blind.
Buzzelli [10] (1991, USA)	Study of visual function in dyslexic boys compared with normal readers matched for sex & age	26 male pupils: 13 dyslexics & 13 controls, all with VA 6/6 (normal or corrected) Average age 13 years Exclusions included amblyopia, strabismus & nystagmus.	Stereopsis (random dot stereograms), accommodation & vergence facility tested.	Reading performance: reading age assessed by Woodcock word recognition test	Dyslexics did not have poor stereopsis or poor VA, but took longer to make accurate shifts between successive vergence eye movements. Less efficient dynamic vergence facility may contribute to reading impairment & warrants further investigation.	Small sample. Assessment not blind.

Study	Study Type	Sample	Visual Defect or Function & Tests	Disability or Affected Activity & Methods of Assessment	Results	Comments
Evans [20, 21] (1994 & 1996, UK)	Study of visual function in dyslexic children compared with that in non dyslexic children of similar age, sex , socio-economic status & intelligence. Control group taken from 2 primary school populations similar in socio-economic status to dyslexic group.	39 dyslexic & 43 control children aged 7-12 years	Deficits of visual function including reduced VA with specatcles if usually worn (Bailey-Lovie), reduced contrast sensitivity (Vistech VCTS Near Vision Test), saccadic eye movements, vergence amplitude, vergence stability and amplitude of accommodation	Reading performance (simulated reading visual search task)	Dyslexics had worse near & and slightly worse distance binocular VA & impaired contrast sensitivity. No difference between groups in refractive errors. Vergence amplitude and stability and amplitude of accommodation all poorer in dyslexic group. Scores on vision tests not correlated with WISC-R coding test except for saccadic eye movements. Authors concluded that the visual deficit in dyslexic children is unlikely to be the cause of their specific reading difficulty.	Not stated whether assessment was blind.
Henderson [35] (1994, UK)	Study of visual defects in clumsy children compared with children who were not clumsy. Groups matched for age, sex & verbal IQ	Two groups of 16 children aged 7-12 years	Visuospatial difficulties. Discriminative ability assessed by Lord & Hulmes' triangular stimuli & their graphic reproduction tasks. Also Draw-a-Man task.	Clumsiness. Motor competence assessed by Test of Motor Impairment	Clumsy children performed less well on test of visuospatial discrimination but no relationship found between magnitudes of perceptual & motor impairment, & no trend towards increase in correlation between visuospatial & motor ability seen when focused on the less able children.	Small sample. Drawings assessed by experienced raters, blind to group allocation.

Study	Study Type	Sample	Visual Defect or Function & Tests	Disability or Affected Activity & Methods of Assessment	Results	Comments
Sucher [69] (1993, USA)	Study of visual defects in all children with learning difficulties in one school compared with those in all children in the same grade in a normal school.	5th & 6th grade children, 72 with learning difficulties & 64 controls. No information available on IQ.	Vertical fixation disparity (Turville Infinity Balance test), horizontal pursuits, accommodative infacility, refractive error, depth perception (Wirt stereo rings), phoria (cover test). Testing undertaken by 2 masked examiners	Children classified learning disabled based on academic tests indicating that the child's grade equivalent is more than 2 years behind age group. These children were in a special class at school.	There were three times as many instances of vertical fixation disparities in learning disabled group. Inaccurate pursuits, accommodative infacility & uncorrected refractive error also showed an association with learning difficulties at or above the 90% confidence level.	Children with uncorrected refractive errors excluded from the vertical fixation disparity, depth perception, pursuits & accommodative facility tests. This removed 21% learning difficulties group & 9.5% control group. 18 false positives found on re-testing (equal number from each group) & were removed.
Kani [38] (1980, UK)	Study of undergraduates with amblyopia & controls matched for monocular acuities in the good eye	Undergraduates with amblyopia paired with undergraduates without amblyopia but with monocular acuity deficits owing to uncorrected refractive errors. Sample sizes varied (up to 53) for different tests	Amblyopia	Perceptual skills (judgment of spatial relationships, ability to detect depth in stereopsis tests, contrast sensitivity)	Results suggest that the everyday life of the person with amblyopia is unlikely to be affected as a consequence of his/her perceptual losses. Monocular amblyopia seems to have little impact on perception of space & contrast. Reduced stereopsis is likely to hamper perception only in very restricted visual situations.	Levels of amblyopia were not specified. Small samples. Control group also had monocular acuity deficits which might explain the similar performance of the two groups.

Study	Study Type	Sample	Visual Defect or Function & Tests	Disability or Affected Activity & Methods of Assessment	Results	Comments
Fielder [30] (1996, UK)	Review of studies of aspects of binocular function including normal stereopsis, how it may be disrupted and its functional significance	Conclusions of a range of studies are presented.			Experimental studies suggest that binocularity is an advantage in certain tasks eg. those requiring complex hand-eye co-ordination. Anecdotal evidence suggests binocular-dependent motor skills improve in children following surgical correction of squint. In a study of the attrition rate from US Air Force pilot training absent stereopsis was not significant. In a survey of dentists 26% had poor stereopsis; the consequences were not explored.	Non-systematic review. Critical appraisal of studies not described.
Helveston [34] (1985, USA)	Study of a representative sample of schoolchildren investigating the relationship between visual functions & reading performance	1,910 schoolchildren, grades 1-3	Visual function including VA, muscle balance, preferred eye & hand, colour vision, refraction, convergence, accommodation, stereopsis. Each attribute defined as a continuous variable.	Academic performance as measured by reading. Tests included Metropolitan Readiness Test, Cognitive Abilities Test, Iowa Test of Basic Skills, & the teacher's assessment of reading level.	No significant relationship found between reading performance & ocular abnormalities.	Large representative sample. Different testers for vision and reading. Not clear whether the other educational tests were assessed blind.
Bishop [8] (1979, UK)	Study of all children of a given age registered at a one GP practice for whom reading ability & IQ were known	147 children aged 8 years	Convergence, stereopsis (TNO test), VA, squint, reference eye (Dunlop test). Tests conducted by an orthoptist. Each attribute defined as a continuous variable.	IQ (Wechler Intelligence Scale for Children) Reading (Neale Analysis of Reading Ability) Tests conducted by a psychologist.	No significant correlation between VA, squint (all treated or well-controlled), stereopsis (5 children with manifest squint excluded) or crossed-dominance (ie. lack of correspondence between sighting eye & preferred hand) and reading ability. Only 2 cases of mild convergence insufficiency found - number too small for statistical analysis.	Orthoptist & psychologist conducted independent assessments.

Study	Study Type	Sample	Visual Defect or Function & Tests	Disability or Affected Activity & Methods of Assessment	Results	Comments
Hall [33] (1991, USA)	Study of all children in a small primary school exploring the relationship between 11 visual functions & reading performance	111 children in grades 1 to 6. 14 children with manifest squint, significant uncorrected refractive errors or low IQ excluded.	'Normal vision' with at most small refractive errors & 'minimal heterophorias' (not defined). Also tested accommodation, stereopsis (Titmus & Randot measures), convergence & vertical fixation disparity.	Reading performance :King-Devick Test (simulates movements demanded by efficient reading) & composite reading score from Stanford Achievement Test	Multivariate correlation used to analyse the data. No relationship found between ocular functions and reading performance.	Assessment was blind.

Study	Study Type	Sample	Visual Defect or Function & Tests	Disability or Affected Activity & Methods of Assessment	Results	Comments
Jones [6] (1981, UK)	Experimental study with cross over design in normal volunteers . Subjects did the tests in bright and dim light, with one eye and two eyes with dominant eye first and last. The order of the tests was randomised	10 adults, all staff or students of a university department, with normal or corrected-to-normal vision	Subjects were required to detect black letters on a white card and a camouflaged octopus in a colour photograph, complete the Farnsworth-Munsell 100-Hue test of color discrimination, thread beads on a string with hands only visible on a TV monitor, stand with one foot in front of the other without swaying, track a moving target , thread a needle, pour water into narrow-necked beaker and reach for an object with hand visible and occluded.	Advantage of binocular vision for exteroception (the pick up of information about the environment) and exproprioception (the detection of information about position, orientation and movement of the body relative to the environment) in conditions where the influence of stereopsis could be estimated	Subjects scored higher on all five tasks with two eyes than with one. They also scored higher in bright light than dim and in five out of nine tests there was a significant interaction between intensity of lighting and binocular vision . Binocular stereopsis did not facilitate performance significantly in the four tasks requiring visual control of movements and distance estimations.	Well conducted tightly controlled experiment . Results are at variance with earlier studies. The authors suggest that this is because subjects were free to move their heads in these experiments whereas in earlier experiments their heads were held stationary. They suggest that head movement may be an important part of the orientating mechanism involved in the use of binocular concordance.
Sonksen [66] (1987, UK)	Controlled study of performance of visual tasks in children with artificially superimposed refractive errors	60 normal-sighted children with refractive error artificially superimposed & 10 controls, ages 6-10 years	Refractive errors	Recognition of letters & life-sized pictures of objects	Compared with acuity measures based on Snellen letters, pictures had to be brought closer than expected before children with induced minor refractive errors could recognise them. Highlights importance of correcting refractive errors in young children who learn from this type of material.	Small control group

Study	Study Type	Sample	Visual Defect or Function & Tests	Disability or Affected Activity & Methods of Assessment	Results	Comments
Tommila [75] (1981, Finland)	Retrospective study of amblyopes treated for loss of vision in the healthy eye or for impending blindness	35 people with amblyopia (details available for 23), 1958-'78 aged 8-72 years (mean 30.5 years) at time of treatment for loss of vision in the healthy eye	Amblyopia	Incidence of loss of vision in healthy eye	Loss of healthy eye caused by trauma in 60.9% & disease in 39.1% of sample. Incidence of loss of vision in healthy eye: 1.75 ± 0.30 per 1000. Same period, overall blindness rate 0.11/1000 children, 0.66/1000 adults aged 15-64 years. Risk of blindness for amblyopes is higher than for general population.	Data collected on all amblyopes who received pleoptic treatment at Helsinki University Eye Hospital, the main centre for pleoptic treatment in Finland If the birth rate or incidence of amblyopia changed during this period the calculations are likely to be inaccurate. Reason for the cut-off at age 64 not stated.

RESULTS: TREATMENT

RCTs and CCTs of treatment (Table 2)

We identified five prospective RCTs and six prospective CCTs of treatment for the target conditions. None were found which were specifically relevant to this age group for the three target conditions. As our electronic search was complimented by extensive handsearching of relevant journals undertaken by the Cochrane Collaboration it is unlikely that studies meeting our inclusion criteria were missed.

Study findings

Three RCTs compared the effect of the CAM vision stimulator with conventional orthoptic treatment in children aged five to fifteen.[39, 56, 76] The studies found no significant benefit from CAM treatment, which may explain why it is no longer used in this country.

Only one study was found which compared any treatment for any of the target conditions with placebo.[46] Given the uncertainty about the natural history of these conditions this is a serious gap. Even the one study we found did not have a no-treatment control arm. This study was an RCT in which all patients received orthoptic treatment but the trial investigated whether there was any benefit from additional treatment with the drug levodopa/carbidopa (which had been found in single-dose studies temporarily to improve contrast sensitivity and visual acuity). The control group was given placebo capsules. Improvements in visual acuity and contrast sensitivity were seen in both groups, though the intervention group showed a greater improvement in both than the control group. After one month the levodopa/carbidopa group had regressed slightly and the control group had not maintained any improvement.

The final RCT looked at the beneficial effect of prism adaptation on surgery for acquired esotropia.[59] Many of the participants had squints that would have been cosmetically obvious. Success rates were highest in those in whom surgery was based on the prism-determined angle. No controlled studies, with or without randomisation, of treatment for latent squints were found.

We found one prospective controlled trial of the efficacy of preoperative prism correction for acquired esotropia,[57] which had similar findings to the RCT of this intervention.[59] The other five prospective CCTs that we found compared different approaches to amblyopia treatment.[47, 50, 70, 73, 77] The studies that compared treatment with CAM gratings and either blank discs (instead of gratings)[70] or occlusion[47] found no significant difference in visual acuity between the groups after treatment. Small improvements in visual acuity were seen but the small number of participants in each study limits the value of the findings. Confidence intervals are wide due to small sample sizes. Further, in the study comparing treatment with blank discs or gratings, people in both groups received both types of treatment at each session and, although visual acuity was measured before, between and after each treatment, there remains a possibility that the two interventions might have interacted. In the study

comparing three different occlusion regimes,[50] 'improvement' in visual acuity and fixation is reported but not defined, and it lacks information on baseline measurements, the method of allocation to treatment groups, the personnel involved, and any explanation of the variety in the length of treatment. The study comparing minimal occlusion and full-time occlusion in addition to CAM treatment[73] shares several of these flaws. It reports a greater improvement in visual acuity in the group prescribed full-time occlusion, and notes that 33% of those with improved acuity after treatment showed some deterioration three months later. The study comparing occlusion with pleoptics[77] found that pleoptics offered no advantage over treatment with occlusion.

The validity of the findings

Some of the limitations of the studies have been outlined above, and further details are given in Table 2. Appraising the quality of these studies is made difficult by the lack of information on one or more aspects of the study design. Information on the means by which people were allocated to each treatment group is essential when assessing study validity. If they were allocated according to the clinician's judgment, it is likely that the groups were not comparable at baseline. To reduce the potential for investigator bias it is important for the personnel examining participants for the outcome measure of interest, such as visual acuity, to remain 'blind' to their status in terms of exposure to a particular treatment. This was done in some of the studies but in one of the RCTs it was not,[56] and in other studies blind assessment was not mentioned and presumably was not part of the study design. Knowledge of the comparability of control and treatment groups at the start of the study is essential when interpreting treatment outcomes, but this was missing from several studies. A lack of information about compliance with treatment also weakens the findings. Most importantly none of these studies compared a treated group with an untreated group so they cannot provide an answer to the question "does treatment for the target conditions work?"

Other studies of treatment

Because of the paucity of evidence from prospective RCTs and CCTs we reconsidered including retrospective controlled trials in the review. Such studies suffer from all the problems outlined above as well as loss of data through missing case-notes and inadequate recording of outcomes. It was decided that such studies were methodologically weak and would not be able to answer the research questions. However, some retrospective studies provided data on two important areas of treatment: compliance and outcomes at different ages. These have been included in the text but the methodological limitations of these studies need to be remembered when evaluating the 'evidence' they provide.

Outcomes of treatment at different ages

We found one UK study that compared the outcome of treatment for amblyopia in children of different ages.[81] This was a retrospective uncontrolled study of a large unselected population of children at seven orthoptic centres in the UK. The paper did not discuss the sources of referral for these children. Final visual acuity was not significantly different in children treated at age three to five

years compared with those who started treatment at five to eight years. The initial visual acuity was a more important determinant of outcome than the child's age.

Non-attendance and compliance

A study of a preschool vision screening programme in an inner city area in Scotland looked at factors affecting the attendance rate for treatment of amblyopia detected on screening.[80] Stepwise regression analysis showed that socioeconomic status was the only variable to significantly affect the attendance rate, which declined as socioeconomic status fell. The probability of non-attendance from the model was 20.5% for classes one and two, and 37.1% for class three. In a prospective controlled study comparing visual outcomes in children from three different screening programmes in Newcastle and Northumberland.[14] of the 97 children across all three groups who were identified as having defective vision, 26.8% defaulted from further investigation or treatment.

Two studies were found which looked at attendance at follow-up appointments and parental reports of compliance with patching in different age groups. One study retrospectively reviewed the records of 496 children with amblyopia and found that 11.7% of three to six year olds were non-compliant compared with 14.5% of six to nine year olds.[55] The other, a prospective study of 350 children with amblyopia, recorded non-compliance in 28% of two to five and a half year olds, 36% of five and a half to eight year olds and 53% of eight to eleven year olds.[58] The recent development of an occlusion dose monitor has made possible the objective monitoring of occlusion.[25]

We identified no studies that attempted to assess any negative impact of orthoptic treatment on the child or the family. Preschool children are thought to be more compliant, but enforcing patching in a reluctant child would be likely to have a negative impact on family life. Some children are admitted to hospital to enforce patching. How commonly such difficulties occur is not documented in the literature but the fact that non-compliance is a problem implies that patching is not easy.

Visual improvement following treatment for amblyopia

Seven of the screening programme studies discussed in the next section attempted to measure the improvement in visual acuity that occurred in children who were screened positive, referred and treated.[5, 9, 14, 23, 36, 54, 80] These results are equivalent methodologically to those that would be gained from uncontrolled observational studies of treatment. They substantiate clinical beliefs that children's vision does improve during treatment, but without a comparison group of untreated children they cannot show that treatment works. They provide an indication of the extent of improvement that can be expected from an unselected sample of children whilst undergoing treatment. In these studies visual acuity improved two or more lines in between 50% and 85% of children and between 60% and 80% of children achieved 6/6 vision.

Few studies looked at the extent to which these observed improvements in visual acuity following treatment are maintained. Three studies of CAM therapy[39, 73, 76] reported that some of those who had responded to treatment subsequently deteriorated, and in the RCT of levodopa/carbidopa treatment[46] neither group maintained the initial improvement in visual acuity, although deterioration was greater

in the control group. However, these studies evaluated short-term outcomes only, giving results of follow-up between one and three months after the completion of treatment.

Treatment of refractive errors

The immediate effect of spectacle correction of refractive errors on visual acuity is sufficiently well established for an RCT of treatment to be superfluous. Questions remain, however, about the significance of reduced visual acuity in preschool children. If these children do not suffer problems from isolated refractive errors before they get to school age they could be identified and treated at school entry. Orthoptists treat children with minor refractive error to prevent the development of squint or amblyopia. The search did not reveal any studies of the impact of this intervention.

Summary

Our search for evidence that treatment for any of the three target conditions is effective has been disappointing. We have been able to substantiate clinical beliefs that children with amblyopia do improve during treatment, but without sound evidence on the natural history of these conditions this evidence falls very far short of showing that treatment works. Whether the documented improvement in visual acuity is accompanied by a reduction in disability is a question that does not seem to have been posed. All the studies of amblyopia treatment we have examined have taken as given that an improvement of visual acuity in one eye is important to children. Studies on compliance with treatment suggest that orthoptic treatment is not without problems for families but potential negative effects of treatment have not been explored. Our search did not pick up studies that followed the progress of children with non cosmetically obvious squint through treatment. As the natural history of these conditions has not been documented such evidence would not amount to proof that these treatments work. The case for identifying and treating refractive errors in this age group could only be made in studies which demonstrated that children with these problems were in some way disabled and that the disability could be corrected with spectacles. These have not apparently been undertaken.

Table 2. Treatment Studies

Study	Type	Sample	Intervention	Visual or other outcome	Comments
Keith [39] (1980, Australia)	RCT of treatment for amblyopia	60 people with amblyopia aged 5-15 years	Intervention group: CAM treatment Control group: same visuomotor tasks but gratings replaced by a grey background	Mean improvement for those with initial VA <6/60 was the same in both groups (0.48 log units). For those with VA >6/60 there was a small, non-significant difference in improvement between groups: gratings group 0.17 log units (CI 0.12, 0.22) & control group 0.14 log units (CI 0.09, 0.19). No difference in rate of improvement or tendency for improvement to be sustained. No difference according to type of amblyopia or whether previously treated. The vision of some children in each group deteriorated after the end of the study.	Not stated how the participants were found. Blind assessment undertaken.
Leguire [45, 46] (1993, USA)	RCT of treatment for amblyopia	10 people with amblyopia aged 6-14 years	Intervention group: Levodopa/carbidopa capsules plus part-time occlusion Control group: placebo capsules plus part-time occlusion Treatment period 3 weeks Follow-up 4 weeks after completion of treatment	Levodopa/carbidopa group improved VA by 2.7 lines & contrast sensitivity by 72% in amblyopic eye Placebo group improved VA by 1.6 lines, little change in contrast sensitivity. Tolerance & occlusion compliance similar in both groups, but capsule ingestion significantly lower in levodopa/carbidopa group. At 1 month after treatment, levodopa/carbidopa group maintained significant improvement of 1.2 lines; placebo group did not maintain improvement.	Children had previously participated in 8 hour long single dose study of the effects of levodopa/carbidopa. No significant side-effects found. Blind assessment undertaken.

Study	Type	Sample	Intervention	Visual or other outcome	Comments
Nyman [56] (1983, Sweden)	RCT of treatment for amblyopia	50 people with amblyopia aged 4-6.5 years	Intervention: CAM treatment (25 cases) Control: occlusion therapy - patching over the eye or occlusion with Einschleich filter on spectacle lens over best eye (25 cases)	VA improved by 2 Snellen lines or more in 80% of both groups: CAM group: mean improvement in VA 3.11 lines (CI 2.7, 3.5) Occlusion group: mean 3.3 lines (CI 2.8, 3.8) No significant differences. Groups comparable before treatment re VA, fixation, refractive errors & strabismus.	Lack of information on, personnel, compliance & duration of treatment. Those testing VA after treatment not blinded to allocation.
Prism Adaptation Study Group [59] (1990, USA)	RCT of the effectiveness of prism adaptation in improving outcomes of surgery for acquired esotropia.	333 people with esotropic deviations of 12 to 40 Δ, aged 3 years & over. 322 included in analysis.	Randomization at 2 levels. 199 underwent prism adaptation & 134 did not. Those responding to prisms (131) were randomized to undergo conventional surgery (67) or surgery based on prism-adapted angle of deviation (64).	Success rates (0 to 8 Δ 6 months after surgery) highest in PA responders who had prism angle based surgery (89%) & lowest in the non-prism adaptation group (72%). Non-responders had a success rate of 73%. Significant beneficial effect of prism adaptation in people with acquired esotropia: success rates 83% vs 72%.	Post-surgical deviations were measured by a masked examiner.
Tytla [76] (1981, Canada)	RCT of treatment for amblyopia	15 people with amblyopia aged 5-12 years	Intervention: CAM therapy (9 cases) Control: CAM with grey discs instead of gratings (6 cases) One 7 minute session per week for 4 weeks VA & contrast sensitivity measured before, during & after CAM sessions Complete optical correction worn during tests & treatment	No difference between groups. Distance linear VA : 6 unchanged, 4 (inc. 3 in controls) improved 2 lines, 3 improved 1 line or more, 2 regressed 1 line. Mean 2 lines improvement in single letter acuity. At 1 month follow-up, both positive & negative changes seen. Some improvement in contrast sensitivity in 6 (inc. 4 controls).	Small study & groups uneven size. Lack of information on how sample selected. During VA testing, children were urged to read beyond what appeared to be their limit. Different personnel used to administer treatment and assess vision but not clear whether the assessment was blind.

Study	Type	Sample	Intervention	Visual or other outcome	Comments
Lennerstrand [47] (1983, Sweden)	Partly randomised controlled study of treatment for amblyopia	38 previously untreated people with amblyopia aged 4 years. All children meeting amblyopia criteria & accepted for treatment for 6 months entered study.	Intervention group: CAM treatment Control group: full-time occlusion	Measured VA (adjusted for time-dependent changes in VA of best eye), stereopsis & fixation. VA improved with both CAM & occlusion ($p<0.01$). Mean VA (& CI) in amblyopic eye at start & finish of treatment & at 3 month follow-up (decimal values given; 0.5 is approx. 6/12 Snellen, 0.66 6/9): (Anisometropic amblyopia) CAM: 0.46 (0.54, 0.38), 0.78 (0.93, 0.63), 0.76 (0.86, 0.66) Occlusion: 0.44 (0.53, 0.33), 0.61 (0.70, 0.51), 0.71 (0.83, 0.58) (Strabismic amblyopia) CAM: 0.29 (0.41, 0.17), 0.48 (0.70, 0.27), 0.56 (0.70, 0.42). No significant difference in outcome between treatments, although grating stimulation was slightly better than occlusion in improving VA of those with anisometropic amblyopia with central fixation ($p=0.05$). (Groups initially comparable in VA & binocular function).	Grouped according to amblyopia type & some randomly assigned to treatment groups, but distance from hospital precluded allocation to CAM in some cases. Interventions not standardized eg. some had occlusion after CAM & CAM group had more hospital visits. Lack of information on compliance, attrition & whether assessment was blind. Wide confidence intervals.

Study	Type	Sample	Intervention	Visual or other outcome	Comments
Malik [50] (1970, India)	Prospective controlled study of treatment for amblyopia	70 people with amblyopia with eccentric fixation aged 3-6, 7-9, 10-12, & 12+ years	Group 1: Full-time occlusion of the unaffected eye (18 cases) Group 2: Full-time occlusion of the affected eye (24 cases) Group 3: Red-filter occlusion of the affected eye (28 cases)	Assessed VA & fixation. Gp 1: 83.3% (15) improved in VA &/or fixation pattern. Initial VA & fixation more important than age. Gp 2: 33.3% (8) improved in VA &/or fixation. Results poor in all subgroups. Gp 3: 57.1% (16) improved in VA &/or fixation. Better results in children under 12 yrs. Response to all treatments better in those with better initial VA & eccentric fixation close to the fovea.	'Improvement' is not defined. Lack of information on baseline measurements, method of allocation, personnel used. Treatment period ranged from 6-30 weeks, no details given
Ohtsuki [57] (1993, Japan)	Prospective controlled study of preoperative prism correction for acquired esotropia	77 people with esodeviations of 18-50 Δ, aged 5 years and over (one patient was under 4 years, 53% aged 5-7 & 44% aged 8+)	All wore Fresnel prisms for 5-7 days. 63 responders randomly assigned to have surgery for original angle (PCR/OS group, n=31) or prism-adapted angle (PCR/PS group, n=32). 14 non-responders had surgery for angle before prism correction (PCNR group). Follow-up at 1 week, 3 & 6 months, & I year after surgery, with no re-operation or prism correction.	Success rates with deviations of 0-10 Δ a year after surgery: PCR/PS group 84%, PCR/OS group 78%, PCR/NS group 50%. No significant difference in success rates between PCR/PS & PCR/OS groups ($p=0.41$), but both had significantly higher success rate than PCNR group ($p<0.05$).	93% of non-responders were aged 5-7 years, had strabismus of earlier onset & larger initial angles than the other groups.

Study	Type	Sample	Intervention	Visual or other outcome	Comments
Terrell Doba [73] (1981, Australia)	Prospective controlled study of treatment for amblyopia	80 people with amblyopia (20 anisometropic & 60 strabismic) aged 4-16 years (mean 7.8 years). 49 had previously been occluded.	Group 1: CAM therapy + minimal occlusion (69 cases) Group 2: CAM + full time occlusion (11 cases)	Group 1: 47% achieved VA 6/12 or better, mean improvement 0.3-1.0 lines. Group 2: 91% achieved VA 6/12 or better, mean improvement 0.4-2.3 lines Of those improved & followed up at 3 months (n?), VA in 33% had deteriorated	No. in group 1 given as 60 & 69 in different places. Groups uneven - 11 in one & 60 (or 69?) in other. People with anisometropia not previously occluded had been prescribed spectacles 2-4 weeks before treatment. Lack of information on allocation to groups, personnel conducting testing & treatment, compliance & follow-up.
Veronneau-Troutman [77] (1974, USA)	Prospective controlled study of treatment for amblyopia	90 people with amblyopia aged 5+ years, average age 7.4 years	Group 1: 'Direct occlusion', constant or intermittent. Group 2: Occlusion of amblyopic eye, then pleoptics followed by direct occlusion.	Direct occlusion: initial VA <20/100 45%, 20/60-20/100 55%; final VA 20/100 9%, 20/60-20/100 32%, 20/40-20/50 31%, 20/30 or better 28% Pleoptics then direct occlusion: initial VA <20/100 68%, 20/60-20/100 32%; final VA after pleoptics (& after both treatments) <20/100 27% (16%), 20/60-20/100 57% (38%), 20/40-20/50 11% (35%), 20/30 or better 5% (11%) Significantly better results after occlusion alone than pleoptics alone (p>0.001) but not after occlusion applied to the pleoptics group (p>0.30). Groups comparable at baseline in VA & refractive state.	Blind assessment not carried out.

RESULTS: SCREENING PROGRAMMES

RCTs of screening

We identified no RCTs of screening programmes for three to four year olds. An RCT comparing the effectiveness of two preschool vision screening programmes offered to children under 37 months of age in Avon, England has recently been completed.[72] In this trial 2029 children were randomised into the intervention group and were offered vision screening at the ages of 4, 8, 12, 18, 25, and 31 months. 1461 children were randomised into the control group and were offered the current screening programme, which consisted of a check for squint at the age of seven months by a health visitor and a secondary screen at orthoptic clinics for those whom the health visitor or GP referred. The children in both groups received a 'Gold Standard' visual examination at 37 months of age, and the results of this examination were used to compare the effectiveness of the two programmes. The main outcomes of the trial were the sensitivities and specificities of the programmes, and also the sensitivities of the individual tests used at different ages. The data also provides some information on the natural history of refractive error up to the age of three or until the development of squint and/or amblyopia if sooner. Because the study is nested within an observational study of a population birth cohort, data is available on other aspects of the children's development and the investigators will be looking at whether any disabilities are associated with squint, amblyopia or refractive errors.[105] This study will not be able to answer other questions relating to the three and a half year old screen, such as when and how to treat the target conditions.

CCTs of screening

We found one highly relevant prospective CCT[14] comparing visual outcomes at the age of seven years, in children who were screened at three by orthoptists, GPs or HVs. Following the introduction of a pilot community-based orthoptic screening programme in Newcastle in 1987, a cohort of 1026 three-year-olds who were offered screening by this method was compared with children from two local districts, matched for demographic factors, who were screened through the existing programmes. In one of these areas, screening by health visitors was offered to 1380 children, and in the other 1151 children were invited for screening by HVs, GPs or CMOs in clinics. The initial report on the programmes[37] suggested that orthoptic screening led to children receiving earlier treatment for 'straight-eyed' visual acuity deficits and squints. The uptake, referral and false positive rates, and the positive predictive value, for these programmes are given in Tables 4 and 5.

The cohorts examined at seven years of age were slightly larger, owing to the extension of the initial study.[125] At this stage, children from all three cohorts with suspected visual defects were identified from six sources, including records from school entry visual screening (known to have more than 95% coverage). Children without a record of examination at the hospital were examined at school by an orthoptist. This study[14] demonstrated a significant difference ($p< 0.0001$) in the age at which children presented with straight-eyed amblyopia in the orthoptic screening cohort (3.4 years) compared with

the HV (5.6 years) or GP (4.5 years) screening cohorts. This was also true of refractive errors (3.8 years in the orthoptic screening cohort compared with 5.4 and 5.1 years in the HV and GP cohorts respectively) but there was no significant difference in the presentation of squint (3.8, 3.9, and 4.1 years). Many more children with amblyopia were identified in the orthoptic screening cohort (Table 3a). However the prevalence of amblyopia at seven years of age was very similar in all three cohorts (Table 3b). This study was adequately powered to detect a 40% difference in prevalence of the conditions at seven years and may have missed a smaller difference. The implication of the finding from this study is that orthoptic screening successfully identifies children with amblyopia which improves following treatment but possibly to no greater extent than it would have improved spontaneously without treatment. The study did not look at the outcome of screening in terms of the prevalence of non cosmetically obvious squints not associated with amblyopia.

The study design, although very much more appropriate to our research questions than any of the other studies we found, has a number of deficiencies. Firstly, at seven years the children did not undergo a 'gold standard' examination by which outcomes could be compared. Final outcomes were determined from a number of sources and by the results of tests conducted by different types of practitioner. Secondly, the children in the three cohorts came from areas that were matched for demographic factors and numbers of children but, as with all non-randomised trials, there remains a possibility that they differed in some other way. Family history of squint is an important risk factor for squint and consequently amblyopia in children.[115] A higher prevalence of squint amongst parents in the orthoptic screening cohort could account for these findings. The prevalence of squint was lower in the HV screening cohort but not to a statistically significant degree. Thirdly, children known to have visual abnormalities prior to 30 months of age were excluded from the analysis in all three cohorts. Fewer of these exclusions in the orthoptic screening cohort could account for the findings. The report does not provide data on the comparability of the cohorts in these respects so it is impossible to be sure that such bias does not exist. Taken together these methodological problems limit the certainty that can be placed on the findings of the study.

Other studies of screening

We found one other study[24] that compared the prevalence of visual defects in two groups of school entrants, only one of which had undergone preschool vision screening. There was a significant difference in the number of children with 'visual impairment' in the two groups: 10% in the screened and 15% in the unscreened group ($p<0.01$). When divided into those with mild and moderate/severe visual impairment (VA 20/40, equivalent to 6/12 Snellen, and 20/50+ respectively), the difference reached statistical significance only for those with moderate/severe impairment ($p<0.01$).

We found a number of other studies of screening programmes which provided information on uptake rates, referral rates, positive predictive value and programme yield. The commonest type of screening researched in these studies is the primary orthoptic programme. Some of these studies[9, 20, 83] compared this information from more than one type of programme (primary orthoptic screening and another type), but none of the latter studies were set up as controlled experiments nor were the data collected

prospectively. These studies allow a slightly more accurate comparison to be made between the outcome of different programmes than studies providing data on a single type of programme because the data would have been collected in the same way and the same diagnostic tests are likely to have been used. However, the extent to which data from these studies compares to that collected in uncontrolled studies of the different programmes is also important. We have presented the results of these studies according to programme type, with the studies which compared more than one programme identified in bold.

The largest group of studies provided information on uptake rates and referral rates (Tables 4 and 5). Fifteen of these provided data on primary orthoptic screening programmes, two on CMO screening, one on both HV and GP screening and one from Sweden on combined paediatrician and nurse screening. Thirteen studies published referral rates or provided data from which they could be derived by secondary calculation in primary orthoptic screening and the same four studies provided referral rates on HV or doctor screening These studies are all observational studies or audits. They have the advantage over studies carried out in the context of a research programme in that they represent current practice, but there may be bias in terms of which centres record and write up their results.

Ten studies of primary orthoptic screening and the four studies of other types of screening programme provided data on detection rates from which positive predictive value and programme yield could be calculated. Two studies produced figures for false negative cases (Table 5).

Eight studies produced information on visual outcomes following treatment of children identified in screening programmes, as discussed in the section on treatment.

Uptake Rates (Tables 4a and 4b)

Studies reporting uptake rates have been based on programmes using a variety of methods of invitation to parents of children in a range of socioeconomic circumstances. In the majority of these programmes, children were invited to attend screening locally and some had a choice of sites.

Overall rates for primary orthoptic screening ranged from 43.9% to 80.3% with a mean of 64.8%. This is excluding one study[11] that reported an uptake rate of 86% for the first three months of a new screening programme in Ayrshire. This was exceptional and may reflect the enthusiasm with which the programme was launched, with coverage in the local media as well as information sent directly to parents of eligible children.

Studies that reported that a second invitation was sent to parents of children who failed to turn up following the first had a higher mean rate (77%) than studies which reported one invitation only (50.5%). In one area[54] a second invitation resulted in the attendance of 40% of those who had previously failed to do so.

The rate of uptake following one invitation was higher in more affluent areas[36, 83] than less affluent areas;[7, 19] it was also higher than the rate of uptake following two invitations in a less affluent area.[37] The rate in studies where the number of invitations was not specified was intermediate between those with two invitations and those with one.

Vision screening by HVs, GPs and CMOs is undertaken as part of a routine surveillance contact in which parents are offered more than vision screening alone. These programmes would be expected to have a higher uptake rate. The range shown in Table 4b is from 53.5% to 84%, with a mean of 76.2%. The Swedish study should be considered separately.[41] It evaluates a preschool vision screening programme provided in the context of the four year old 'health control' in Sweden, for which the uptake rate was 95.1%.

A study comparing primary orthoptic screening with screening by health visitors in an area of Kent also requires separate consideration.[20] The 21 health visitors received training from the orthoptists and were invited to screen children in their areas. Their co-operation was variable, with eight screening no children at all, three screening 66% or more and the remainder less than 66% of their caseload of eligible children. There is no information on the reasons why health visitors who did screen, screened some children and not others.

A proportion of the target population is not invited to attend screening because the children are not located. This is a problem that few studies addressed. Early screening programmes suffered from the problem of poor record-keeping and locating children could present a serious challenge.[101] A study dating from the 1970's[11] found that 39% of the children were untraceable if information provided by the department of community health and child care was used alone. Enlisting the help of health visitors proved to be an effective means of reducing this figure. It should now be possible to locate the majority of children through GPs. In a recent study[80] it was estimated that 87-90% of the target population were sent appointments.

Referral Rates (Tables 5a and 5b)

Referral rates determine the level of diagnostic resources required to support a screening programme and are predictive of an important component of the total costs. It should be possible to vary the rate by changing the referral criteria from the screening test. Referring all children with 6/9 vision or worse should result in a higher referral rate than referring only those with 6/12 or worse. Referrals should also depend on the type of test used. Some studies did not report which screening tests or referral criteria were used but the majority of those that did used a battery of tests (in orthoptic screening programmes) - the cover test, 20D base out prism, monocular visual acuity using Sheridan Gardiner single optotypes. Some programmes included a test of stereopsis but there was no consistency in the type of stereotest. With the exception of the Swedish programme,[41] all those for which a visual acuity test was named used Sheridan Gardiner optotypes, sometimes with the Kay Picture test as an alternative if children were unable to cope with the Sheridan Gardiner test.

In some programmes a significant proportion of children were recalled for a second test before a decision was made to refer on or not. The non-attendance rate for recall appointments was given in one study only and was 30.6%.[37] The same study noted that the referral rate from the recalled group was increased threefold. The re-examination of children should reduce the number of inappropriate referrals to eye hospitals and clinics, but increase the workload in the community. In the two studies which gave figures, the proportions re-screened and found to be normal were 14.8% and 6.4%.[20, 61] Three studies gave rates of non-attendance at referral appointments of 4%, 4.3% and 5%.[80, 54, 28] An unpublished audit[78] which looked at whether children who failed visual screening at five years of age had undergone orthoptic screening aged three reported that of the 21 children who had previously been screened, nine had been unable to complete the vision test. Of these, six had refused to co-operate at the initial appointment and three of the six failed to attend the follow-up appointment. Of the remaining three, one was not followed up and two again failed to complete the tests. They were not sent for again, as they were soon to start school.

Rates of referral from primary orthoptic screening programmes (Table 5a) ranged from 4.1% to 10.6% of the screened population. The programme with a referral rate of 10.6% included 'family history' amongst its referral criteria.[80] The lack of details given in some of the studies makes it difficult to comment on the impact of different types of test and referral criteria on referral rates, but the relationship does not seem to be straightforward.

Referral rates from HV/GP/CMO screening programmes (Table 5b) were very low in the Newcastle study[37] but rates from the other two studies are comparable with those for primary orthoptic screening. One study from Sweden is exceptional, with a referral rate of 15.2%,[41] but the referral criteria for this programme were both stringent and broad.

One study[9] noted the problem of calculating referral rates from hospital records. Whilst it was possible to ascertain which health professional made each referral, it was not possible to detect whether this was a result of primary screening. No other study discussed this problem, but the problem may also have applied to other retrospective studies.

Detection rates (Tables 5a and 5b)

The two measures of the effectiveness of a screening programme which can be calculated relatively simply using the number of true positive cases are the yield, that is the proportion of cases of the target conditions in the screened population which are correctly identified, and the positive predictive value - the proportion of people with a positive test result who do have a target condition. These can be calculated either by obtaining and recording the results of the referral examination or by a retrospective analysis of hospital case records. All of the studies identified did the latter. Two other important indicators of screening test performance are sensitivity, the proportion of people with a target condition who were correctly identified on screening, and specificity, the proportion of individuals without a target condition who had a negative screening test result. The calculation of

these measures, along with the identification of false negative cases, requires the entire screened population to be re-examined at a later date.

Programme yield

The figures for programme yield have already been discussed under prevalence. Given the variety of different types of screening programme from which they are derived they provide a consistent picture of a prevalence of all target conditions of between 2.4% and 6.1%. Most studies gave a yield for broad categories of defect which included more than one of the target conditions. Studies which gave figures for distinct conditions reported a range of yields for straight-eyed amblyopia of 0.3%-1.0%,[9, 54] strabismic amblyopia 0.2%-0.6%,[9, 54] amblyopia (all types) 1.8%,[41] strabismus without amblyopia 0.1%-0.8%,[9, 54] strabismus with or without amblyopia 1.1%-1.7%[5, 20, 41, 80] and refractive errors 1.3%-5.6%.[5, 20, 41, 54, 80] One study gave a yield for micro-squint, 0.7%.[80]

Positive predictive value (PPV)

The positive predictive value depends on the definition of a positive case. Most studies have defined as positive all children who received treatment with patching, spectacles or surgery. This definition can only provide consistent data if there is complete agreement amongst orthoptists as to which children should be treated. The literature suggests that this is unlikely to be the case. In six studies of orthoptic screening programmes for which this figure could be calculated,[9, 37, 52, 54, 80, 83] the PPV varied from 47.5% to 66.4%. Three studies gave much higher PPVs. One study[5] recorded only 4.1% false positives, giving a PPV of 95.9%. This study classified as true positive children with hypermetropia of two dioptres or more. In the other studies tabulated the majority of these children would have been counted as false positives. Another study[20] recorded a similarly high PPV but in this study a large number of children were reviewed twice before referral. In the third recording a PPV of over 90%,[83] children were reviewed before referral where there was doubt, and positive cases were broadly defined as those with 'reduced vision in one or both eyes and/or squint'.

In health visitor and CMO programmes the PPV was much more variable, ranging from 14.4-61.5%, and the yields lower. If the study which excluded refractive errors and gave a yield of 0.6% is considered separately,[9] the yield from these programmes ranges from 0.9-2.6%.

Another study,[15] not included in the tables because it covers school aged as well as preschool children, throws some light on the predictive value of health visitor screening. This was a study of all referrals of children aged under eleven years attending a first outpatient appointment at Suffolk eye clinics. Amongst those attending hospital eye clinics, a similar proportion assessed as normal by HVs or school nurses had visual defects detected (68%, 71% and 80% in the three districts) as amongst those whom they had referred as abnormal. The positive predictive value of HV or school nurse screening was estimated to be 62%, 64% and 80%, but with a similar false positive rate. Those whom the health visitors regarded as normal may have been referred because of parental concern or if the child had a family history of a visual defect such as squint. Health visitors undertaking formal visual acuity testing did no better than those carrying out a general check with no formal visual acuity test in terms of the yield of children with amblyopia. This study is discussed further below.

Negative predictive value

Two studies[36, 42] have attempted to identify the false negatives of preschool vision screening and have based their results on the findings at school entry vision screening. These studies give a negative predictive value of 98.1% and 99.3% respectively. The problem with this study design is that it is impossible to be sure that the visual defect identified at five to six years of age was present when the child was examined at three. Screening at school entry is easier than at three because children find it easier to complete the tests. The accuracy however depends on the tester, usually school nurses whose training and skills may vary. A minimum estimate of the number of false negatives can be made by examining all eye hospital records and identifying children who were screened as normal but presented to the eye hospital with a problem at a later date. Eye hospital records rarely record sufficient detail about screening to allow this to be done.

Studies of other types of screening programme

Three studies were found which attempted to evaluate secondary community orthoptic screening clinics. The aim of the first of these studies[49] was only to assess whether such a service reduced unnecessary referrals to eye hospitals. This was an audit evaluating a mobile orthoptic service, to which health visitors made referrals, 18 months after its introduction. It reported a 25% reduction in inappropriate referrals of children aged under five. The second[15] was the study of referrals of all children under eleven attending a first outpatient appointment at Suffolk eye clinics in one year. It sought to assess the impact of different community based vision assessment services on referral patterns for assessment of visual acuity or ocular motility. Three districts were compared, in which HVs checked children's eyes at three and a half years. In district one, HVs referred to GPs or opticians. In both the others a secondary orthoptic screening service was in place which took referrals from HVs. The secondary orthoptic service appeared to offer little advantage over direct referral to the eye hospital in district two but in district three there were fewer false positive referrals to the eye clinics. There was no significant difference in the age at presentation of amblyopia between districts, despite the operation of a secondary orthoptic service to which health visitors could refer in two districts. No relationship was found between community vision screening and the referral of new cases of manifest squint.

A third study[65] also examined data on all referrals to eye hospitals over a long period. Two cohorts of amblyopic children from before and after the introduction of a secondary orthoptic screening service and the transfer of responsibility for child health surveillance to GPs were compared. The initial screening at three and a half years continued to be carried out by health visitors throughout this period. For children with large angle strabismus no change was detected in the mean age of presentation and regression analysis showed no significant effect of ethnic origin or social deprivation (estimated using the Townsend deprivation score) in either cohort. For children with amblyopia without large angle strabismus, the average age of presentation was reduced by nineteen months following the changes from 6.6 years to 5.0 years and a link between social deprivation and age at presentation was no longer seen.

We know of one study in progress that is attempting to evaluate a secondary screening programme based on family history of visual defects or parental concern. In this district all parents are sent a questionnaire and those with a positive family history or parental concern invited for a screening test.[108]

Factors influencing presentation

Some evidence was found relating to the spontaneous presentation of children with visual defects. A Swedish study of children found to be strabismic and/or amblyopic over a period of nine years noted that micro-squints and straight-eyed amblyopia were mostly detected at preschool vision screening and manifest large-angle squints by parents.[1] A survey of 525 children (mean age 3.7 years) referred from any source to an ophthalmology department in Leicester[79] found that parents and other relatives made up the largest group of those first noticing the defect and that they had an overall accuracy of 76%. They first picked up 47% of suspected, and 54% of confirmed, squints, 62% of cases of strabismic or mixed strabismic/anisometropic amblyopia and 17% of amblyopia with anisometropia only. No distinction was made in this study between cosmetically obvious squints and those that cannot be detected without screening. Parents who noticed a defect did not always take action, a referral being made only after the child had been seen by a health visitor. An unpublished audit of an orthoptic screening programme[61] looked at parental concern in those for whom a record was available (74% of those referred). Of 31 children referred with an initial visual acuity of 6/24 or worse, 17 had no history of parental concern, and of 24 strabismic children (no details of the type of squint given) 18 had no history of parental concern.

Three studies[62, 64, 65] examined variables which it was thought might influence presentation. The first looked at 1531 new cases of amblyopia and found that the median age of presentation for strabismic amblyopia (3.64 years) was significantly lower than for strabismic/anisometropic amblyopia (4.68 years) and anisometropic amblyopia (6.27). Only 15% of children with anisometropic amblyopia presented before the age of five. Boys presented later than girls and Asians later than Caucasians. At the time of this study, vision screening at three and a half years of age was undertaken by health visitors. There was no significant association with ethnic origin. Another study,[64] which used data from a historical cohort of 897 children in seven orthoptic centres in the UK, found no significant association between sex or ethnicity and age at presentation for any type of amblyopia. A relationship between social deprivation and age at presentation was found only in children with anisometropic amblyopia, with those from the most deprived areas presenting twenty-two months later than those from the least deprived. The third study[65] is discussed above. A limitation of these studies is the lack of information on the source of referral for each child.

A case-control study from the USA[12] compared several characteristics in 75 children with late diagnoses of amblyopia (median age 5.5 years) and 86 with early diagnoses (median age 3 years). This was a selective population of predominantly white, upper-middle class children with good access to primary care during the preschool years. Children with early diagnoses more often had a positive family history of strabismus, larger angles of strabismus, higher maternal educational level, greater

parental suspicion that a defect was present and an increased chance that the parents requested the examination that led to diagnosis.

Summary

Taken together these studies provide reasonable evidence that primary orthoptic screening programmes can be provided in the UK with acceptable uptake and referral rates. In the one prospective controlled study that has been undertaken primary orthoptic screening was shown to be more effective at identifying children with the straight eyed amblyopia and refractive errors (but not necessarily squint) than health visitor, GP or CMO programmes. Primary orthoptic screening has not been compared with open access secondary orthoptic screening or with spontaneous presentation. The former has been shown to reduce unnecessary referral to eye hospitals and possibly to reduce the age at presentation of amblyopia. In order for spontaneous presentation to be more effective than HV or doctor screening it would need to be postulated that the latter actually inhibit parents from seeking specialist advice for children about whom they are concerned. Children with straight-eyed amblyopia rarely present spontaneously.

The one prospective controlled study we identified, however, does not support the belief that identifying children with amblyopia in the preschool period reduces the prevalence of this condition in children aged seven years of age. We identified no studies that enable comment to be made on the benefit of identifying and treating refractive errors in this age group. None of the studies provide evidence for or against screening for non cosmetically obvious squint.

Prospective controlled trial of preschool vision screening[14]

Table 3a. Total number (%*) & (confidence interval*) of children with the target conditions identified in each area by final diagnosis

Study	Type	Cohort (n)	Squint	Straight-eyed amblyopia	Refractive errors
Bray [14] (1996, UK)	**Prospective controlled trial comparing visual outcomes at 7 years in three cohorts of children screened at 3 years by orthoptists, HVs or GPs**	Orthoptic Screening (1582)	**19 (1.2%)** (0.7, 1.7)	**43 (2.7%)** (1.9, 3.5)	**14 (0.9%)** (0.4, 1.3)
		Health Visitor Screening (2081)	**16 (0.8%)** (0.4, 1.1)	**12 (0.6%)** (0.3, 0.9)	**17 (0.8%)** (0.4, 1.2)
		General Practitioner Screening (1701)	**22 (1.3%)** (0.8, 1.8)	**24 (1.4%)** (0.9, 2.0)	**16 (0.9%)** (0.5, 1.4)

*** Secondary calculation**

Table 3b. Total number of amblyopic seven year olds in each cohort and prevalence of amblyopia

Study	Cohort	Number of seven year olds with amblyopia	Prevalence per 1000 of population & (confidence interval)
Bray [14] (1996, UK)	Orthoptic Screening	18	**11** (7-18)
	Health Visitor Screening	21	**10** (6-15)
	General Practitioner Screening	21	**12** (8-12)

Table 4a. Uptake Rates - Primary Orthoptic Population Screening

Study	Type	Method of invitation & other relevant information	%(n) screened & (confidence interval)
		One invitation sent	
Birmingham [7] (1995/6, UK)	Unpublished data for a primary orthoptic screening programme	HVs gave parents information leaflet about PSVS with 'Bobby Bunny' motif. Same motif used on invitations.	43.9 (3164) (42.8, 45.1)
Dudley & Sandwell [19] (1993/4, UK)	Unpublished data for a primary orthoptic screening programme	One invitation sent.	51.0 (3967) (49.6, 51.8)
Ingram [36] (1986, UK)	Retrospective study of a primary orthoptic/ophthalmic screening programme	One invitation sent.	66.4*(1507) (64.4, 68.3)
Wormald [83] (1991, UK)	Retrospective study of a primary orthoptic screening programme	One invitation sent.	67.2** (402) (63.5, 71.0)
mean			**50.5%**
		Two invitations sent	
Jarvis [37] (1990, UK)	Prospective study comparing a pilot orthoptic & established HV &HV/GP/CMO preschool vision screening programmes in 3 matched areas	Two invitations sent.	59.6 (611) (56.5, 62.6)
Newman [54] (1996, UK)	Retrospective study of referrals from a primary orthoptic screening programme	Approximately 40% of those who failed to attend attended after second invitation.	79.3 (6794) (78.5, 80.2)

Study	Type	Method of invitation & other relevant information	%(n) screened & (confidence interval)
Gallaher (1994/5, UK)	Unpublished audit of a primary orthoptic screening programme	Second invitation sent if child failed to attend.	76.3 (2823) (75.0, 77.7)
mean			
		Number of invitations sent not stated	
Beardsell [5] (1989, UK)	Retrospective study of a primary orthoptic screening programme	Number of invitations sent not stated.	75.4 (2475) (73.9, 76.8)
Bolger [9] (1991, UK)	Retrospective cohort study using case notes of referrals, comparing primary orthoptic & CMO preschool vision screening programmes	Number of invitations sent not stated.	72.8 (5176) (71.8, 73.9)
Edwards [20] (1989, UK)	Retrospective study comparing primary orthoptic & HV screening programmes	Where possible, HVs contacted parents to explain the nature & purpose of the examination. Number of invitations sent not stated.	73.1 (3239) (72.0, 74.4)
Milne [52] (1994, UK)	Retrospective study of referrals from a community orthoptic service; figure for primary screening given here	Number of invitations sent not stated.	60.8 (1858) (59.0, 62.5)
Swindon [71] (1991, UK)	Unpublished data for a primary orthoptic screening programme	HVs gave invitations for PSVS at 3.5 yr check. Number of invitations sent not stated.	80.3 (1317) (78.3, 82.2)

Study	Type	Method of invitation & other relevant information	%(n) screened & (confidence interval)
Williamson [80] (1995, UK)	Retrospective study of a primary orthoptic vision screening programme	Estimated 87-90% eligible population sent invitations. Number of invitations sent not stated.	57.0 (8142) (56.2, 57.8)
mean			**64.8%**
		Other	
Cameron [11] (1978, UK)	Audit of the first three months of a primary orthoptic screening programme	First 3 months of scheme, launched with publicity in local media. Parents informed about scheme & purpose of tests. In the feasability study, 23.6%* did not attend. Authors cited difficulties with obtaining addresses & 9.2% were not traced. This was improved in the new programme by HVs helping to identify eligible children.	86.0 (442) (83.0, 89.0)

* Secondary calculation

** Estimated rate calculated from random sample.

Table 4b. Uptake rates - HV/GP/CMO Population Screening

Study	Type	Method of invitation & other relevant information	%(n) screened & (confidence interval)
Allen [3] (1992, UK)	Audit of a CMO preschool vision screening programme using a random sample of school health records	No details of method of invitation. Estimated rate calculated from random sample.	53.5 (284) (49.2, 57.7)
Bolger [9] (1991, UK)	Retrospective cohort study using case notes of referrals, comparing primary orthoptic & CMO preschool vision screening programmes	Vision checked as part of developmental screening. No details.	85.0 (2530) (83.7, 86.3)
Jarvis [37] (1990, UK) Prospective study of a cohort of children screened by health visitors at 30 months as part of a general surveillance check (part of a study of three different cohorts).	Prospective study comparing a pilot orthoptic & established HV &HV/GP/CMO preschool vision screening programmes in 3 matched areas	Home visit. Estimated rate as proportion of records seen (1259/1380 records seen)	59.0 (743) (56.3, 61.7)
Jarvis [37] (as above) Prospective study of a cohort of children screened at 30-36 months by a combination of health visitors, CMOs and GPs as part of a general surveillance check (part of a study of three different cohorts).	As above	Local arrangement; no details of method of invitation. Estimated rate as proportion of records seen (967/1151 records seen)	84.0 (812) (81.7, 86.3)
mean			**76.2%**
Kohler [41] (1973, Sweden)	Cohort study of a primary preschool vision screening programme with testing by nurses & a paediatrician	Parents sent invitation and questionnaire re family history of eye disorders, history of birth & neonatal period, & symptoms of eye disorders.	95.1 (2447) (94.3, 95.9)

Table 5a. Referral and Detection Rates - Primary Orthoptic Screening

Study	Screening Tests (ST) & Referral Criteria (RC)	%(n) of screened referred & (confidence interval)	Target Condition	Yield %(n)	Positive Predictive Value %(n)	False Positive Rate	Comments
Beardsell [5]	ST: Cover test, ocular movements (OM), convergence, 20 D. base out prism, Frisby stereotest, monocular VA Sheridan Gardiner (single optotype) at 6m. RC: VA 6/9 or less either eye &/or manifest strabismus.	4.1 (102) (3.3, 4.9)	Anisometropic amblyopia Strabismus Bilateral refractive errors Total	0.7* (18) 1.7* (41) 1.3* (31) 3.6*		Maximum 4.1* (see comments)	False positive rate is from primary & secondary screening combined.
Birmingham [7]	No details.	9.4 (297) (8.4, 10.4)					
Bolger [9]	No details.	5.1*(263) (4.5, 5.7)	Amblyopia without strabismus Strabismic amblyopia Strabismus without amblyopia Total	1.0* 0.6* 0.8* 2.4*	19.0(50) 11.8 (31) 16.7 (44) 47.5	46.4* (122)	Some referrals may have come from CMOs or orthoptists outside routine screening. True positive cases defined as those with amblyopia &/or strabismus. Refractive errors excluded. 4 children unaccounted for.

Study	Screening Tests (ST) & Referral Criteria (RC)	%(n) of screened referred & (confidence interval)	Target Condition	Yield %(n)	Positive Predictive Value %(n)	False Positive Rate	Comments
Cameron [11]	No details	**8.4 (3.7)** (5.8,11.0)					32 others had defects already detected through child health surveillance programme.
Dudley & Sandwell [19]	No details.	5.9 (236) (5.2, 6.7)					
Edwards [20]	ST: Appearance of eyes, cover test, ocular movements, monoc. VA Sheridan Gardiner optotypes, 20 D. base out prism, Lang stereotest. RC(1 or more): VA < 6/9 either eye, > 1 line difference in VA between eyes, eso/exophoria > 10 D base out/in near/distance, heterotropia, abnormalilty of muscle balance, convergence insufficiency 8cm or worse, abnormal response to prism, abnormal appearance of eyes. Re-examined, if any doubt, before referral.	6.1 (198) Inc.40 reviewed. (5.3, 6.9)	Strabismus Refractive errors (inc. anisometropia) 'Reduced vision aetiology unknown' Total	1.4* 4.3* 0.1* 5.9*	23.2 (4) 70.7 (140) 2.0 (4) 96.0	1.0 (2)	14.8% reviewed & found normal. Additional 112 referred from child health surveillance programme (83 GP, 29 HV referrals). No definition of refractive error & amblyopia not identified as a separate entity. Other defects were also included in the study's definition of true positives & when these are included the PPV is 97.5%*. 5 (2.5%) lost to follow-up & excluded.

Study	Screening Tests (ST) & Referral Criteria (RC)	%(n) of screened referred & (confidence interval)	Target Condition	Yield %(n)	Positive Predictive Value %(n)	False Positive Rate	Comments
Ingram [36]	ST: Cover test, VA *linear* Sheridan gardiner or Snellen. *All children also underwent cycloplegic refraction by an ophthalmologist.* Vision deemed abnormal if there was a squint &/or VA 6/12 or less in either eye &/or > 1 line difference in VA between eyes.		Defective acuity without optical correction &/or strabismus	4.9			False negatives: 1.9 (26), defined as those who screened +ve at school entry & had passed PSVS.
Jarvis [37]	ST: Cover tests, ocular movements, 20 D. base out prism, VA Sheridan Gardiner letter matching or Kaye pictures. RC: unknown.	7.9* (48) (5.7, 10.0)	Squints &/or VA loss (due to refractive errors or amblyopia), newly confirmed &/or treatment prescribed.	4.4*	56.2 (27)	25.0* (12)	19.8%* called for review. 30.6%* of these failed to attend. Referral rate for reviewed group was 3 times higher. Different figures given for referral rate in Figs 1 & 2. Children with non-target conditions given repeat appointments for observation included in the false positives

Study	Screening Tests (ST) & Referral Criteria (RC)	%(n) of screened referred & (confidence interval)	Target Condition	Yield %(n)	Positive Predictive Value %(n)	False Positive Rate	Comments
Milne [52]	ST: Cover test, ocular movements, convergence, 20 D. base out prism, VA Sheridan Gardiner single optotype or Kaye pictures. RC (1 or more): VA < 6/6 either eye, significant eso/exophoria, manifest strabismus, nystagmus, abnormal head posture, ptosis, facial asymmetry, ocular muscle imbalance, poor fusion or binocular vision. Recalled once before referral if cooperation poor.	4.5 (83) (3.5, 5.4)	Children requiring immediate treatment with spectacles, patching or surgery.	4.4*	58.6 (82)	41.4* (58)	19.3 % recalled (outcome unknown). Of 349 recalled from a previous visit, 16.3% were referred. Author gives false positive rate of 10.4% based on 14 children discharged as normal within 9 months of initial visit. Secondary calculation based on all those not treated.
Newman [54]	ST: Cover tests, ocular movements, convergence, 20 D. base out prism, TNO stereotest, monoc. VA Sheridan Gardiner single optotypes at 6m. RC: VA < 6/6 either eye, manifest strabismus, decompensating heterophoria, abnormal ocular movements, abnormal response to prism test, negative response to stereotest, any other ocular abnormality. Recalled, if in doubt, before referral.	5.1 (348) (4.6, 5.6)	Amblyopia without strabismus Strabismic amblyopia Strabismus Refractive errors Total	0.7* 0.6* 0.6* 1.5* 3.4	15.8 (48) 14.1 (43) 13.2 (40) 32.8 (100) 66.4 (231)	20.1 (61)	No child referred solely on failing prism test or stereotest. 4.3% failed to attend referral appointment.

Study	Screening Tests (ST) & Referral Criteria (RC)	%(n) of screened referred & (confidence interval)	Target Condition	Yield %(n)	Positive Predictive Value %(n)	False Positive Rate	Comments
Seng [61]	No details.	6.4 (140) (5.4, 7.5)					6.4%* reviewed & found normal.
Gallaher [28]	ST: Cover test, ocular movements, convergence, 20 D. base out prism, stereotest (usually Lang), VA (usually Sheridan Gardiner single optotypes). RC: VA < 6/9 one or both eyes, manifest of significant latent squint, any other test not completed to orthoptist's satisfaction.	6.3 (178) (5.4, 7.2)					5% opted for a private consultation. 5% failed to attend referral appointment.

Williamson [80]	ST: Cover test (33cm & 6m), ocular movements, 20 D. base out prism, stereotest (randot circles or TNO), VA Sheridan Gardiner single optotypes. RC (any): VA 6/9 or less either eye, squint, abnormal ocular movements, *family history*, lack of response to prism or stereotests.	10.6 (863) (9.9, 11.3)	Strabismus, excluding microtropia Microtropia Refractive errors including anisometropia (These groups include people with amblyopia) Total	1.1* 0.7* 4.3* 6.1	74 (528)		4% failed to attend referral appointment. Based on the 712 referrals for whom records were available & who had not been diagnosed before screening. Of confirmed cases of amblyopia (VA < 6/9) 82.7% were correctly identified as positive at screening by VA test result of < 6/9. Of those children who failed the VA test at < 6/9, 46.9% were found to be false positives. This study gives similar details for the other screening tests used.
Wormald [83]	ST: Cover tests, convergence, ocular movements, 20 D. base out prism, stereotest (Wirt Fly & pictures of animals), head posture, VA Snellen 6m with card (Sheridan Gardiner chart at 6m or Kaye pictures when cooperation poor). RC (any): VA < 6/9 (Snellen) either eye, inward/outward deviation on cover test (>8 prism dipotres), obvious squint or other clinical abnormality. May be reviewed if any doubt.	6.7* (27) (4.3, 9.2)	Reduced vision in one or both eyes &/or squint	4.0	94.6 (317)	5.4* (18)	Referral rate estimated from sample.

* Secondary calculation.

Table 5b. Referral and Detection Rates - HV/GP/CMO Screening

Study	Screening Tests (ST) & Referral Criteria (RC)	%(n) of screened referred	Target Condition	Yield %(n)	Positive Predictive Value %(n)	False Positive Rate	Comments
Bolger [9] (CMO, with referral to secondary orthoptic centres)	ST: VA each eye, ocular movements. No further details. RC: unknown	4.4 (111) (3.6, 5.2)	Amblyopia without strabismus Strabismic amblyopia Strabismus Total	0.3* 0.2* 0.1* 0.6	7.2 (8) 5.4 (6) 1.8 (2) 14.4	82.0	True positive cases defined as those with amblyopia &/or strabismus. Refractive errors excluded. 4 children unaccounted for.
Jarvis [37] (HV; no secondary orthoptic programme)	ST: (At 30 months) Standard check, 'pick up a thread'. RC: unknown.	1.7* (13) (0.8, 2.7)	Squints &/or VA loss (due to refractive error or amblyopia), newly confirmed or treatment prescribed	0.9*	53.8 (7)	38.5*(5)	Screening coverage estimated from records seen.
Jarvis [37] (HV/GP/CMO; no secondary orthoptic programme)	ST: (At 30-36 months) Squint check -parents asked if squint noticed, then checked for obvious squint & for symmetry of corneal reflections for far & near vision. RC: unknown	1.6* (13) (0.7, 2.5)	Squints &/or VA loss (due to refractive error or amblyopia), newly confirmed or treatment prescribed	1.0*	61.5 (8)	38.5*(5)	Screening coverage estimated from records seen.

Study	Screening Tests (ST) & Referral Criteria (RC)	%(n) of screened referred	Target Condition	Yield %(n)	Positive Predictive Value %(n)	False Positive Rate	Comments
Edwards [20] (HV; referral to hospital-based orthoptist)	HVs instructed in following screening methods & referral criteria: ST: Appearance of eyes, cover test, ocular movements, monoc. VA Sheridan Gardiner optotypes, 20 D. base out prism, Lang stereotest. RC(1 or more): VA < 6/9 either eye, > 1 line difference in VA between eyes, eso/exophoria > 10 D base out/in near/distance, heterotropia, abnormalilty of muscle balance, convergence insufficiency 8cm or worse, abnormal response to prism, abnormal appearance of eyes.	7.4 (52) (5.5, 9.4)	Strabismus Refractive errors (inc-luding anisometropia) Total	1.0* 1.6* 2.6*	13.4 (7) 21.2 (11) 34.6		Rates given are for primary HV screening. 61 GP referrals from same area: false positive rate 27.9% (17), true positive rate squint 55.7%* (34) & refractive errors 14.8%* (9).In orthoptic screening area, 83 referrals from Gps with a false positive rate of 37.3%* (31) & 29 from HVs with a false positive rate of 72.4%* (21).
mean		**3.9%**					

Study	Screening Tests (ST) & Referral Criteria (RC)	%(n) of screened referred	Target Condition	Yield %(n)	Positive Predictive Value %(n)	False Positive Rate	Comments
Kohler [41,42] (nurse/paediatrician)	ST: Appearance, cover test, ocular movements, monoc. VA Marquez-Bostr^m's hooks at 5m, Wirt Fly stereotest. RC: VA 5/6 or less either eye, signs of strabismus or defective stereoscopic vision. After first year of programme, referrals made only if failed on re-testing.	15.2 (364) (13.7, 16.6)	Amblyopia Manifest strabismus 'Significant' refractive errors (hyperopia 2.5 or more, myopia 1.0 or more, astigmatism 2.5 or more) Anisometropia (1D or more) Significant disorders needing treatment immediately or after observation	1.8 1.6 5.6 1.4 6.4	12.3 (44) 10.3 (37) 36.9(132) 9.2 (33) 43.0 (153)	16.4 (59)	96% referred for failing VA test. 1.6% (6) failed to attend referral appointment. Children with muscle imbalance without amblyopia & 'other types of strabismus' were treated. 1530 (62.5%) were re-screened at age 7. 11 had newly-detected defects & were either the false negatives of preschool screening or had developed the defects since the age of 4.

* Secondary calculation.

RESULTS: COSTS

Costs for childhood screening, including vision, is a topic that has been prioritised by the Standing Group on Health Technology, and a review is being carried out by the York Health Economics Consortium. No studies were identified in this review which were designed with the primary aim of evaluating the costs of screening. Some of the observational studies and audits of screening programmes included some cost data. An audit of an orthoptic screening programme reported an estimated cost of £417 (1990 prices) per child with an initial visual acuity of 6/24 or less who improved by two lines or more after treatment.[61] In the same year, the cost of primary vision screening requiring 15 sessions a month in another area was calculated to be around £33 per session, with an additional cost to the NHS of providing salaries for orthoptic screening of £6000.[9] The costs from a primary orthoptic screening programme from April 1995 to March 1996, for which the uptake rate was 44%, are given as £4.82 per child sent for and £10.99 per child seen.[7] These figures include the cost of the orthoptists' salaries, travel and stationery, but exclude the cost of training, dressings and equipment. The costs of a secondary orthoptic screening programme in 1995 are given as £58 per session (almost £7000 per year), £4.49 per child sent for and £7.30 per child seen, where the uptake rate was 61%.[27] These figures suggest that the cost of orthoptic screening is not great. This means that a relatively small benefit to children's visual health from these programmes may be judged cost effective when compared to the benefits to be gained form other more expensive programmes.

DISCUSSION

Although systematic reviews of other screening programmes have been carried out, the methodology for this work is both less well developed and more complicated than that for reviews of treatment RCTs. This review is unusual in that it concerns screening for a non-fatal disease. This has raised the issue of the appropriateness of the health outcome used to measure success or failure. This has been the most intellectually taxing part of this review and it is likely that it could be improved and developed with further work.

Search strategies

Search strategies were devised for each database with the aim of producing a high yield of potentially relevant studies. The Cochrane Collaboration's 'optimally sensitive strategy' for searching Medline was used with that database. This search strategy has been developed over a number of years and is continually being revised. It was developed with the aim of identifying RCTs and CCTs. At the same time the Cochrane Collaboration has been working with Medline to improve the coding of RCTs and CCTs so that their search strategies are even more sensitive. This study has relied on searches of other databases for which there has been much less developmental work. Because we were only able to identify one RCT or CCT that aimed to answer the principle question "is screening worthwhile?" we have searched for studies answering a number of different research questions relevant to the assessment of screening programmes.

Selection of studies

The searches initially yielded over five thousand references and all but those listed in this document were eliminated on the basis of titles and abstracts (where given) by one reviewer (SKS). Any reference that appeared remotely suitable for further scrutiny was downloaded and considered more carefully. We found a number of studies at this stage which did not strictly fulfill the search criteria, and were not sufficiently robust from a methodological point of view to answer our research questions, whose results nevertheless are worthy of mention, either because they question currently held beliefs, or because they throw some light on the research questions. It is possible that some studies of this nature were missed in the initial sift of 5000 references. Finding and critically appraising all of them was beyond the scope of this study.

Literature was also identified late in the course of the study as a result of consultation on the draft report that we had not identified in the electronic search or request for unpublished studies. Our advisory group was particularly helpful in this respect. Where possible and appropriate these studies have been included in the review. This process improves the credibility of the review because it ensures that studies that clinicians believe are important and which underpin their professional practice are included. In a review like this where the adequacy of electronic searching must be open to question it is however important to be aware that this process could lead to bias.

Studies that support current clinical practice are more likely to be included than those that do not. None of the evidence identified late in the review provided definitive answers to our research questions. The problem of failing to identify all relevant literature is more likely to have affected the identification of studies relating to natural history and disability than the other topics.

Appropriateness of outcome measures

The most controversial component of our review is that pertaining to the extent of disability caused by these defects. This is also the area in which the review is least strong. Whilst we can be confident that we would have identified studies which fulfill the criteria for causality we believe we may have missed some studies which might throw light on the subject and be useful for generating hypotheses. To many clinicians working in this field it appears self-evident that a reduction in visual acuity (which may range from one line on the Snellen chart to six) in one eye, or a lack of stereopsis must be disabling. The risk of severe visual impairment for the person with amblyopia through loss of vision in the good eye is frequently cited as a key reason for identifying and treating amblyopia, but the contribution of amblyopia to blindness is virtually undocumented. There is also a need for further studies of the prognosis for vision in the amblyopic eye when vision in the better eye is lost. The belief that reduced binocular vision or minor refractive errors cause problems for children and adults is biologically plausible, but it does need supporting by methodologically sound studies and these do not seem to have been carried out. We have attempted to present a range of the studies that are commonly quoted as demonstrating that visual defects must be disabling and demonstrate why they do not prove this.

Effectiveness of treatment

The second most controversial aspect of this review is the conclusion we have reached about the impact of treatment on the three target conditions. There is a strongly held clinical belief that treatment works, and several clinicians have told us that the prevalence of dense amblyopia in childhood has reduced during their working lives. However the evidence relating to the natural history of these conditions is inadequate and there do not appear to be any methodologically sound trials of the effect of treatment of any of the conditions on visual function. Current clinical practice appears to be based on theory and on observational studies of treatment. Whilst this may be considered sufficient as a basis for clinical practice it is not sufficient for the establishment of a screening programme. In the absence of knowledge about the disabilities attributable to the target conditions it is difficult to see how clinicians will be able to give parents a clear picture of how treatment will benefit their child and to achieve informed consent to treatment.

Side effects of screening and treatment

We found no studies that aimed to measure negative effects of screening. Potential visual side effects of treatment (diplopia, deprivation amblyopia and failure of emmetropisation) are acknowledged[110,115] but the potential psychological impact on the child or the family is seldom

mentioned, still less explored. The evidence that the detrimental effects of screening programmes can outweigh the benefits is mounting.[123] There is evidence that many older children prescribed glasses for refractive error do not wear them,[68] suggesting that the perceived improvement in visual functioning achieved by spectacles is not always sufficient to offset the perceived social disability attributable to wearing spectacles. Patching is likely to be more socially and psychologically disabling than spectacle wearing and could have deleterious effects on both the child and the family.

CONCLUSIONS

Our conclusions and recommendations differ from those of other recent reviews [eg. 111, 112, 122] which judge that preschool vision screening is worthwhile. These reviews have based their conclusions on literature that has been appraised in this review. Our review differs from these in that it has taken a more rigorous approach to the evidence relating to disability and treatment. We believe that this evidence is essential to support a screening programme for a non-fatal condition for which there have been no rigorously controlled trials. An invitation to preschool vision screening carries with it the implicit assumption that screening is going to benefit the child. In the absence of sound evidence that the target conditions sought in these programmes are disabling and that the interventions available to correct them do more good than harm, the ethical basis for such interventions is very insecure.

RECOMMENDATIONS

Clinical Practice

Purchasers and providers should be appraised of the results of this review and advised not to implement new screening programmes.

Providers currently offering screening programmes should consider discontinuing them. From an ethical point of view it is appropriate to continue screening only in the context of a controlled trial of treatment such as that described below.

Research

There is an urgent need to research:

Disability

a) the extent of disability attributable to amblyopia. A variety of different types of study are needed, including qualitative studies exploring with sufferers the ways in which they feel their condition has affected them. We are currently conducting a small qualitative study exploring this area. There is also a need for comparative experimental studies measuring the performance of people with amblyopia at tests that might be expected to be affected by monocular function.

b) disability attributable to refractive errors, particularly the possibility that hypermetropia might cause problems with reading which could be corrected with spectacles, or might contribute to the development of a squint. These possibilities could be studied in an RCT.

c) whether there is any disability associated with non cosmetically obvious squints.

d) the prevalence of blindness or partial sight attributable to amblyopia in the UK. A national survey of the incidence and causes of loss of vision in the better eye in children and adults with unilateral amblyopia, from data collected by the British Ophthalmic Surveillance Unit, is planned to start this year.[124] Data will be collected for a period of not less than 18 months. Studies are also needed to assess the extent to which an amblyopic eye can regain function late in life if the good eye fails.

Until it is established that these conditions are disabling and in what ways, it will remain impossible to demonstrate that pre-school vision screening programmes offer any health gain. Once these studies have been completed, and it has been demonstrated that the conditions are disabling, appropriate health outcome measures can be devised.

Treatment

e) the impact of orthoptic treatment on family life and psychological wellbeing of the child. Initially, qualitative studies are needed to explore possibly unexpected consequences.

f) the effectiveness of orthoptic treatment on amblyopia and quality of life. This needs to be a randomised controlled trial of treatment versus no treatment. The outcome of treatment needs to be measured in terms of health outcomes defined in studies of disability. Trials should be undertaken in children both of three to four years of age and of five to six years

to determine whether screening at age three and four confers any benefit over screening at school entry. This type of study would also provide data on natural history.

g) the effectiveness of treatment of non cosmetically obvious squint and refractive errors in this age group. This also needs to be a no-treatment controlled RCT, but if d) is underway could use amblyopia as an outcome.

Screening

No further studies of the efficiency of screening in identifying children with the target conditions should be undertaken the research on disability and treatment has been undertaken.

STUDIES INCLUDED IN THE REVIEW

Information about individual studies is given in the text and/or tables.

1. Abrahamsson, M., Fabian, G., and Sjostrand, J. Refraction changes in children developing convergent or divergent strabismus. *British Journal of Ophthalmology* 1992; 76:723-727.

2. Alberman, E.D., Butler, N.R., and Gardiner, P.A. Children with squints - a handicapped group? *The Practitioner* 1971; 206:501-506.

3. Allen, J.W. and Bose, B. An audit of preschool vision screening. *Archives of Disease in Childhood* 1993; 67:1292-1293.

4. Bax, M. and Whitmore, K. Neurodevelopmental screening in the school-entrant medical examination. *The Lancet* 1973; 2(825):368-370.

5. Beardsell, R. Orthoptic Visual Screening at 3.5 years by Huntingdon Health Authority. *British Orthoptic Journal* 1989; 46:7-13.

6. Jones, R.K. Lee, D.N. Why are two eyes better than one: the two views of binocular vision, *J Experimental Psychology, Human Perception and Performance* 1981; 7:30-40.

7. Birmingham Unpublished data on preschool vision screening in S. Birmingham, April 1995-March 1996. Personal communication from Mrs J. Nolan (Head Orthoptist)

8. Bishop, D.V., Jancey, C., and Steel, A.M. Orthoptic status and reading disability. *Cortex* 1979; 15:659-666.

9. Bolger, P.G., Stewart Brown, S.L., Newcombe, E., and Starbuck, A. Vision screening in preschool children: comparison of orthoptists and clinical medical officers as primary screeners. *BMJ.* 1991; 303(6813):1291-1294.

10. Buzzelli, A.R. Stereopsis, accommodative and vergence facility: do they relate to dyslexia? *Optom.Vis.Sci.* 1991; 68(11):842-846.

11. Cameron, H. and Cameron, M. Visual screening of pre-school children. *BMJ* 1978; 1693-1694.

12. Campbell, L.R. and Charney, E. Factors associated with delay in diagnosis of childhood amblyopia. *Pediatrics* 1991; 87(2):178-185.

13. Carney, C.V., Lysons, D.A. and Tapley, J.V Is the incidence of constant esotropia in childhood reducing? *Eye* 1995;.9(6):.40-41.

14. Bray, L.C., Clarke, M.P., Jarvis, S.N., Francis, P.M., and Colver, A. Preschool vision screening: A prospective comparative evaluation. *Eye* 1996; 10: 714-718.

15. Conway, M. A Study of the Referral Patterns of Childhood Amblyopia in Suffolk. Unpublished Part II thesis, Faculty of Public Health Medicine:1995.

16. Cornelissen, P., Bradley, L., Fowler, S., and Stein, J. Covering one eye affects how some children read. *Developmental Medicine And Child Neurology* 1993; 34:296-304.

17. Cornelissen, P., Bradley, L., Fowler, S., and Stein, J. What children see affects how they spell. *Developmental Medicine And Child Neurology* 1994; 36(8):716-726.

18. Cornelissen, P., Bradley, L., Fowler, S.A., and Stein, J. What children see affects how they read. *Developmental Medicine And Child Neurology* 1991;33(9):755-762.

19. Dudley & Sandwell Eye Departments Unpubished audit of preschool vision screening, April 1993-March 1994.Personal communication: Miss SM Thompson FRCOpth.

20. Edwards, R. Orthoptists as pre-school screeners: A 2-year study. *British Orthoptic Journal* 1989; 46:14-19.

21. Evans, B.J., Drasdo, N., and Richards, I.L. An investigation of some sensory and refractive visual factors in dyslexia. *Vision Res.* 1994; 34(14):1913-1926.

22. Evans, B.J., Drasdo, N., and Richards, I.L. Dyslexia- The link with visual deficits. *Ophthalmic and Physiological Optics* 1996; 16(1):3- 10.

23. Fathy, V.C., and Elton, P.J. Orthoptic screening for three- and four-year-olds. *Public Health* 1993; 107 (1):19-23,.

24. Feldman, W., Sackett, B., Milner, R., and Gilbert, S. Effects of preschool screening and hearing on prevalence of vision and hearing problems 6-12 months later. *The Lancet* 1980; 1014-1017.

25. Fielder, A.R., Irwin, M., Auld, R., Cocker, K.D., Jones, H.S., and Moseley, M.J. Compliance in amblyopia therapy: objective monitoring of occlusion. *British Journal of Ophthalmology* 1995; 79(6):585-589.

26. Flom, M. and Neumaier, R. Prevalence of amblyopia. *Public Health Reports* 1966; 81(4):329-341.

27. Freeman, C.F. Costings for the secondary orthoptic screening programme in South Worcestershire for 1995 - data presented at the Royal College of Ophthalmologists, June 1996.

28. Gallaher, R. Community Orthoptic Visual Screening: First Year Report 1994-1995. South Bucks NHS Trust. (Unpublished).

29. Good, W.V., da Sa, L.C.F., Lyons, C.J., and Hoyt, C.S. Monocular visual outcome in untreated early onset esotropia. *British Journal of Ophthalmology* 1993; 77(8):492-494.

30. Fielder, A.R., Moseley, M.J. Does stereopsis matter in humans? *Eye* 1996; 10:233-238.

31. Grisham, D. and Simons, H. Refractive error and the reading process: A literature analysis *J.Am.Optom.Assoc.* 1986; 57(1):44-55.

32. Grosvenor, T. Are visual anomalies related to reading ability? *J.Am.Optom.Assoc.* 1977; 48(4):510-517.

33. Hall, P. The relationship between ocular functions and reading achievement. *J.Pediatr.Ophthalmol.Strabismus* 1991; 28(1):17-19.

34. Helveston, E. et al Visual function and academic performance. *Am J Opth* 1985; 99:346-355.

35. Henderson, S., Barnett, A., and Henderson, L. Visuospatial difficulties and clumsiness: on the interpretation of conjoined deficits. *Journal of Child Psychology & Psychiatry* 1994; 35(5):961-969.

36. Ingram, R.M., Holland, W.W., Walker, C., Wilson, J.M., Arnold, P.E., and Dally, S. Screening for visual defects in preschool children. *British Journal of Ophthalmology* 1986; 70:16-21.

37. Jarvis, S.N., Tamhne, R.C., Thompson, L., Francis, P.M., Anderson, J., and Colver, A.F. Preschool vision screening. *Arch.Dis.Child* 1990; 65:288-294.

38. Kani, W. Human Amblyopia and its Perceptual Consequences.PhD thesis, University of Durham., 1980.

39. Keith, C.G., Howell, E.R., Mitchell, D.E., and Smith, S. Clinical trial of the use of rotating grating patterns in the treatment of amblyopia. *British Journal of Ophthalmology.* 1980; 64(8):597-606.

40. Kheterpal, S., Jones, H.S., Auld, R., and Moseley, M.J. Reliability of visual acuity in children with reduced vision. *Ophthal. Physiol. Opt.* 1996; 16(5):447-449.

41. Kohler, L. and Stigmar, G. Vision screening of four-year-old children. *Acta Paediatr.Scand.* 1973; 62(1):17-27.

42. Kohler, L. and Stigmar, G. Visual disorders in 7-year old children with and without previous vision screening. 1978; *Acta Paediatr Scand* 67:373-377.

43. Larson, W.L. Disabled stereopsis may be the norm among well-educated people. *Medical Hypotheses* 1995; 44:309-310.

44. Latvala, M.L., Korhonen, T.T., Penttinen, M., and Laippala, P. Ophthalmic findings in dyslexic schoolchildren. *British Journal of Ophthalmology* 1994; 78(5):339-343.

45. Leguire, L.E., Rogers, G.L., Bremer, D.L., Walson, P.D., and McGregor, M.L. Levodopa/carbidopa for childhood amblyopia. *Investigative Ophthalmology & Visual Science* 1993; 34:3090-3095.

46. Leguire, L.E., Walson, P.D., Rogers, G.L., Bremer, D.L., and McGregor, M.L. Longitudinal study of levodopa/carbidopa for childhood amblyopia. *J.Pediatr.Ophthalmol.Strabismus.* 1993; 30(6):354-360.

47. Lennerstrand, G. and Samuelsson, B. Amblyopia in 4-year-old children treated with grating stimulation and full-time occlusion; a comparative study. *British Journal of Ophthalmology.* 1983; 67(3):181-190.

48. Levartovsky, S., Oliver, M., Gottesman, N., and Shimshoni, M. Factors affecting long term results of successfully treated amblyopia: initial visual acuity and type of amblyopia. *British Journal of Ophthalmology.* 1995; 79(3):225-228.

49. MacLellan, A. and Harker, P. Mobile orthoptic service for primary screening of visual disorder in young children. *BMJ* 1979; 994-995.

50. Malik, S.R., Gupta, A.K., and Grover, V.K. Occlusion therapy in amblyopia with eccentric fixation. *British Journal of Ophthalmology. 1970*; 54(1):41-45.

51. McGee, R., Williams, S., Simpson, A., and Silva, P.A. Stereoscopic vision and motor ability in a large sample of seven-year-old children. *Journal Of Human Movement Studies* 1991; 13:343-352.

52. Milne, C. An evaluation of cases referred to hospital by the Newcastle Pre-School Orthoptic Service. *British Orthoptic Journal* 1994; 51:1-5.

53. Monfardini, A. Incidenza dell'astigmatismo nella oftalmometria preventiva nel terzo anno di vita in 2000 Bambini (The incidence of astigmatism in preventive ophthalmometry in the third year of life, in 2000 children.) *Bollettino Di Oculistica* 1988; 67:113-116.

54. Newman, D.K., Hitchcock, A., McCarthy, H., Keast-Butler, J., and Moore, A.T. Preschool vision screening: outcome of children referred to the hospital eye service. *British Journal of Ophthalmology. 1996*; 80:1077-1082.

55. Nucci, P., Alfarano, R., Piantanida, A., and Brancato, R. Compliance of antiamblyopia occlusion therapy. *Acta Ophthalmologica* 1992; 70:128-131.

56. Nyman, K.G., Singh, G., Rydberg, A., and Fornander, M. Controlled study comparing CAM treatment with occlusion therapy. *British Journal of Ophthalmology* 1983; 67(3):178-180.

57. Ohtsuki, H., Hasebe, S., Tadokoro, Y., Kishimoto, F., Watanabe, S., and Okano, M. Preoperative prism correction in patients with acquired esotropia. *Graefes.Arch.Clin.Exp.Ophthalmol.* 1993; 231(2):71-75.

58. Oliver, M., Neumann, R., Chaimovitch, Y., Gotesman, N., and Shimshoni, M. Compliance and results of treatment for amblyopia in children more than 8 years old. *Am.J.Ophthalmol.* 1986; 102(3):340-345.

59. Prism Adaptation Study Research Group Efficacy of prism adaptation in the surgical management of acquired esotropia. *Arch.Ophthalmol.* 1990; 108(9):1248-1256.

60. Repka, M.X. and Wentworth, D. Predictors of prism response during prism adaptation. Prism Adaptation Study Research Group. *J.Pediatr.Ophthalmol.Strabismus.* 1991; 28(4):202-205.

61. Seng, C., and Curson, J. Study of the outcomes of referrals from the orthoptic vision screening programme, 1991. Bedfordshire Health, Charter House, Alma St, Luton. (Unpublished)

62. Shaw, D.E., Fielder, A.R., Minshull, C., and Rosenthal, A.R. Amblyopia: Factors influencing age of presentation. *The Lancet* 1988; 2:207-209.

63. Simons, H.D. and Gassler, P.A. Vision anomalies and reading skill: A meta-analysis of the literature. *American Journal of Optometry & Physiological Optics* 1988; 65(11):893-904.

64. Smith, L.K., Thompson, J.R., Woodruff, G., and Hiscox, F. Social deprivation and age at presentation in amblyopia. *Journal of Public Health Medicine,* 1994; 16 (3):348- 351.

65. Smith, L.K., Thompson, J.R., Woodruff, G., Children's vision screening- Impact on inequalities in central England. *Journal of Epidemiology and Community Health,* 1995; 49 (6):606-609.

66. Sonksen, P.M. and Macrae, A.J. Vision for colored pictures at different acuities: The Sonksen picture guide to visual function. *Developmental Medicine And Child Neurology* 1987; 29:337-347.

67. Stayte, M., Reeves, B., and Wortham, C. Ocular and vision defects in preschool children. *British Journal of Ophthalmology* 1993; 77:228-232.

68. Stewart Brown, S., Haslum, M.N., and Butler, N. Educational attainment of 10-year-old children with treated and untreated visual defects. *Developmental Medicine And Child Neurology* 1985; 27:504-513.

69. Sucher, D.F. and Stewart, J. Vertical fixation disparity in learning disabled. *Optometry And Vision Science* 1993; 70(12):1038-1043.

70. Sullivan, G. and Fallowfield, L. A controlled test for the CAM treatment for amblyopia. *British Orthoptic Journal* 1980; 37:47-55.

71. Swindon Unpublished data on preschool vision screening in Highworth, Swindon, 1983-1991. Personal communication from Mrs J M James (Head Orthoptist, Princess Margaret Hospital)

72. Williams, C., Harvey, I., Frankel, S., Golding, J, Sparrow, J.M., Harrad, R.A and the ALSPAC Children in Focus Study Team: Preschool Vision Screening – Results of a randomised controlled trial. *Investigative Ophthalmology and Vision Science* 1996; 37:S1111.

73. Terrell Doba, A. Cambridge stimulator treatment for amblyopia. An evaluation of 80 consecutive cases treated by this method. *Aust.J.Ophthalmol.* 1981; 9(2):121-127.

74. Thompson, J.R., Woodruff, G., Hiscox, F., Strong, N., and Minshull, C. The Incidence and prevalence of amblyopia detected in childhood. *Public Health* 1991; 105:455-462.

75. Tommila, V. and Tarkkanen, A. Incidence of loss of vision in the healthy eye in amblyopia. *British Journal of Ophthalmology* 1981; 65:575-577.

76. Tytla, M.E. and Labow Daily, L.S. Evaluation of the CAM treatment for amblyopia: a controlled study. *Invest.Ophthalmol.Vis.Sci.* 1981; 20(3):400-406.

77. Veronneau Troutman, S., Dayanoff, S.S., Stohler, T., and Clahane, A.C. Conventional occlusion vs. pleoptics in the treatment of amblyopia. *Am.J.Ophthalmol.* 1974; 78(1):117-120.

78. Waddingham, P. and Whale, K. Children who failed visual screening at age 5. Were they seen by the orthoptist at age 3? Unpublished audit, Birmingham & Midland Eye Hospital, 1993.

79. Wang, Y.D., Thompson, J.R., Goulstine, D.B., and Rosenthal, A.R. A survey of the initial referral of children to an ophthalmology department. *British Journal of Ophthalmology* 1991; 74:650-653.

80. Williamson, T.H., Andrews, R., Dutton, G.N., Murray, G., and Graham, N. Assessment of an inner city visual screening programme for preschool children. *British Journal of Ophthalmology,* 1995; 79 (12):1068- 1073.

81. Woodruff, G., Hiscox, F., Thompson, J.R., and Smith, L.K. Factors affecting the outcome of children treated for amblyopia. *Eye* 1994; 8:627-631.

82. Woodruff, G., Hiscox, F., Thompson, J.R., and Smith, L.K. The presentation of children with amblyopia. *Eye* 1994; 8:623-626.

83. Wormald, R.P. Preschool vision screening in Cornwall: performance indicators of community orthoptists. *Arch.Dis.Child* 1991; 66(8):917-920.

84. Ygge, J., Lennerstrand, G., Rydberg, A., Wijecoon, S., and Pettersson, B.M. Visual functions in a Swedish population of dyslexic and normally reading children *Acta Ophthalmologica* 1993; 71: 1-9.

85. Oculomotor functions in a Swedish population of dyslexic and normally reading children. *Acta Ophthalmologica* 1993; 71:10-21.

Other references

86. Church, C. The identification and management of visual impairment. In: *Screening And Surveillance In General Practice*, edited by Hart, C.R. and Burke, P.Edinburgh: 1992,

87. Department of Health, EL (95) 105, 2; (7.12.95).

88. Dickersin, K., Scherer, R., and Lefebvre, C. Identifying relevant studies for systematic reviews. In: *Systematic Reviews*, edited by Chalmers, I. and Altman, D.G.London:BMJ Publishing Group, 1995,p. 17-36.

89. Fielder, A.R. and Moseley, M.J. Anisometropia and amblyopia - chicken or egg? *British Journal of Ophthalmology* 1996; 80:857-858.

90. Teasdale, T.W., Fuchs, J., Goldschmidt, E. Degree of myopia in relation to intelligence and educational level. *The Lancet* 1988; 1351-1354.

91. Hall, D. Health For All Children. New York:Oxford University Press. First edition, 1989.

92. Hall, S., Pugh, A., and Hall, D. Vision screening in the under-5's. *BMJ* 1982; 285:1096-1098.

93. Hess, R. Is amblyopia an impediment to binocular function? *Eye* 1996; 10:245-249.

94. Howland, H.C. Early refractive development. In: *Early Visual Development, Normal And Abnormal*, edited by Simons, K.Oxford, New York:Oxford University Press, 1993,p. 5-13.

95. Johnson, A. Visual problems in children:detection and referral. *JRCGP* 1984; 34:32-35.

96. Jones, R. and Lee, D. Why two eyes are better than one: The two views of binocular vision. *Journal of Experimental Psychology Human Perception and Performance* 1981; 7(1):30-40.

97. Lysons, D., Horne, G., Newcomb, E., Robinson, J., and Stephenson, G. British Orthoptic Society Visual Screening Project 1991. (Unpublished)

98. Moseley, M.J. and Fielder, A.R. Occlusion therapy for childhood amblyopia: current concepts in treatment evaluation. In: *Infant Vision*, edited by Vital-Durand, F., Atkinson, J., and Braddick, O.J. Oxford, New York, Tokyo: Oxford University Press, 1996,p. 383-400.

99. NHS Executive, Promoting Clinical Effectiveness - a framework for action in and throughout the NHS. 1996.

100. Price, D., Minshull, C., Moseley, M., and Fielder, A. The acuity card procedure: its use in orthoptics. *British Orthoptic Journal* 1987; 44.

101. Roy, B., Cameron, M., Paterson, D., Taylor, W., and Cameron, J. The place of the orthoptist in visual screening of pre-school children. *British Orthoptic Journal* 1977; 34.

102. Servos, P., Goodale, M., and Jakobson, L. The role of binocular vision in prehension: kinematic analysis. *Vision Research* 1992; 32(8):1513-1521.

103. Stewart Brown, S.L., Haslum, M.N., and Howlett, B. Preschool vision screening: A service in need of rationalization. *Archives of Disease in Childhood* 1988; 63:356-359.

104. Vital-Durand, F., Atkinson, J., and Braddick, O.J. *Infant Vision*. Oxford, New York, Tokyo: Oxford University Press. , 1996.

105. Williams, C. Senior Registrar in Ophthalmology, Bristol Eye Hospital. Personnal communication.

106. Wilson, J. M. G., and Jungner, G. Principles and Practice of Screening for Disease. Public Health Papers, WHO, Geneva, 1968.

107. Auld, R. Head Orthoptist, Birmingham & Midland Eye Hospital. Personal communication.

108. Dodridge, C. Head Orthoptist, Oxford Eye Hospital. Personal communication.

109. Schmidt, P. P. Allen figure and broken wheel visual acuity measurement in preschool children. *Journal of the American Optometric Association* 1992; 63 (2): 124.

110. Campos, E. Amblyopia. *Survey of Opth* 1995 40(1):23-39.

111. Guide to Clinical Preventive Services. Report of the U.S. Services Preventive Task Force. Williams & Wilkins, Baltimore, second edition 1994: 373-382.

112. Canadian Task Force on the Periodic Health Examination. The Canadian Guide to Clinical Preventive Health Care. Ottawa: Canada Communication Group, 1994:298-304.

113. Hill, A.B. *Principles of Medical Statistics.* London, Lancet 1971: 313.

114. Hard, A.L., Williams, P., Sjostrand, J. Do we have optimal screening limits in Sweden for vision testing at the age of 4 years? *Acta Ophthalmologica Scandinavica,* 1995; 73 (6) 483- 485.

115. Aurell, E., Norrsell, K. A longitudinal study of children with a family history of strabismus: factors determining the incidence of strabismus. *British Journal of Ophthalmology* 1990; 74:589-594.

116. Ingram, R.M., Traynar, M.J., Walker, C., Wilson, J.M. Screening for refractive errors at age 1 year: a pilot study. *British Journal of Ophthalmology* 1979; 63:243-250.

117. Ingram, R.M. and Walker, C. Refraction as a means of predicting squint or amblyopia in preschool siblings of children known to have these defects. *British Journal of Ophthalmology* 1979; 63:238-242.

118. Burian, H.M., von Noorden, G.K. *Binocular vision and ocular motility.* 2nd edition. Mosby, 1980:219-220.

119. McManus, I.C., Mascie-Taylor, C.G.N. Biosocial correlates of cognitive abilities. *J. Biosoc. Sci.* 1983; 15:289-306.

120. Peckham, C.S., Gardiner, P.A., Goldstein, H. Acquired myopia in 11-year-old children. *BMJ:* 1977; 542-544.

121. Vereecken, E.P., Brabant, P. Prognosis for vision in amblyopia after the loss of the good eye. *Archives of Ophthalmology* 1994; 102: 220-224,.

122. Simons, K. Preschool vision screening: rationale, methodology and outcome. *Survey of Ophthalmology* 1996; 41(1):3-30.

123. Stewart-Brown, S. Screening could seriously damage your health. *BMJ* 1997; 314:533.

124. Rahi, J. MRC Clinical Training Fellow, Great Ormond Street Hospital/Institute of Child Health. Personal communication.

125. Mr M P Clarke, Consultant Ophthalmologist, Royal Victoria Infirmary, Newcastle. Personal communication.

126. NHS Centre for Reviews and Dissemination. *Undertaking Systematic Reviews of Research on Effectiveness – CRD Guidelines for Those Carrying Out or Commissioning Reviews.* CRD Report 4, University of York, 1996.

APPENDIX A

GLOSSARY

1. Terms relating to vision

Amblyopia Reduced visual acuity in the absence of organic disease, which cannot be improved by spectacles. It is usually uniocular. Amblyopia is held to be reversible up to the age of about eight years. Children presenting with amblyopia will be treated with occlusion or other therapies in order to reverse the visual loss. It is thought to be caused by hypermetropia and/or anisometropia as well as the various types of squint. Some practitioners will treat these refractive errors in preschool children to prevent the development of amblyopia. Others will follow up these children and intervene as soon as the amblyopia appears.

Anisometropia A difference in refractive error between the two eyes.

Binocular single vision (BSV) The simultaneous use of both eyes so that each eye contributes to a common singular perception. There are grades of BSV. In the highest form the object is fixated at the centre of the retina in both eyes and fusion of the two images allows depth perception (stereopsis).

Cover/uncover test A test used to detect squint, in which each eye is covered in turn while the child fixes on a specified target, and the tester observes the movements of the eyes.

Cycloplegic drugs These are drugs which block the action of the ciliary muscle, preventing accommodation. In addition, pupillary dilation occurs.

Diplopia Double vision, or seeing two images of one object simultaneously.

Hypermetropia Refractive error where the principal focus is behind the eye ('long sight').

Intermittent squint There is a manifest squint at some times or distances but the visual axes are aligned at others. Children with intermittent squints may respond to spectacle correction alone if they are also hypermetropic. They may be followed up and undergo surgery if the squint becomes less well controlled, in order to prevent the loss of binocular vision and the development of a cosmetically obvious squint.

Latent squint (heterophoria) With both eyes open the visual axes are aligned. When one eye is covered, the eye under cover deviates; when the cover is removed, it comes back into alignment. A small heterophoria is present in the majority of people without ocular symptoms. Small latent *divergent* squints are regarded as common in children children aged 3-4.5 years and are not thought to be associated with any adverse effects. No intervention is recommended. Small latent *convergent* squints are often accompanied by hypermetropia, for which spectacle correction is prescribed with the aim of preventing further deterioration of the squint.

Manifest squint (heterotropia) With both eyes open the visual axis of one eye is deviated from the point of fixation. It may be constant or intermittent.

Microsquint (microtropia) A small angle heterotropia usually of 10 dioptres or less. These are associated with abnormal binocular function but cannot be treated. They are often associated with anisometropia and both of these conditions are thought to predispose children to developing amblyopia. Children with microtropias are prescribed spectacles if they are anisometropic and they are followed up to allow incipient amblyopia to be detected and treated early.

Myopia A refractive error where parallel rays of light focus in front of the retina when the eye is at rest ('short sight').

Occlusion Obscuring the vision of one eye, either totally or partially, to prevent or reduce visual stimulation.

Refractive error An abnormal refractive index.

Squint The lay term for strabismus.

Stereopsis The image seen by each eye is slightly different; the fusion of these two images allows perception of depth.

Strabismus The misalignment of the visual axes of the two eyes. It may be manifest or latent.

Visual acuity The limit of spatial visual discrimination, commonly measured using letters or other geometrical forms (optotypes). Two of the scales used to measure visual acuity, the Snellen and LogMAR scales, are given below.

Snellen	LogMAR
6/60	1.0
-	0.9
6/36	0.8
-	0.7
6/24	0.6
6/18	0.5
-	0.4
6/12	0.3
6/9	0.2
6/7.5	0.1
6/6	0.0
6/5	-0.1
6/4	-0.2
6/3	-0.3

NB. Many Snellen charts stop at 6/5.

2. Epidemiological terms

False Negatives Individuals with a negative test result who actually have a target condition.

False Positives Individuals with a positive test result who do not have a target condition.

Negative Predictive Value (NPV) The proportion of individuals who test negative who do not have a target condition.

Positive Predictive Value (PPV) The proportion of individuals with a positive test result who have a target condition.

Screening The presumptive identification of unrecognised disease or defect by the application of tests, examinations, or other procedures which can be applied rapidly to a whole population. Screening sorts out apparently well people who probably have a disease/defect from those who probably do not.

Sensitivity (true positive rate) The proportion of individuals with the target condition in a population who are correctly identified by a screening test.

Specificity (true negative rate) The proportion of individuals free of the target condition in a population who are correctly identified by a screening test.

Surveillance Ongoing observation of the health of individuals or populations.

Yield. The proportion of individuals in the screened population who are found to have a target condition

APPENDIX B

SEARCH STRATEGIES

Medline

1 RANDOMIZED-CONTROLLED-TRIAL in PT
2 "RANDOMIZED-CONTROLLED-TRIALS"/ all subheadings
3 RANDOM-ALLOCATION
4 DOUBLE-BLIND-METHOD
5 SINGLE-BLIND-METHOD
6 #1 or #2 or #3 or #4 or #5
7 explode "REFRACTIVE-ERRORS"/ all subheadings
8 explode "OCULAR-MOTILITY-DISORDERS"/ all subheadings
9 explode "VISION-DISORDERS"/ all subheadings
10 explode "VISION-TESTS"/ all subheadings
11 (VISION near SCREENING) in TI,AB,MESH
12 RETINOBLASTOMA in TI,AB,MESH
14 (VISION or SIGHT or EYE) near TEST*
15 DEFECT* near VISION
16 (EYE or SIGHT) near PROBLEM*
17 SPECTACLES or GLASSES
18 explode "CHILD"/ all subheadings
19 CHILD* or PRESCHOOL*
20 #18 or #19
21 #6 and #20 and (#7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17)
22 CLINICAL-TRIAL in PT
23 explode "CLINICAL-TRIALS"/ all subheadings
24 (CLIN* near TRIAL*) in TI,AB
25 "PLACEBOS"/ all subheadings
26 PLACEBO* in TI,AB
27 RANDOM* in TI,AB
28 RESEARCH-DESIGN"/ all subheadings
29 (SINGL* or DOUBL* or TREBL* or TRIPL*) near (BLIND* or MASK*)
30 #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29
31 #30 and #20 and (#7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17)
32 #31 not #21
33 TG=COMPARATIVE-STUDY
34 explode "EVALUATION-STUDIES"/ all subheadings
35 FOLLOW-UP-STUDIES
36 PROSPECTIVE-STUDIES
37 (CONTROL* or PROSPECTIV* or VOLUNTEER*) in TI,AB
38 #33 or #34 or #35 or #36 or #37
39 #38 and #20 (#7 or #8 or #9 or #10 or #11or #12 or #13 or #14 or #15 or #16 or #17)
40 #39 not (#31 or #21)

Biological Abstracts

1 AMBLYOP*
2 REHABILITAT*
3 DISABILIT*
4 #1 and (#2 or #3)

1 AMBLYOP*
2 OCCLUSION
3 THERAP* or TREATMENT* or MANAG*
4 SCREEN* or TEST*
5 #1 and (#2 or #3 or #4)
1 REFRACTION or REFRACTIVE
2 STRABISMUS or SQUINT
3 SPECTACLES or GLASSES
4 VISION near SCREEN*
5 MICROTROPI*
6 MYOPI*
7 HYPERMETROPI*
8 ANISOMETROPI*
9 ASTIGMAT*
10 DEFECT* near VISION
11 (VISION or SIGHT or EYE) near TEST*
12 CHILD* or PRESCHOOL*
13 #12 and (#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11)

Psychlit

1 explode VISION DISORDERS
2 explode EYE DISORDERS
3 explode OCULAR ACCOMMODATION
4 explode HYSTERICAL VISION DISTURBANCES
5 explode REFRACTION ERRORS
6 VISION near SCREENING
7 VISION SCREENING
8 6 or 7
9 AMBLYOP*
10 (VISION or SIGHT or EYE) near TEST*
11 SPECTACLES or GLASSES
12 DEFECT* near VISION
13 (VISION or SIGHT or EYE) near (PROBLEM* or DISORDER*)
14 MICROTROPIA
15 SQUINT or STRABISMUS
16 MYOPI*
17 HYPERMETROP*
18 ANISOMETROP*
19 ASTIGMAT*
20 REFRACTIVE
21 PRESCHOOL* or CHILD*
22 21 and (1 or 2 or 3 or 4 or 5 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20)

Science Citation Index (SciSearch)

1 RANDOMI?ED CONTROLLED TRIAL*
2 RANDOM ALLOCATION
3 DOUBLE BLIND
4 SINGLE BLIND
5 1,2,3,4
6 CHILD*,PRESCHOOL*
7 AMBLYOPIA
8 REFRACTIVE ERROR*
9 STRABISMUS,SQUINT
10 VIS* SCREENING
11 VISION TEST*
12 SIGHT TEST*
13 EYE TEST*
14 SPECTACLES,GLASSES
15 OCULAR MOTILITY DISORDER*
16 5+6+(7,8,9,10,11,12,13,14)
17 CONTROL* TRIAL*
18 CONTROL* STUD*
19 CLINICAL TRIAL*
20 DOUBLE BLIND
21 SINGLE BLIND
22 TRIPLE BLIND
23 TREBLE BLIND
24 DOUBLE MASK*
25 SINGLE MASK*
26 TREBLE MASK*
27 TRIPLE MASK*
28 RANDOM*
29 PLACEBO*
30 RESEARCH DESIGN*
31 MULTICENT* STUD*
32 17,18,19,20,21,22,23,24,25,26,27,28,29,30,31
33 32+6+(7,8,9,10,11,12,13,14,15)
34 33-16
35 PROSPECTIV* STUD*
36 VOLUNTEER*
37 COMPARATIVE STUD*
38 EVALUATI* STUD*
39 FOLLOW?UP STUD*
40 LONGITUDIN* STUD*
41 COHORT STUD*
42 35,36,37,38,39,40,41
43 42+6+(7,8,9,10,11,12,13,14,15)
44 43-(33,16)

Embase

Search strategy for RCTs and other controlled studies.

1 RANDOMIZED CONTROLLED TRIAL
2 RANDOMIZATION
3 randomi?ed control* trial*
4 DOUBLE BLIND PROCEDURE
5 SINGLE BLIND PROCEDURE
6 1,2,3,4,5
7 CHILD*, PRESCHOOL*
8 REFRACTI* ERROR*
9 AMBLYOPIA
10 explode EYE DISEASE
11 RETINOBLASTOMA
12 explode VISUAL DISORDER
13 explode VISUAL IMPAIRMENT
14 explode VISION TEST
15 explode VISUAL SYSTEM EXAMINATION
16 explode STRABISMUS
17 SPECTACLES,GLASSES
18 6+7+(8,9,10,11,12,13,14,15,16,17)
19 explode CLINICAL TRIAL
20 explode CONTROLLED STUDY
21 explode MAJOR CLINICAL STUDY
22 clinical trial*
23 control* stud*
24 control* trial*
25 double blind
26 single blind
27 treble blind
28 triple blind
29 double mask*
30 single mask*
31 triple mask*
32 treble mask*
33 explode PLACEBO
34 placebo*
35 random*
36 METHODOLOGY
37 INTERMETHOD COMPARISON
38 TECHNIQUE
39 19,20,21,22,23,24,25,26,2,28,29,30,31,32,33,34,35,36,37,38
40 7+39+(8,9,10,11,12,13,14,15,16,17)
41 40-18
42 COMPARISON
43 comparative stud*
44 evaluati* stud*
45 EVALUATION AND FOLLOW UP
46 FOLLOW UP
47 LONGITUDINAL STUDY

48 PROSPECTIVE STUDY
49 RETROSPECTIVE STUDY
50 COHORT ANALYSIS
51 control*
52 prospectiv*
53 volunteer*
54 PRACTICE GUIDELINE
55 42,43,44,45,46,47,48,49,50,51,52,53,54
56 7+55+(8,9,10,11,12,13,14,15,16,17)
57 56-(40,18)

APPENDIX C

CROS SEARCH

This is conducted over all 60 Biomedical Sciences Databases plus Social Sciences and General Reference on DATASTAR and ranks them according to the number of 'hits'.

Vision and Screening:
- Medline
- Embase
- IAC Health Periodicals
- Biological Abstracts
- Science Citation Index
- PsychLit

Vision and Disability:
- IAC Health Periodicals
- Medline
- Embase
- Science Citation Index
- Biological Abstracts
- PsychLit

Vision and Treatment:
- Medline
- Embase
- IAC Health Periodicals
- Biological Abstracts
- Science Citation Index
- PsychLit

Vision and Screening and Preschool:
- Medline
- Embase
- PsychLit
- IAC Health Periodicals
- Biological Abstracts
- Cinahl
- Science Citation Index

APPENDIX D

STUDIES EXCLUDED FROM THE REVIEW

The reasons for exclusion are given in parentheses at the end of each reference. Subjects (S) , outcome (O) and design (D) refer to the criteria given in section 5.3. Studies excluded on the basis of one of those criteria may also have failed to satisfy one or more of the others but, for most studies, only one reason is stated. Where studies have been rejected for other reasons these are stated. Studies of tests used for screening have been marked (T) - see 8.5.12. Some studies found on disability were suitable only for background reading, for example those reviewing current opinion, and have been marked (B).

Abrahamsson, M., Fabian, G., Andersson, A.K., and Sjostrand, J. A longitudinal study of a population based sample of astigmatic children. I. Refraction and amblyopia. Acta Ophthalmol.Copenh. 1990; 68(4): 428-434. (S)

Abrahamsson, M., Fabian, G., and Sjostrand, J. Changes in astigmatism between the ages of 1 and 4 years: a longitudinal study. *British Journal of* Ophthalmology 1988; 72(2): 145-149. (S)

Abrahamsson, M. and Sjostrand, J. Contrast sensitivity and acuity relationship in strabismic and anisometropic amblyopia. *British Journal of* Ophthalmology 1988; 72: 44-49. (O&D)

Adams, RJ Courage, ML Contrast sensitivity in 24- and 36-month-olds as assessed with the contrast sensitivity card procedure. *Optometry and Vision Science* 1993 70(2): 97-101 ,. (T)

Adoh, T.O., Woodhouse, J.M., and Oduwaiye, K.A. The Cardiff Test: a new visual acuity test for toddlers and children with intellectual impairment. A preliminary report. *Optom.Vis.Sci.* 1992; 69(6): 427-432. (T)

Aichmair, H. and Rubi, E. Objective vision test in very young children (author's transl). *Klin.Monatsbl.Augenheilkd*1976; 169(2): 255-258. (T)

3(6):.735-740 , Allen, SM The effectivity of screening a comparative study of visual screening. *British Orthoptic Journal* 1990; 47: 57-60. (Insufficient data - author contacted but unable to supply the necessary information).

Almeder, L.M., Peck, L.B., and Howland, H.C. Prevalence of anisometropia in volunteer laboratory and school screening populations. *Invest.Ophthalmol.Vis.Sci.* 1990; 31(11): 2448-2455. (Inadequate age breakdown)

Amphlett, M. and Smithson, G. Occlusion and dominance - their effect on amblyopia. *British Orthoptic Journal* 1977; 34. (Inadequate information on ages, & children compared with an adult control group)

Angi, M.R., Baravelli, S., Bergamo, L., and Pucci, V. Screening for amblyogenic refractive defects using manifest autorefractometry in 711 nursery school children. *Bollettino Di Oculistica* 1991; 70: 191-202. (O)

Arnoult, J.B., Yeshurun, O., and Mazow, M.L. Comparative study of the surgical management of congenital esotropia of 50 prism diopter or less. *J.Pediatr.Ophthalmol.* 1976; 13(3): 129-131. (S)

Arthur, B.W., Marshall, A., and McGillivray, D. Worth vs polarized four-dot test. *J.Pediatr.Ophthalmol.Strabismus* 1993; 30(1): 53-55. (T)

Arthur, BW Cake, S Bagolini lenses vs the polarized four-dot test. *Journal of Pediatric Ophthalmology and Strabismus* 1996; 33(2): 98-103. (T)

Assaf, A.A. The sensitive period: transfer of fixation after occlusion for strabismic amblyopia. *British Journal of Ophthalmology* 1982; 66(1): 64-70. (O)

Atkinson, S. and Butler, N.R. Vision problems in under 5's. In *The At-Risk Infant: Psycho/Socio/Medical Aspects* edited by Harel,S. & Anastasiow,N.J. (S& D)

Avilla, CW Von, Noorden, GK Limitation of the TNO random dot stereo test for visual screening. *American Orthoptic* Journal 1981; 31: 87-90. (T)

Awaya, S. Studies of form vision deprivation amblyopia. *Acta Societatis Ophthalmologicae Japonicae* 1987; 91: 519-544. (S & O)

Bacharach, J.-A. Lazy eyes and public vision. *American Journal of Public Health* 1991; 81(12): 1668-1669. (D)

Baker, J.D. and DeYoung Smith, M. Accommodative esotropia following surgical correction of congenital esotropia, frequency and characteristics. *Graefes.Arch.Clin.Exp.Ophthalmol.* 1988; 226(2): 175-177. (D)

Bando, K. The state of amblyopic patients in an eye clinic and visual acuity examinations in Kisiwada City kindergartens and nursery schools. *Folia Ophthalmologica Japonica* 1992; 42: 1263-1268. (D)

Banks, R., Campbell, F.W., Hess, R., and Watson, P.G. A new treatment for amblyopia. *British Orthoptic Journal* 1978; 35. (D)

Baravelli, S., Panozzo, G., Tosi, R., and Tomazzoli, L. Screening methods of amblyopia: Part II. *Bollettino Di Oculistica* 1991; 70: 367-376. (T)

Barry, J.C., Effert, R., Kaupp, A., Kleine, M., and Reim, M. Computer-based detection of small ocular misalignments in toddlers, infants and preschool children through digital Purkinje Reflection Pattern Evaluation. *Ophthalmologe* 1994; 91: 51-61. (T)

Bateman, J.B., Parks, M.M., and Wheeler, N. Discriminant analysis of acquired esotropia surgery. Predictor variables for short- and long-term outcomes. *Ophthalmology.* 1983; 90(10): 1154-1159. (D)

Beardsell, M.R. Audit of outcome - meaningless data or quality of care? *British Orthoptic Journal* 1993; 50. (S)

Beardsell, M.R., Clarke, S., Hill, M. Outcoem of occlusion treatment for amblyopia. Pre-print. (D)

Bedwell, C.H., Grant, R., and McKeown, J.R. Visual and ocular control anomalies in relation to reading difficulty. *British Journal of Educational Psychology* 1980; 50: 61-70. (D)

Bechara, S.J. and Kara Jose, N. Detection and treatment of amblyopic patients in the city of Sao Paulo, Brazil. *Revista De Saude Publica* 1992; 21: 326-330. (D)

Bennet, R., Blondin, M., and Ruskiewicz, J. Incidence and prevalence of selected visual conditions. *J Am Optom Assoc* 1982; 53(8): 647-657. (D)

Berriman, J. and Bradshaw, P. Pilot Orthoptic Screening Study - Harwich & District Hospital, A Twelve Month Study of Orthoptic Referrals. Unpublished data.1995. (S)

Bevan, J Dale, T Kavur, M Preschool visual acuity tests- A comparison between two prototype charts and two visual acuity charts in current use. *Clinical and Experimental Optometry* 1989; 72 (6): 186-193. (T)

Birch, E.E. and Hale, L.A. Criteria for monocular acuity deficit in infancy and early childhood. *Invest.Ophthalmol.Vis.Sci.* 1988; 29(4): 636-643. (T)

Birnbaum, M., Koslowe, K., and Sanet, R. Success in amblyopia therapy as a function of age: a literature survey. *Am J Optom Phys Opt* 1977; 54(5): 269-275. (D)

Bishop, A.M. Vision screening of children: a review of methods and personnel involved within the UK. *Ophthalmic Physiol.Opt.* 1991; 11(1): 3-9. (D)

Blanchard, D.L. Amblyopia patches--a preliminary study. *Yen.Ko.Hsueh.Pao.* 1986; 2(1): 63-4,49. (D)

Borg, G. and Sundmark, E. A comparative study of visual acuity test for children. *Acta Ophthalmol.Copenh.* 1967; 45(1): 105-113. (T)

Bourron Madignier, M., Caprili, J., and Michiels, M. Results of early treatment of functional amblyopia. *Bull.Soc.Ophtalmol.Fr.* 1987; 87(5): 664-667. (S)

Bradford, G.M., Kutschke, P.J., and Scott, W.E. Results of amblyopia therapy in eyes with unilateral structural abnormalities. *Ophthalmology* 1992; 99: 1616-1621. (D)

Brady, F.B. A singular view:the art of seeing with one eye.Anonymous Anonymous Annepolis:Brady,FB. 5th, 1994. (O - on the loss of an eye)

Brant, J.C. and Nowotny, M. Testing of visual acuity in young children: an evaluation of some commonly used methods. *Dev.Med.Child Neurol.* 1976; 18(5): 568-576. (T)

Bremner, M.H. Visual acuity in the primary school child aged four to twelve years: a review of amblyopia treatment in this age group at Princess Margaret Hospital. *Aus J Opth* 1984; 12: 395-399. (D)

Bremner, M.H. The use of spectacles in the treatment of congenital esotropia and amblyopia – a financial hazard. *Aust.N.Z.J.Ophthalmol.* 1990; 18(2): 191-195. (O)

Broadbent, H. and Westall, C. An evaluation of techniques for measuring stereopsis in infants and young children. *Ophthalmic Physiol.Opt.* 1990; 10(1): 3-7. (T)

Brovarone, F.V., Fea, A., Chiado Piat, L., Porro, G., Ponzetto, M., and Cortassa, F. Preferential looking techniques yield important information in strabismic amblyopia follow-up. *Doc.Ophthalmol.* 1993; 83(4): 307-312. (S)

Brown, V.A., Doran, R.M., and Woodhouse, J.M. The use of computerized contrast sensitivity, Arden gratings and low contrast letter charts in the assessment of amblyopia. *Ophthalmic Physiol.Opt.* 1987; 7(1): 43-51. (T)

Brown, V.A. and Woodhouse, J.M. Assessment of techniques for measuring contrast sensitivity in children. *Ophthalmic Physiol.Opt.* 1986; 6(2): 165-170. (T)

Calcutt, C. Indication for the use of contact lenses in the amblyopic and strabismic infant. *British Orthoptic Journal* 1983. (S)

Campos, E.C. Update on strabismus and amblyopia. *Acta Ophthalmologica Scandinavica* 1995; 73: 17-24. (D)

Campos, E.C., Schiavi, C., Benedetti, P., Bolzani, R., and Porciatti, V. Effect of citicoline on visual acuity in amblyopia: preliminary results. *Graefes.Arch.Clin.Exp.Ophthalmol.* 1995; 233(5): 307-312. (S)

Carlentini, S., Toschi, P.G., Conci, P., Signori, D., and Cappello, E. Evaluation of reeducation treatment of amblyopia with red light flicker stimulator. *Annali Di Ottalmologia E Clinica Oculistica* 1992; 118:73-76. (D)

Carruthers, J.D., Pratt Johnson, J.A., and Tillson, G. A pilot study of children with amblyopia treated by the gratings method. *British Journal of Ophthalmology.* 1980; 64(5): 342-344. (D)

Carta, A., Pinna, A., Aini, M.A., Carta, A.,Jr., and Carta, F. Intermittent exotropia: evaluation of results on the basis of different treatments. *J.Fr.Ophtalmol.* 1994; 17(3): 161-166. (S)

Catford, G.V. Amblyopic occlusion: the results of treatment. *Trans.Ophthalmol.Soc.U.K.* 1967; 87: 179-193. (S&D)

Catford, J., Absolon, M., and Millo, A. Squints - a sideways look. In: *Progress in Child Health*, edited by Macfarlane, J. 1984; 38-50. (D)

Chan, O.Y.C. and Edwards, M. Refraction referral criteria for Hong Kong Chinese preschool children. *Ophthalmic and Physiological Optics* 1994; 14: 249-256. (O)

Chen, J.P., Xiong, D.H., and Song, W.X. Prediction of curative effect of amblyopia by laser interference fringe visual acuity. *Chung.Hua.Yen.Ko.Tsa.Chih.* 1994; 30(4): 283-285. (D)

Chuman, Y., Ryu, E., Yugo, S., and Kato, K. Visual screening of three-year old children in Tatsukuchi (Japan). *Folia Ophthalmologica Japonica* 1990; 40: 772-775. (T)

Cibis, L. Penalization, treatment of ARC and amblyopia. *Am.Orthopt.J.* 1975; 25: 79-84. (D)

Ciner, E.B., SchanelKlitsch, E., and Herzberg, C. Stereoacuity development- 6 months to 5 years. A new tool for testing and screening. *Optometry and Vision Science* 1996; 73(1): 43-48. (T)

Ciuffreda, K.J., Goldner, K., and Connelly, R. Lack of positive results of a physiologically based treatment of amblyopia. *British Journal of Ophthalmology* 1980; 64(8): 607-612. (S)

Ciuffreda, K.J., Hokoda, S.C., Hung, G.K., Semmlow, J.L., and Selenow, A. Static aspects of accommodation in human amblyopia. *Am.J.Optom.Physiol.Opt.* 1983; 60(6): 436-449. (O & D)

Clarke, W.N. and Noel, L.P. Amblyopia and the monofixation syndrome. *Can.J.Ophthalmol.* 1979; 14(4): 239-242. (D)

Clarke, W.N., and Noel, L.P. Prognostic indicators for avoiding occlusion therapy in anisometropic amblyopia. *Am.Orthopt.J. 1990* 1990; 40: 57-63. (S)

Cooper, E.L. and Leyman, I.A. The management of intermittent exotropia: a comparison of the results of surgical and nonsurgical treatment. *Am.Orthopt.J.* 1977; 27: 61-67. (S - no details of ages)

Cooper, J., Feldman, J., and Medlin, D. Comparing stereoscopic performance of children using the Titmus, TNO, and Randot stereo tests. *J.Am.Optom.Assoc.* 1979; 50(7): 821-825. (T)

Coulehan, J.L. Screening yield in an urban low income practice. *Am.J.Public Health* 1975; 65(5): 474-479. (O, little on vision)

Dana, M.R., Tielsch, J.M., Enger, C., Joyce, E., Santoli, J.M., and Taylor, H.R. Visual impairment in a rural Appalachian community: prevalence and causes. *Jama* 1985; 264: 2400-2405. (S)

De Becker, I., Macpherson, H.J., Laroche, G.R., Braunstein, J., Cottle, R., Mcintyre, L.L., and Kozousek, V. Negative predictive value of a population-based preschool vision screening program. *Ophthalmology.* 1992; 99(6): 998-1003. (S)

De Vries, J. Anisometropia in children: analysis of a hospital population. *British Journal of Ophthalmology* 1985; 69: 504-507. (S)

Denis, D., Bardot, J., Volot, F., Saracco, J.B., and Maumenee, I.H. Effects of strabismus surgery on refraction in children. *Ophthalmologica* 1996; 209: 136-140. (S)

Dholakia, S. The application of a comprehensive visual screening program to children aged 3-5 years: Can a modified procedure be devised for visual screening by ancillary staff? *Ophthalmic & Physiological Optics* 1988; 7: 469-476. (O)

Dobson, V Luna, B Prototype and teller acuity cards yield similar acuities in infants and young children despite stimulus differences. *Clinical Vision Sciences, 1993,* 1993; 8, (5): 395-400. (T)

Doran, R. Assessment of vision in amblyopia. *Trans. Opth. Soc. UK* 1986; 105: 699-704. (T)

Dortmans, R.J., Mckenny, B.S., and Gole, G.A. Eccentric photorefraction: improving the predictive value and yield in detection of refractive errors. *Aust.N.Z.J.Ophthalmol.* 1989; 17(4): 417-425. (T)

Effert, R., Jansen, W., Broichhagen, S., Rau, G., and Reim, M. Measurement of visual acuity in children. *Klinische Monatsblaetter fuer Augenheilkunde* 1992; 199: 415-418. (T)

Egan, D.F. and Brown, R. Vision testing of young children in the age range 18 months to 4.5 years. *Child Care Health And Development* 1984; 10: 381-390. (T)

Eggers, H. Current state of therapy for amblyopia. *Trans. Opth. Soc. UK* 1979; 99: 457-459. (D)

Ehrlich, M.I., Reinecke, R.D., and Simons, K. Preschool vision screening for amblyopia and strabismus. Programs, methods, guidelines, 1983. *Surv.Ophthalmol.* 1983; 28(3): 145-163. (O & D)

Eibschitz, N., Friedman, Z., and Neumann, E. Comparative results of amblyopia treatment. *Opthalmic Opthalmology* 1978; 2: 111-112. (S)

Elder, MJ Occlusion therapy for strabismic amblyopia. *Australian and New Zealand Journal of Ophthalmology* 1994; 22(3): 187-191. (D)

Elliott, R. A new linear picture test. *British Orthoptic Journal* 1985; 42. (T)

Elliott, DB Whitaker, D Clinical contrast sensitivity chart evaluation. *Ophthalmic and Physiological Optics,* 1992; 12(.3): 275-280. (T)

Elsas, T. Anisohypermetropic amblyopia: results of treatment. *Tidsskrift For Den Norske Laegeforening* 1987; 107: 839-840. (D)

Elston, J. Strabismus in childhood. *Br J Hosp. Med.* 1985; 34(1): 8-12. (D)

Endo, M. / The treatment of childhood psychogenic amblyopia using fantastic stories. *Japanese Journal of Child and Adolescent Psychiatry* 1983; 24(5): 354-363. (D)

Esaki, H. and Oono, S. Treatment of eccentric fixation via inverse prism. *Folia Ophthalmologica Japonica* 1991; 41: 1479-1486. (D)

Essman, S.W., and Essman, T.F. Screening for pediatric eye disease. *American Family Physician* 1992; 46(4): 1243-1452. (D)

Etting, G.L. Strabismus therapy in private practice: Cure rates after three months of therapy. *J.Am.Optom.Assoc.* 1978; 49(12): 1367-1373. (D)

Eustis, H., Chamberlain, D. Treatment for amblyopia: results using occlusive contact lens. *J.Pediatr.Ophthalmol.Strabismus* 1996; 33: 319-322. (D)

Everhard-Halm, Y. and Maillette be Buy Wenninger-Prick, L. Amblyopia treatment in microstrabismus. *Br Orthoptic J* 1989; 46: 109-111. (D)

Fariza, E., Kronheim, J., Medina, A., and Katsumi, O. Testing visual acuity of children using vanishing optotypes. *Jpn.J.Ophthalmol.* 1990; 34(3): 314-319. (T)

Ferguson, J., Goldacre, M., Henderson, J., and Bron, A. Opthalmology in the Oxford Region: analysis of time trends from linked statistics. *Eye* 1991; 5: 379-384. (S & O)

Fern, K. and Manny, R. Visual acuity of the preschool child: a review. *Am J Optom Physiol Opt* 1986; 63(5): 319-345. (T)

Fischbach, L.A., Lee, D.A., Englehardt, R.F., and Wheeler, N. The prevalence of ocular disorders among Hispanic and Caucasian children screened by the UCLA Mobile Eye Clinic. *J.Community.Health* 1993; 18(4): 201-211. (S)

Flabetich, Dickey, C Scott, WE The deterioration of accommodative esotropia- frequency, characteristics, and predictive factors. *Journal of Pediatric Ophthalmology and Strabismus* 1988; 25(4): 172-175. (D)

Flax, N. The treatment of strabismus in the four to ten year old child. Special Issue: The health and physical well-being of children. *Child and Adolescent Social Work Journal* 1993; 10(5): 411-416. (D)

Fletcher, M.C. Natural history of strabismus. A resume. *Ann.Ophthalmol.* 1971; 3(5): 503-505. (D)

Fowler, M.S., Mason, A.J., Richardson, A., and Stein, J.F. Yellow spectacles to improve vision in children with binocular amblyopia *The Lancet* 1991; 338(8775): 1109-1110. (D)

Fowler, M.S., Richardson, A., Mason, M., and Stein, J. Bilateral amblyopia in children can be improved by yellow filters. *British Orthoptic Journal* 1992; 49. (D)

France, T.D. and France, L.W. Low-contrast visual activity cards in pediatric ophthalmology. *Graefe'S Archive For Clinical And Experimental Ophthalmology* 1986; 226: 158-160. (T)

Franceschetti, A., Donati, G., Jeanneret, O., and Hazeghi, H. Lang stereotest for screening in kindergarten. *Klinische Monatsblaetter fuer Augenheilkunde* 1994; 204: 363-365. (T)

Frantz, K.A., Cotter, S.A., and Wick, B. Re-evaluation of the four prism diopter base-out test. *Optom.Vis.Sci.* 1992; 69(10): 777-786. (T)

Freedman, H.L. and Preston, K.L. Polaroid photoscreening for amblyogenic factors. An improved methodology. *Ophthalmology.* 1992; 99(12): 1785-1795. (T)

Freeman, RS Isenberg, SJ The use of part-time occlusion for early onset unilateral exotropia. *J.Pediatr. Ophthalmol. Strabismus* 1989; 26(2): 94-96. (D)

Fricker, S.J., Kuperwaser, M.C., Stromberg, A.E., and Goldman, S.G. Use of a video-game/stripe presentation for amblyopia therapy. *J.Pediatr.Ophthalmol.Strabismus* 1981; 18(2): 11-16. (S)

Fricker, S.J., Kuperwaser, M.C., Stromberg, A.E., and Goldman, S.G. Stripe therapy for amblyopia with a modified television game. *Arch.Ophthalmol.* 1981; 99(9): 1596-1599. (S)

Friendly, D.S. Preschool visual acuity screening tests. *Trans.Am.Ophthalmol.Soc.* 1978; 76: 383-480. (T)

Friendly, D.S., Jaafar, M.S., and Morillo, D.L. A comparative study of grating and recognition visual acuity testing in children with anisometropic amblyopia without strabismus. *Am.J.Ophthalmol.* 1990; 110(3): 293-299. (T)

Friendly, D.S., Weiss, I.P., Barnet, A.B., Saumweber, R., and Walker, J.A. Pattern-reversal visual-evoked potentials in the diagnosis of amblyopia in children. *American Journal Of Ophthalmology* 1985; 102: 329-339. (T)

Frisby, J.P. Random-dot stereograms for clinical assessment of stereopsis in children. *Developmental Medicine And Child Neurology* 1975; 17(6): 802-806. (T)

Fukushima, M., Masaki, Y., and Tsutsui, J. Clinical application of visually evoked saccadic reaction time (V-SRT) in the occlusion therapy of anisometropic amblyopia. *Acta Societatis Ophthalmologicae Japonicae* 1987; 91: 420-424. (O & S)

Fulton, A.B. and Mayer, D.L. Esotropic children with amblyopia: effects of patching on acuity. *Graefe'S Archive For Clinical And Experimental Ophthalmology* 1988; 226: 309-312. (D)

Galassi, F., Lenzetti, I., and Maggiori, F. The treatment of the amblyopia with Buridano sectors. *Bollettino Di Oculistica* 1996; 64: 827-832. (D)

Garzia, R.P. and Nicholson, S.B. Visual function and reading disability: an optometric viewpoint. *Journal of the American Optometric Association* 1990; 61(2): 88-97. (D)

Garzia, R.P. Efficacy of vision therapy in amblyopia: a literature review. *Am J Optom Physiol Opt* 1987; 64(6): 393-404. (D)

Getz, LM Dobson, V Luna, B Mash, C Interobserver reliability of the Teller Acuity Card procedure in pediatric patients. *Investigative Ophthalmology and Visual Science* 1996; 37(1): 180-187. (T)

Giardini, P. and Bellucci, R. Late treatment of neglected amblyopia. *Bollettino Di Oculistica* 1989; 68: 167-174. (D)

Giaschi, D.E., Regan, D., Kraft, S.P., and Kothe, A.C. Crowding and contrast in amblyopia. *Optometry And Vision Science* 1993; 70: 192-197. (S & O)

Gofin, R. and Falk, M. Comparison of the automated vision screening test to the Snellen test. *Public Health* 1991; 105(2): 139-144. (T)

Gole, GA Douglas, LM Validity of the Bruckner reflex in the detection of amblyopia. *Australian and New Zealand Journal of Ophthalmology* 1995; 23(4): 281-285. (T)

Gonzalez, C. and Jaros, P.A. Strabismus surgery on the nonamblyopic eye. *Graefes.Arch.Clin.Exp.Ophthalmol.* 1988; 226(4): 304-308. (D)

Gottfried, A.W. and Gilman, G. Visual skills and intellectual development: A relationship in young children. *Journal of the American Optometric Association* 1985; 56(7): 550-555. (S)

Gottlob, I., Charlier, J., and Reinecke, R.D. Visual acuities and scotomas after one week Levodopa administration in human amblyopia. *Investigative Ophthalmology & Visual Science* 1992; 33(9): 2722-2728. (S)

Graef, M. and Dietrich, H. Objective Vernier acuity testing of adults, children, and infants. *Klinische Monatsblaetter fuer Augenheilkunde* 1994; 204: 98-104. (T)

Graham, P. Epidemiology of strabismus. *BJO* 1974; 58: 224-231. (S)

Greene, E. Cyclic esotropia. *Journal of the American Optometric Association* 1974; (6): 737-740. (D)

Gruber, J., Dickey, P., and Rosner, J. Comparison of a modified (two-item) Frisby with the standard Frisby and Random-Dot E stereotests when used with preschool children. *Am.J.Optom.Physiol.Opt.* 1985; 62(5): 349-351. (T)

Gwiazda, J., Thorn, F., Bauer, J., and Held, R. Emmetropization and the progression of manifest refraction in children followed from infancy to puberty. *Clinical Vision Science* 1993; 8(4): 337-344. (Some children were given spectacles, so no good for natural history)

Gwiazda, JE Detection of amblyopia and development of binocular vision in infants and children. *Current Opinion in Ophthalmology.* 1992; 3(6): 735-740. (S)

Hacker, HD, O.H. Flotation devices to facilitate amblyopia therapy. *American Journal of Ophthalmology* 1991; 111(1): 110-111. (D)

Hadaway, E., Ingram, R.M., and Traynar, M. Day case surgery for strabismus in children. *Trans Opth Soc UK* 1977; 97: 23-25. (D)

Hagan, M.C. and Dinning, W.J. Day case strabismus surgery without post-operative ocular medication. A masked randomised study. *Eye* 1987; 1(Pt 5): 581-584. (S)

Hammond, R.S. and Schmidt, P.P. A Random Dot E stereogram for the vision screening of children. *Arch.Ophthalmol.* 1986; 104(1): 54-60. (T)

Hardesty, H.H., Boynton, J.R., and Keenan, J.P. Treatment of intermittent exotropia. *Arch.Ophthalmol.* 1978; 96(2): 268-274. (D)

Hardman Lea, S.J., Snead, M.P., Loades, J., and Rubinstein, M.P. Microtropia versus bifoveal fixation in anisometropic amblyopia. *Eye* 1993; 5: 576-584. (D)

Harris, S.J., Hansen, R.M., and Fulton, A.B. Assessment of acuity of amblyopic subjects using face, grating, and recognition stimuli. *Investigative Ophthalmology & Visual Science* 1986; 27: 1184-1187. (T)

Hartman, D.K. CAM vision stimulator; a controlled study. *N.Y.State.J.Med.* 1982; 82(5): 723-724. (S)

Harvey, E.M., Miller, J.M., and Dobson, V. Reproducibility of corneal astigmatism measurements with a hand held keratometer in preschool children. *Br.J.Ophthalmol.* 1995; 79(11): 983-990. (T)

Hatch, S.W. and Laudon, R. Sensitive period in stereopsis: random dot stereopsis after long-standing strabismus. *Optom.Vis.Sci.* 1993; 70(12): 1061-1064. (D)

Hatch, S.W. and Richman, J.E. Stereopsis testing without polarized glasses: a comparison study on five new stereoacuity tests. *J.Am.Optom.Assoc.* 1994; 65(9): 637-641. (T)

Hatsukawa, Y. Some clinical problems in the treatment of amblyopia. *Folia Ophthalmologica Japonica* 1996; 42: 1279-1284. (D)

Haugen, O.H. and Stole, M.P. The results of surgical treatment for concomitant strabismus in children less than 15 years of age. *Tidsskrift For Den Norske Laegeforening* 1995; 115: 600-603. (D)

Hazell, C. Evaluation of the cardiff acuity test in uniocular amblyopia. *British Orthoptic Journal* 1995; 52. (T)

Henc Petrinovic, L., Deban, N., Gabric, N., and Petrinovic, J. Prognostic value of visual evoked responses in childhood amblyopia. *Eur.J.Ophthalmol.* 1993; 3(3): 114-120. (S)

Hiatt, R.L. Medical management of accommodative esotropia. *J.Pediatr.Ophthalmol.Strabismus* 1983; 20(5): 199-201, (D)

Hiatt, R.L., Ringer, C., and Cope Troupe, C. Miotics vs glasses in esodeviation. *J.Pediatr.Ophthalmol.Strabismus* 1979: 16(4): 213-217. (S)

Hillis, A., Flynn, J., and Hawkins, B. The evolving concept of amblyopia: a challenge to epidemiologists. *Am J Epidemiology* 1983; 118(2): 192-205. (D)

Hilton, A.F. and Stanley, J.C. Pitfalls in testing children's vision by the Sheridan Gardiner single optotype method. *British Journal of Ophthalmology.* 1972; 56(2): 135-139. (T)

Hiscox, F., Strong, N., Thompson, J.R., Minshull, C., and Woodruff, G. Occlusion for amblyopia: A comprehensive survey of outcome. *Eye* 1992; 6: 300-304. (D)

Hodes, D.T., Sonksen, P.M., and McKee, M. Evaluation of the Sonksen picture test for detection of minor visual problems in the surveillance of preschool children. *Dev.Med.Child Neurol.* 1994; 36(1): 16-25. (T)

Hohmann, A. and Creutzfeldt, O.D. Squint and the development of binocularity in humans. *Nature* 1975; 254(5501): 613-614. (S & D)

Hohmann, A. and Haase, W. Effective visual screening can lower rate of amblyopia. *Ophthalmologe* 1993; 90: 2-5. (T)

Hokoda, S.C. and Ciuffreda, K.J. Different rates and amounts of vision function recovery during orthoptic therapy in an older strabismic amblyope. *Ophthalmic and Physiological Optics* 1986; 6(2): 213-220. (D)

Hope, C. and Maslin, K. Random dot stereogram E in vision screening of children *Aust.N.Z.J.Ophthalmol.* 1990; 18(3): 319-324. (T)

Hopkisson, B. and Clarke, J. Residual amblyopia in recruits to the British Army. *BMJ* 1982; 285: 940. (S & D)

Horwood, A. The Cardiff acuity test in amblyopic children. *British Orthoptic Journal* 1994; 51. (T)

Hotsubo, M., Kii, T., Umemoto, T., Ogasawara, K., Ohba, M., and Nakagawa, T. Visual outcome of microtropic amblyopia. *Folia Ophthalmologica Japonica* 1989; 42: 273-277. (D)

Houghton, S. The use of optical penalization in the treatment of amblyopia. *British Orthoptic Journal* 1976; 33. (D)

Howland, H.C. and Sayles, N. Photokeratometric and photorefractive measurements of astigmatism in infants and young children. *Vision Research* 1985; 25: 73-82. (T)

Hulme, C. The implausibility of low-level visual deficits as a cause of children's reading difficulties. *Cognitive Neuropsychology* 1988; 5(3): 369-374. (B)

Hunold, W., Auffarth, G., and Effert, R. Clinical application of the Canon R 10 autorefractor in children with squint. *Klinische Monatsblaetter fuer Augenheilkunde* 1988; 192: 58-65. (T)

Ingram, R.M. The problem of screening children for visual defects. *British Journal of Ophthalmology* 1977; 61: 4-7. (S)

Ingram, R.M. Amblyopia: the need for a new approach? *BJO* 1979; 63: 236-237. 164. (D)

Ingram, R.M., Arnold, P.E., Dally, S., and Lucas, J. Emmetropisation, squint, and reduced visual acuity after treatment. *Br.J.Ophthalmol.* 1991; 75(7): 414-416. (S)

Ingram, R.M. and Walker, C. Occlusion and amblyopia. *British Orthoptic Journal* 1977; 34. (D)

Ingram, R.M., Walker, C., Billingham, B., Lucas, J., and Dally, S. Factors relating to visual acuity in children who have been treated for convergent squint. *British Journal of Ophthalmology* 1990; 74: 82-83. (D)

Ingram, R.M., Walker, C., Wilson, J.M., Arnold, P.E., Lucas, J., and Dally, S. A first attempt to prevent amblyopia and squint by spectacle correction of abnormal refractions from age 1 year. *British Journal of Ophthalmology* 1985; 69(11): 851-853. (S)

Ismail, H. and Lall, P. Visual acuity of school entrants. *Child Care, Health and Development* 1981, 7(3): 127-134. (Only discusses acuity, not the different conditions)

Jackson, G.R., Jessup, N.S., Kavanaugh, B.L., Moats, V.L., Daum, K.M., Marsh Tootle, W.L., and Rutstein, R.P. Measuring visual acuity in children using preferential looking and sine wave cards. *Optom.Vis.Sci.* 1990; 67(8): 590-594. (T)

Jacob, J.L., Milot, J., Beaulieu, Y., and Brunet, E. Preschool vision testing with a new device, the Scolatest. *Can.J.Ophthalmol.* 1988; 23(4): 159-163. (T)

Jones, H. Reliability of Vision Tests.Leicester. , 1991. MSc Medical Statistics & Information Technology. (T)

Jones, J.C., Batchelor, L., Gordon, N., and West, M. The preschool medical: An evaluation of this examination and its role in child health surveillance. *Child Care, Health and Development* 1989; 15(6): 425-434. (O, only a little on vision)

Kaakinen, K. Photographic screening for strabismus and high refractive errors of children aged 1-4 years. *Acta Ophthalmol.Copenh.* 1981; 59(1): 38-44. (T)

Kaakinen, K., Kaseva, H., and Kause, E.R. Mass screening of children for strabismus or ametropia with two-flash photoskiascopy. *Acta Ophthalmol.Copenh.* 1986; 64(1): 105-110. (T)

Kaakinen, K. and Tommila, V. A clinical study on the detection of strabismus, anisometropia or ametropia of children by simultaneous photography of the corneal and the fundus reflexes. *Acta Ophthalmol.Copenh.* 1979; 57(4): 600-611. (T)

Kaban, T., Smith, K., Beldavs, R., Cadera, W., and Orton, R.B. The 20-prism-dioptre base-out test: an indicator of peripheral binocularity. *Canadian Journal Of Ophthalmology* 1996; 30: 247-250. (T)

Kanda, T., Kawase, Y., Mizutani, N., and Noda, C. Ophthalmological screening in the health check program for low-age children. *Japanese Journal Of Clinical Ophthalmology* 1987; 40: 1275-1278. (S)

Kanda, T., Kawase, Y., and Uchida, N. Strabismus screening in the health check of 3-year-old children: 2. Long-term visual prognosis. *Japanese Journal Of Clinical Ophthalmology* 1985; 38: 1275-1279. (D)

Kanda, T., Kawase, Y., and Uchida, N. Screening of visual function in health program of 3-year-old children: 3. *Japanese Journal Of Clinical Ophthalmology* 1985; 38: 993-997. (O)

Kastenbaum, S.M., Kepford, K.L., and Holmstrom, E.T. Comparison of the STYCAR and lighthouse acuity tests. *Am.J.Optom.Physiol.Opt.* 1977; 54(7): 458-463. (T)

Katsumi, O., Hirose, T., Okuno, H., and Miyanaga, Y. Grating discs: a simplified method of testing vision in infants and young children. *Acta Ophthalmol.Copenh.* 1990; 68(3): 253-258. (T)

Kearns, P.P. and Cullen, J.F. Fucithalmic, chloramphenicol or no treatment after squint surgery in children. A single blind randomised study. *Acta Ophthalmol.Copenh.* 1992; 70(1): 132-134. (S)

Keech, R.V. and Kutschke, P.J. The gradient filter test to assess amblyopia. *American Journal Of Ophthalmology* 1991; 110: 57-61. (T)

Keech, RV Stewart, SA The surgical overcorrection of intermittent exotropia. *Journal of Pediatric Ophthalmology and Strabismus* 1990; 27(4): 218-220. (S)

Keenan, J.M. and Willshaw, H.E. The outcome of strabismus surgery in childhood esotropia. *Eye* 1993; 7: 341-345. (D)

Keith, C.G., Diamond, Z., and Stansfield, A. Visual acuity testing in young children. *British Journal of Ophthalmology.* 1972; 56(11): 827-832. (T)

Kendall, J., Stayte, M., and Wortham, C. Ocular defects in children from birth to 6 years. *British Orthoptic Journal* 1989: 46. (D)

Kennedy, R., Sheps, S.B., and Bagaric, D. Field trial of the Otago photoscreener. *Can.J.Ophthalmol.* 1995; 30(4): 193-197. (T)

Kennedy, R.A. and Sheps, S.B. A comparison of photoscreening techniques for amblyogenic factors in children. *Can.J.Ophthalmol.* 1989; 24(6): 259-264. (T)

Keys, M.P. and Silver, L.B. Learning disabilities and vision problems: are they related? *Pediatrician* 19901 17(3): 194-201. (B)

Kishishita, H., Kawamura, M., Takeuchi, K., Yazawa, K., and Hayakawa, Y. Visual acuity screening for 3-year-old children by home eye test chart. *Japanese Journal Of Clinical Ophthalmology* 1988; 41: 1117-1120. (T)

Kivlin, J.D. and Flynn, J.T. Therapy of anisometropic amblyopia. *J.Pediatr.Ophthalmol.Strabismus* 1981; 18(5): 47-56. (D)

Konstantinovskaia, K.E. and Gerbenko, V.P. Results of treatment of dysbinocular amblyopia in the immediate and remote periods. *Oftalmol.Zh.* 1975; 30(2): 151-153. (D)

Kornder, L.D., Nursey, J.N., Pratt Johnson, J.A., and Beattie, A. Detection of manifest strabismus in young children. 2. A retrospective study. *Am.J.Ophthalmol.* 1974; 77(2): 211-214. (S)

Koskela, P.U. Contrast sensitivity in amblyopia I. Changes during CAM treatment. *Acta Ophthalmologica* 1986; 64: 344-351. (S)

Koskela, P.U. Contrast sensitivity in amblyopia: II. Changes during pleoptic treatment. *Acta Ophthalmologica* 1986; 64: 563-569. (S)

Koskela, P.U. and Hyvarinen, L. Contrast sensitivity in amblyopia: IV. Assessment of vision using vertical and horizontal gratings and optotypes at different contrast levels. *Acta Ophthalmologica* 1986; 64: 570-577. (T)

Koskela, P.U. and Hyvarinen, L. Contrast sensitivity in amblyopia: III. Effect of occlusion. *Acta Ophthalmologica* 1986; 64: 386-390. (S)

Koskela, P.U., Mikkola, T., and Laatikainen, L. Permanent results of pleoptic treatment. *Acta Ophthalmologica* 1991; 69: 39-44. (D)

Kragha, I.K. The distribution of refractive errors in Nigeria. *Ophthalmic Physiol.Opt.* 1987; 7(3): 241-244. (S)

Kubota, N. and Usui, C. The development of occlusion amblyopia following atropine therapy for strabismic amblyopia. *Nippon Ganka Gakkai Zasshi* 1996; 97: 763-768. (D)

Kushner, B.J. Partly accommodative esotropia. Should you overcorrect and cut the plus? *Arch.Ophthalmol.* 1995; 113(12): 1530-1534. (S)

Kushner, B.J., Lucchese, N.J., and Morton, G.V. Grating visual acuity with Teller cards compared with Snellen visual acuity in literate patients. *Arch.Ophthalmol.* 1995; 113(4): 485-493. (T)

Kushner, B.J., Preslan, M.W., and Morton, G.V. Treatment of partly accommodative esotropia with a high accommodative convergence-accommodation ratio. *Arch.Ophthalmol.* 1987; 105(6): 815-818. (S)

Kushner, BJ Fisher, MR Lucchese, NJ Morton, GV Factors influencing response to strabismus surgery. *Archives Of Ophthalmology* 1993; 111: 75-79. (D)

Kusube, T., Matsumoto, F., Wakayama, A., Nakamura, H., and Otori, T. Visual acuity of amblyopic patients tested under binocular condition. *Folia Ophthalmologica Japonica* 1989; 41: 731-733. (T)

Lam, G.C., Repka, M.X., and Guyton, D.L. Timing of amblyopia therapy relative to strabismus surgery. *Ophthalmology* 1993; 100: 1751-1756. (S)

Lang, J. The two-pencil test and the new Lang test. *B Orthoptic J* 1984; 41. (T)

Lange, W. De, and Decker, W. Two therapeutic concepts in intermittent divergent squint. *Documenta Ophthalmologica* 1993; 84(2): 187-200. (D)

Lang,J.I. and Lang, T.J. Eye screening with the Lang Stereotest. *American Orthoptic Journal,* 1988; 38: 48-50. (T)

Larson, M.R. Comprehensive vision screening program: Illinois' approach. *J.Am.Optom.Assoc.* 1988; 59(1): 26-30. (O & D)

Lea, S.J.H., Loades, J., and Rubinstein, M.P. The sensitive period for anisometropic amblyopia. *Eye* 1989; 3: 783-790. (D)

Leardi, E., Bonacini, M., and Nuzzi, G. The "Binocular Polaroid Test" in large scale screening for sensorial disturbances in pre-school age children. *Annali Di Ottalmologia E Clinica Oculistica* 1986; 111: 1113-1117. (T)

Leguire, L., Rogers, G., Bremer, D., and Walson, P. Double masked placebo controlled randomized trial for childhood amblyopia. *Investigative Opthalmology & Vis.Sci.* 1993; 33(4): 1337. (D - poster)

Leguire, L., Walson, P., Rogers, G., Bremer, D., and McGregor Levodopa carbidopa treatment for amblyopia in older children. *J Ped.Opthalmol.& Strabismus* 1995; 32(3): 143-151. (S)

Leguire, LE Suh, S Rogers, GL Bremer, DL SKILL card results in amblyopic children. *Journal of Pediatric Ophthalmology and Strabismus, 1994,* 1993; 31(4): 256-261. (T)

Lehmkuhle, S., Garzia, R.P., Turner, L., Hash, T., and Baro, J.A. A defective visual pathway in children with reading disability. *The New England Journal of Medicine* 1993; 328(14): 989-996. (B - this only looks for an association)

Leicester RI Trust, O.D. Screening Referrals - A Clinical Audit. 1995 (unpublished).(S)

Lennerstrand, G. and Gallo, J.E. Prevalence of refractive errors and ocular motility disorders in 5- to 10-year-old Swedish children born prematurely or at full-term. *Acta Ophthalmol.Copenh.* 1989; 67(6): 717-718. (S)

Lennerstrand, G., Jakobsson, P., and Kvarnstrom, G. Screening for ocular dysfunction in children: Approaching a common program. *Acta Ophthalmologica Scandinavica* 1995; 73: 26-38. (D)

Lennerstrand, G., Kvarnstrom, G., Lundh, B.L., and Wranne, K. Effects of grating stimulation on visual acuity in amblyopia. *Acta Ophthalmol.Copenh.* 1981; 59(2): 179-188. (D)

Lennerstrand, G. and Ygge, J. Dyslexia; ophthalmological aspects 1991. *Acta Ophthalmol.Copenh.* 1992; 70(1): 3-13. (B)

Lewis, R.C. and Marsh Tootle, W.L. The reliability of interpretation of photoscreening results with the off PS-100 in Headstart preschool children. *J.Am.Optom.Assoc.* 1995; 66(7): 429-434. (T)

Lewis, TL Reed, MJ Maurer, D Wyngaarden, PA Brent, HP An evaluation of acuity card procedures. *Clinical Vision Sciences.* 1993; 8(6): 591-602. (T)

Lippmann, O. Vision screening of young children. *Am.J.Public Health* 1971; 61(8): 1586-1601. (T)

Lippmann, O. Choice of preschool vision test. *Eye Ear.Nose.Throat.Mon.* 1974; 53(5): 195-199. (T)

Lipton, J.R. and Willshaw, H.E. Prospective multicentre study of the accuracy of surgery for horizontal strabismus.. *British Journal of Ophthalmology* 1995; 79(1): 10-11. (S - no information on ages)

Lithander, J. and Sjostrand, J. Anisometropic and strabismic amblyopia in the age group 2 years and above: a prospective study of the results of treatment.. *British Journal of Ophthalmology.* 1991; 75(2): 111-116. (S & D)

Loeffler, M., Wise, J.S., and Gans, M. Contrast sensitivity letter charts as a test of visual function in amblyopia *J.Pediatr.Ophthalmol.Strabismus* 1990; 27(1): 28-31. (T)

Lovegrove, W., Martin, F., and Slaghuis, W. A theoretical and experimental case for a visual deficit in specific reading disability. *Cognitive Neuropsychology* 1986; 3(2): 225-267. (B)

Ludlam, W.M. The care of amblyopia in the four to ten year old child. Special Issue: The health and physical well-being of children. *Child and Adolescent Social Work Journal* 1993; 10(5): 417-430. (D)

Lundh, B.L. Two years' clinical experience with the preferential looking technique for visual acuity determination in infants and young children. *Acta Ophthalmologica* 1986; 64: 674-680. (T)

Lundh, B.L. and Lennerstrand, G. Effects of amblyopia therapy on contrast sensitivity as reflected in the visuogram. *Acta Ophthalmol.Copenh.* 1983; 61(3): 431-446. (S & O)

Mackie, R. Visual Assessment of Children with, or at Risk of, Neurological Impairment.Glasgow Caledonian University. , PhD thesis, 1995. (T)

MacLellan, A. First catch your squint... *B Orthoptic J* 1979; 36. (D)

Malik, S.R., Virdi, P.S., and Goel, B.K. Follow-up results of occlusion and pleoptic treatment. *Acta Ophthalmol.Copenh.* 1975; 53(4): 620-626. (D)

Mantyjarvi, M.I., Autere, M.H., Silvennoinen, A.M., and Myohanen, T. Observations on the use of three different contrast sensitivity tests in children and young adults. *J.Pediatr.Ophthalmol.Strabismus* 1989; 26(3): 113-119. (T)

Marcinak, J.F. and Yount, S.C. Evaluation of vision screening practices of Illinois pediatricians. *Clin.Pediatr.Phila.* 1995; 34(7): 353-357. (D)

Marsh Tootle, W.L., Corliss, D.A., Alvarez, S.L., Clore, K.A., Daum, K.M., Gordon, A., Houston, G., Perry, F.F., and Swanson, M.W. A statistical analysis of Modified Clinical Technique vision screening of preschoolers by optometry students. *Optom.Vis.Sci.* 1994; 71(10): 593-603. (T)

Marsh, W.R., Rawlings, S.C., and Mumma, J.V. Evaluation of clinical stereoacuity tests. *Ophthalmology.* 1980; 87(12): 1265-1272. (T)

Marucchi, C. and Fouche, B. A new therapeutic approach for strabismus with amblyopia. *Agressologie* 1996; 32: 169-171. (D)

Mash, C., Dobson, V., Carpenter, N. Interobserver agreement for measurement of grating acuity and interocular acuity differences with the teller acuity card procedure. *Vision Research.* 1995; 35(2): 303-312. (T)

Maslin, K. and Hope, C. Photoscreening to detect potential amblyopia. *Aust.N.Z.J.Ophthalmol.* 1990; 18(3): 313-318. (T)

Mayer, D.L. Acuity of amblyopic children for small field gratings and recognition stimuli. *Investigative Ophthalmology & Visual Science* 1986; 27: 1148-1153. (T)

Mayer, D.L., Beiser, A.S., Warner, A.F., Pratt, E.M., Raye, K.N., and Lang, J.M. Monocular acuity norms for the Teller Acuity Cards between ages one month and four years. *Invest.Ophthalmol.Vis.Sci.* 1995; 36(3): 671-685. (T)

Mayer, D.L. and Gross, R.D. Modified Allen pictures to assess amblyopia in young children. *Ophthalmology.* 1990; 97(6): 827-832. (T)

McDonald, M. and Chaudry, N.M. Comparison of four methods of assessing visual acuity in young children. *Optom.Vis.Sci.* 1989; 66(6): 363-369. (T)

McGraw, P.V. and Winn, B. Glasgow Acuity Cards: a new test for the measurement of letter acuity in children. *Ophthalmic Physiol.Opt.* 1993; 13(4): 400-404. (T)

McGraw, P.V. and Winn, B. Measurement of letter acuity in preschool children. *Ophthalmic and Physiological Optics* 1995; 15-S17. (T)

McIntyre, A.and Hogg, C. The crowding phenmenon - can it be detected by the preferential looking test? *British Orthoptic Journal* 1992; 49. (T)

Medved', L.I. Effectiveness of mass therapeutic-preventive measures to control disorders of binocular vision and amblyopia in young children. *Oftalmol.Zh.* 1969; 24(6): 416-418. (D)

Mehdorn, E., Mattheus, S., Schuppe, A., Klein, U., and Kommerell, G. Treatment for amblyopia with rotating gratings and subsequent occlusion: a controlled study. *Int.Ophthalmol.* 1981; 3(3): 161-166. (S)

Miki, K., Yamada, H., Kobayashi, Y., Uji, Y., and Yokoyama, M. Long-term change in refractive error of patients with pure accommodative esotropia and anisometropic amblyopia during growth and development. *Mie Medical Journal* 1987; 37: 85-94. (Subjects treated)

Mitchell, D.E., Howell, E.R., and Keith, C.G. The effect of minimal occlusion therapy on binocular visual functions in amblyopia. *Invest.Ophthalmol.Vis.Sci.* 1983; 24(6): 778-781. (S)

Mitten, M. and Wick, J. British Columbia's (Canada) focus on eyes: An evaluative research study of the Ministry of Health's elementary school vision screening program in Prince George, British Columbia. *Canadian Journal Of Public Health* 1987; 78: 104-108. (S)

Miyazaki, I., Kii, T., Umemoto, T., Ogasawara, K., Hattori, A., and Nakagawa, T. Visual outcome of anisometropic amblyopia: 1. Anisometropic amblyopia. *Folia Ophthalmologica Japonica* 1991; 41: 297-302. (D)

Mohn, G., Van Hof Van Duin, J., Fetter, W.P.F., De Groot, L., and Hage, M. Acuity assessment of non-verbal infants and children: clinical experience with the acuity card procedure. *Developmental Medicine And Child Neurology* 1988; 30: 232-244. (T)

Molgaard, I., Biering-Sorensen, K., Michelsen, N., Elmer, J., and Rydberg, A. Amblyopia screening in kindergartens with TNO stereotest. *Acta Ophthalmologica* 1984; 62: 156-162. (T)

Molnar, L. Contribution to the therapy of strabismus in pre-school children. *Folia Ophthalmologica* 1985; 10: 229-233. (S)

Molteno, A.C., Hoare Nairne, J., Sanderson, G.F., Peart, D.A., and Hodgkinson, I.J. Reliability of the Otago photoscreener. A study of a thousand cases. *Aust.N.Z.J.Ophthalmol.* 1993; 21(4): 257-265. (T)

Molteno, A.C.B., Sanderson, G.F., and Hoare Nairne, J. Clinical experience with Otago photoscreener. *Australian And New Zealand Journal Of Ophthalmology* 1986; 13: 49-58. (T)

Moseley, M.J., Fielder, A.R., Thompson, J.R., Minshull, C., and Price, D. Grating and recognition acuities of young amblyopes. *British Journal of Ophthalmology* 1988; 72: 50-54. (T)

Motoda, K. The effectiveness of prolonged hypnosis on the psychogenic amblyopic. *Japanese Journal of Hypnosis* 1987; 32(2): 14-21. (D)

Nagai, M., Sioda, M., Suzuki, E., and Simizu, Y. Treatment of anisohypermetropic amblyopia by new chart for training of dysopia. *Japanese Journal Of Clinical Ophthalmology* 1989; 43: 909-911. (D)

Nastri, G., Perugini, G.C., Savastano, S., Polzella, A., and Sbordone, G. The evolution of refraction in the fixing and the amblyopic eye. *Doc.Ophthalmol.* 1984; 56(3): 265-274. (D, inadequate data)

Neumann, E., Friedman, Z., and Abel Peleg, B. Prevention of strabismic amblyopia of early onset with special reference to the optimal age for screening. *J.Pediatr.Ophthalmol.Strabismus* 1987; 24(3): 106-110,. (D)

Neumann, R Oliver, M Gottesmann, N Shimshoni, M Prognosis for occlusive therapy for strabismic and anisometropic amblyopia and for different initial depths of amblyopia. *Chibret International Journal of Ophthalmology* 1989; 6(3): 22-27. (D)

Neuschuler, R., Leone, G., Ciccarelli, M.L., and Cappetta, G.L. The social problem of amblyopia in adult age: Therapeutical approaches. *Annali Di Ottalmologia E Clinica Oculistica* 1990; 116: 1009-1013. (D)

Newman, J. and Mazow, M.L. Intermittent exotropia: is surgery necessary? *Ophthalmic Surg.* 1981; 12(3): 199-202. (S)

Noda, S., Hayasaka, S., and Setogawa, T. Occlusion therapy of Japanese children with anisometropic amblyopia without strabismus. *Ann.Ophthalmol.* 1993; 25(4): 145-147. (D)

Nomura, Y., Kumagai, K., Tanaka, K., Yoshizato, K., and Yoshikawa, E. Therapeutic effect of occlusion for anisometropic amblyopia. *Folia Ophthalmologica Japonica* 1988; 39: 643-650. (D)

North, R.V. and Kelly, M.E. Atropine occlusion in the treatment of strabismic amblyopia and its effect upon the non-amblyopic eye. *Ophthalmic & Physiological Optics* 1991; 11: 113-117. (D)

Nowakowska, O., Broniarczyk Loba, A., and Goetz, J. Results of treatment for anisometropic amblyopia with and with squint. *Klin.Oczna.* 1994; 96(6-7): 193-196. (S)

Nuzzi, G., Leardi, E., and Bonacini, M. Binocular Polaroid Test for vision screening of pre-school age children. *J.Pediatr.Ophthalmol.Strabismus* 1987; 24(5): 220-223. (T)

O'Hara, M.A. and Calhoun, J.H. Surgical correction of excess esotropia at near. *J.Pediatr.Ophthalmol.Strabismus* 1990; 27(3): 120-123. (D)

O'Neal, T.D., Rosenbaum, A.L., and Stathacopoulos, R.A. Distance stereo acuity improvement in intermittent exotropic patients following strabismus surgery. *J.Pediatr.Ophthalmol.Strabismus* 1995; 32(6): 353-357. (R & O)

O'Reilly, C. and Smith, D.R. The 10-diopter base-down fixation test for amblyopia: comparison of techniques. *Can.J.Ophthalmol.* 1984; 19(7): 303-305. (T)

Oliver, M. and Nawratzki, I. Screening of pre-school children for ocular anomalies. *BJO* 1971; 44: 467-471. (Unclear methodology)

Oster, J.G., Simon, J.W., and Jenkins, P. When is it safe to stop patching? *Br.J.Ophthalmol.* 1990; 74(12): 709-711. (D)

Paakkala, A.M. Surgical treatment of strabismus. A retrospective investigation of results of surgical treatment of horizontal strabismus. *Acta Ophthalmol.Suppl.* 1982; 156: 1-107. (S & D)

Pantano, F.M. A comparative survey of preschool stereopsis: Titmus versus TNO. *Ophthalmology.* 1979; 86(12): 2134-2139. (T)

Peregrin, J., Sverak, J., Kuba, M., and Vit, F. The use of rotating checkerboard patterns in the treatment of amblyopia. *Acta Neurobiologiae Experimentalis* 1987; 47(2-3): 111-120. (S)

Pestalozzi, D. [Experience with the combination of polatest and prism correction in the treatment of binocular disorders]. *Ophthalmologica* 1975; 170(2-3): 274-279. (D)

Pestalozzi, D. and Schwarzenbach, A. Better prognosis for amblyopics by means of full prismatic correction after monocular treatment (author's transl). *Klin.Monatsbl.Augenheilkd.* 1979; 175(3): 385-393. (D)

Phillips, C.I. and Vaid, R.L. Late reoperations for squint.. *British Journal of Ophthalmology.* 1977; 61(1): 23-26. (S)

Pospelov, V.I. A method and results of using optic penalization in preschoolers with amblyopia and unilateral strabismus. *Oftalmol.Zh.* 1988; (7): 411-416. (D)

Pott, J.W. and Van Hof Van Duin, J. The Rotterdam C-chart: norm values for visual acuity and interocular differences in 5-year-old children. *Behav.Brain Res.* 1992; 49(1): 141-147. (T)

Prakash, P., Karmacharya, P.C., and Menon, V. Evaluation of CAM vision stimulator in the therapy of amblyopia. *Indian J.Ophthalmol.* 1986; 34: 300-303. (D)

Pratt Johnson, J.A. and Tillson, G. Prismotherapy in intermittent exotropia. A preliminary report. *Can.J.Ophthalmol.* 1979; 14(4): 243-245. (S)

Preslan, MW Novak, A Baltimore vision screening project. *Ophthalmology* 1996; 1103(1): 105-109. (S)

Price, D., Minshull, C., Moseley, M., and Fielder, A. The acuity card procedure: its use in orthoptics. *British Orthoptic Journal* 1987; 44. (T)

Pullini, S., Parrozzani, A., Gerhardinger, P., Ferrari, E., and De Vincentiis, L. Ulterior results in the treatment of amblyopia with pattern-flicker MF17 stimulator. *Bollettino Di Oculistica* 1991; 70: 383-390. (D)

Quah, B.L., Tay, M.T.H., Chew, S.J., and Lee, L.K.H. A study of amblyopia in 18-19 year old males. *Singapore Medical Journal* 1991; 32: 126-129. (S)

Quinn, G.E., Berlin, J.A., and James, M. The Teller acuity card procedure. Three testers in a clinical setting. *Ophthalmology.* 1993; 100(4): 488-494. (T)

Raab, E.L. Hypermetropia in accommodative esodeviation. *J.Pediatr.Ophthalmol.Strabismus* 1984; 21(5): 64-8. (Some wore spectacles, so no good for natural history)

Rao, V. and Bonaiti, A. Amblyopia treatment with pattern-flicker MF 17 stimulator. *Annali Di Ottalmologia E Clinica Oculistica* 1992; 119: 509-512. (D)

Reeves, B. Screening for vision defects in pre-school children. *Optician* 1996; 211(5548): 16-21. (D)

Regan, D. Low-contrast visual acuity test for pediatric use. *Can.J.Ophthalmol.* 1988; 23(5): 224-227. (T)

Regan, D., Giaschi, D.E., Kraft, S.P., and Kothe, A.C. Method for identifying amblyopes whose reduced line acuity is caused by defective selection and/or control of gaze. *Ophthalmic Physiol.Opt.* 1992; 12(4): 425-432. (T)

Repka, M.X., Connett, J.E., Baker, J.D., and Rosenbaum, A.L. Surgery in the prism adaptation study: accuracy and dose response. Prism Adaptation Study Research Group. *J.Pediatr.Ophthalmol.Strabismus* 1992; 29(3): 150-156. (S)

Repka, M.X. and Ray, J.M. The efficacy of optical and pharmacological penalization. *Ophthalmology* 1993; 100(5): 769-774. (D)

Repka, MX Atropine eye drops may be effective in amblyopia treatment. *American Family Physician, 1993,* 1993; 47(.5): 1254. (D)

Richman, J.E., Kozol, N., and Crawford, R.D. Use of interferometry in preschool children. *Journal of the American Optometric Association* 1989; 60(5): 357-360. (T)

Riise, R., Flage, T., Hansen, E., Rosenberg, T., Rudanko, S.L., and Warburg, M. Visual impairment in nordic children I. Nordic registers and prevalence data. *Acta Ophthalmologica.* 1992; 70(2): 145-154. (S & O)

Rivara, A., Borghi, E., and Satragno, L. Amblyopia treatment. *Bollettino Di Oculistica* 1989; 70: 183-190. (D)

Robertson, C. Evaluation of screening: an epidemiological approach. 2: a review of vision in preschool children. *Health Visitor* 1981; 54(2): 52-57. (D)

Robertson, C. Evaluation of screening: an epidemiological approach. Part 3: monitoring pre-school screening of visual acuity by health visitors-a feasibility study. *Health Visit.* 1981; 54(3): 104-105. (D)

Rogers, G.L., Bremer, D.L., and Leguire, L.E. The contrast sensitivity function and childhood amblyopia. *American Journal Of Ophthalmology* 1987; 104: 64-68. (D)

Rohatgi, J.N. and Chandra, B. Amblyopia--its treatment with CAM stimulator. *Indian J.Ophthalmol.* 1984; 32(5): 435-436. (D)

Ron, A. and Nawratzki, I. Penalization treatment of amblyopia: a follow-up study of two years in older children. *J.Pediatr.Ophthalmol.Strabismus* 1982; 19(3): 137-139. (D)

Rona, R.-J.,Reynolds-A Audit from preschool developmental surveillance of vision, hearing, and language referrals. *Archives of Disease in Childhood* 1991; 39(2): 63-70. (O, not much on vision)

Rosner, J. The effectiveness of the random dot E stereotest as a preschool vision screening instrument. *J.Am.Optom.Assoc.* 1978; 49(10): 1121-1124. (T)

Russmann, W., Konig, U., Schlimbach, K., Pawlowska Seyda, D., and Wirbatz, B. [Refractive errors, strabismus and amblyopia in pre-school screening--experiences using a vision test in kindergarten]. *Offentl.Gesundheitswes.* 1990; 52(2): 77-84. (T)

Rutstein, R.P. and Eskridge, J.B. Stereopsis in small-angle strabismus. *Am.J.Optom.Physiol.Opt.* 1984; 61(8): 491-498. (S)

Rutstein, R.P. and Fuhr, P.S. Efficacy and stability of amblyopia therapy. *Optom.Vis.Sci.* 1992; 69(10): 747-754. (D)

Ruttum, M.S., Bence, S.M., and Alcorn, D. Stereopsis testing in a preschool vision screening program. *J.Pediatr.Ophthalmol.Strabismus* 1986; 23(6): 298-302. (T)

Ruttum, M.S. and Nelson, D.B. Stereopsis testing to reduce over-referral in preschool vision screening. *J.Pediatr.Ophthalmol.Strabismus* 1991; 28(3): 131-133. (T)

Ruttum, MS Vision screening with random dot stereograms. *American Orthoptic Journal.* 1988; 38: 43-47. (T)

Sagaties, M.J. Screening for strabismus and amblyopia. *Nurse Practitioner: American Journal of Primary Health Care* 1982; 7(4). (D)

Sakai, N., Kii, T., Umemoto, T., Ohba, M., and Nakagawa, T. Visual outcome of strabismic amblyopia. *Folia Ophthalmologica Japonica* 1990; 41: 1145-1151. (D)

Salisbury District Hosp Audit of outcome of occlusion treatment for amblyopia.1994. (Unpublished)(D)

Salt, A.T., Sonksen, P.M., Wade, A., and Jayatunga, R. The maturation of linear acuity and compliance with the Sonksen-Silver Acuity System in young children. *Dev.Med.Child Neurol.* 1995; 37(6): 505-514. (T)

Sarniguet Badoche, J.M., Espinasse Berrod, M.A., Bokobza Fedida, I., and Campinchi, R. The treatment of amblyopia after 5-6 years. Apropos of 100 cases. *Bull.Soc.Ophtalmol.Fr.* 1988; 88(1): 85-88. (D)

Saunders, K. Early refractive development in humans. *Survey of Opthalmology* 1995; 40(3): 207-216. (S)

Saunders, K. and Westall, C. Comparison between near retinoscopy and cycloplegic retinoscopy in the refraction of infants and children. *Optometry & Vision Science* 1992; 69(8): 615-622. (T)

Savir, H. Early detection of amblyopia and squint. *Harefuah* 1996; 108: 69-70. (T)

Schiefer, U., Brenner Delarbre, B., Schutte, E., and Aulhorn, E. Comparison of the Kolling distance vision stereo-test with current stereo-test procedures. *Fortschr.Ophthalmol.* 1989; 86(2): 138-145. (T)

Schmidt, D. and Mattheus, S. Alternate day squint (author's transl). *Klin.Monatsbl.Augenheilkd.* 1975; 167(6): 835-840. (D)

Schmidt, D. and Stapp, M. The effect of euthyscope- and occlusion therapy in cases of convergent strabismus. Comparative, prospective examinations (author's transl). *Klin.Monatsbl.Augenheilkd.* 1977; 171(1): 105-117. Insufficient data on outcomes & some aspects of the methodology unclear)

Schmidt, P.P. Effectiveness of vision-screening in pre-school populations with preferential-looking cards used for assessment of visual acuity. *Optom.Vis.Sci.* 1991; 68(3): 210-219. (T)

Schmidt, P.P. Allen figure and broken wheel visual acuity measurement in preschool children. *J.Am.Optom.Assoc.* 1992; 63(2): 124-130. (T)

Schmidt, P.P. Vision screening with the RDE stereotest in pediatric populations. *Optom.Vis.Sci.* 1994; 71(4): 273-281. (T)

Schmidt, P.P. and Kulp, M.T. Detecting ocular and visual anomalies in a vision screening setting using the Lang stereotest. *J.Am.Optom.Assoc.* 1994; 65(10): 725-731. (T)

Schor, C., Gibson, J., Hsu, M., and Mah, M. The use of rotating gratings for the treatment of amblyopia: a clinical trial. *Am.J.Optom.Physiol.Opt.* 1981; 58(11): 930-938. (S)

Schor, C. and Wick, B. Rotating grating treatment of amblyopia with and without eccentric fixation. *J.Am.Optom.Assoc.* 1983; 54(6): 545-549. (S)

Scio, F., Onori, P., Filippone, K., and Santori, M. Utilization of Reyser's filters in rehabilitative treatment of amblyopia. *Annali Di Ottalmologia E Clinica Oculistica* 1992; 118: 559-565. (D)

Scott, W.E. and Dickey, C.F. Stability of visual acuity in amblyopic patients after visual maturity. *Graefes.Arch.Clin.Exp.Ophthalmol.* 1988; 226(2): 154-157. (D)

Sekovets, L.S. System of exercises for correction of movement coordination in preschoolers with squint and amblyopia. *Defektologiya* 1985; 6: 70-74. (D)

Sekovets, L.S. The state of the motor sphere in preschool children with strabismus and amblyopia during occlusive treatment. *Defektologiya* 1991; 3: 85-87. (D)

Sen, D.K. Results of treatment in amblyopia associated with unilateral high myopia without strabismus. *British Journal of Ophthalmology* 1986; 68: 681-685. (S)

Sha, C.F. Treatment of childhood amblyopia by red and white stripes. *Chung.Hua.Yen.Ko.Tsa.Chih.* 1987; 23(2): 91-93. (D)

Sheps, S.B. Services to preschool aged children: a survey of Canadian health departments. *Canadian Journal Of Public Health* 1987; 78: 31-42. (D)

Shiratori, A., Aoyagi, M., and Shibasaki, K. Treatment of amblyopia by atropinization. *Rinsho Ganka* 1995; 49: 379-383. (D)

Simas, M.L. and Silva, S.L. Vanishing optotypes: is single presentation superior to chart exposure? *Braz.J.Med.Biol.Res.* 1991; 24(2): 145-148. (T)

Simons, K. A comparison of the Frisby, Random-Dot E, TNO, and Randot circles stereotests in screening and office use. *Arch.Ophthalmol.* 1981; 99(3): 446-452. (T)

Simons, K. Stereoacuity norms in young children. *Arch.Ophthalmol.* 1981; 99(3): 439-445. (T)

Simons, K. and Moss, A. A dynamic random dot stereogram-based system for strabismus and amblyopia screening of infants and young children. *Comput.Biol.Med.* 1981; 11(1): 33-46. (T)

Simons, K., Avery, K.E. and Novak, A. Small-target random dot stereogram and binocular suppression testing for preschool vision screening. *Journal of Pediatric Ophthalmology and Strabismus* 1996; 33 (2): 104-113. (T)

Simpson, A., Kirkland, C., and Silva, P.A. Vision and eye problems in seven year olds: a report from the Dunedin Multidisciplinary Health and Development Research Unit. *N.Z.Med.J.* 1984; 97(759): 445-449. (S)

Singh, V., Sinha, S., and Singh, G.K. A retrospective cohort study for prognostic significance of visual acuity for near over that for distance in anisometropic amblyopia. *Indian Journal Of Ophthalmology* 1992; 40: 44-47. (D)

Sireteanu, R., Fronius, M., and Katz, B. A perspective on psychophysical testing in children. *Eye* 1990; 4: 794-801. (T)

Sjostrand and Abrahamsson, M. Risk factors in amblyopia. *Eye* 1990; 4: 787-793. (D)

Smellie, T. Problems of establishing a photorefraction screening programme. *British Orthoptic Journal* 1988; 45: 66-69. (D)

Smith, G. Evaluation of the frisby screening plate and lang II stereotest in primary vision screening in pre-school children. *British Orthoptic Journal* 1995: 52. (T)

Soller, B. Health control of 4-year-olds. 1. Lund pioneers: nearly all vision errors can be corrected. *Lakartidningen.* 1970; 67(26): 3014-3018. (D)

Somersalo, M. and Erkkila, H. Children referred for pleoptic treatment: A survey on aspects considering referral for examination, role of screening programs, previous therapy and compliance. *Acta Ophthalmologica* 1988; 66: 509-513. (D)

Sonksen, P.M. The assessment of vision in the preschool child. *Archives of Disease in Childhood* 1993; 68: 513-516. (D)

South Devon Sub Regional Audit On Amblyopia, 1991. (Unpublished) (D)

Sparrow, J.C. and Flynn, J.T. Amblyopia: a long-term follow-up. *J.Pediatr.Ophthalmol.* 1977; 14(6): 333-336. (D)

Speeg Schatz, C. and Rezaifuia, F. Measurement of the visual acuity to networks with the Teller's cards: efficient detection of amblyopia in infants and young children?. *J.Fr.Ophtalmol.* 1995; 18(8-9): 510-515. (T)

Sprague, J.B., Stock, L.A., Connett, J., and Bromberg, J. Study of chart designs and optotypes for preschool vision screening – I. Comparability of chart designs. *J.Pediatr.Ophthalmol.Strabismus* 1989; 26(4): 189-197. (T)

Stager, D.R., Weakley, D.R.,Jr., Everett, M., and Birch, E.E. Delayed consecutive exotropia following 7-millimeter bilateral medial rectus recession for congenital esotropia. *J.Pediatr.Ophthalmol.Strabismus* 1994; 31(3): 147-150. (S & D)

Stager, D.R., Everett, M.E. and Birch, E.E. Comparison of crowding bar and linear optotype acuity in amblyopia. *American Orthoptic Journal.* 1990; 40: 51-56. (T)

Stangler Zuschrott, E. Eight years' prismatic treatment of convergent alternating squint (author's transl). *Klin.Monatsbl.Augenheilkd.* 1980; 177(6): 835-838. (D)

Stangler Zuschrott, E. and Kulnig, W. Comparative vision tests using objective and subjective testing methods in amblyopia. *Klin.Monatsbl.Augenheilkd.* 1983; 183(6): 459-463. (T)

Stayte, M., Wortham, C., and Reeves, B. Orthoptists reduce false-positive hospital referrals. *Health Trends.* 1992; 24(4): 157-161. (S)

Stein, J. and Fowler, S. Effect of monocular occlusion on visuomotor perception and reading in dyslexic children. *Lancet* 1985; 2: 69-73. (O)

Strogal', A.S. Combined treatment of children with disbinocular amblyopia using chromatic objects. *Oftalmol.Zh.* 1986; (1): 35-38. (D)

Sturner, R.A., Green, J.A., Funk, S.G., Jones, C.K., and Chandler, A.C. A developmental approach to preschool vision screening. *J.Pediatr.Ophthalmol.Strabismus* 1981; 18(2): 61-67. (T)

Su, M.Y. Evaluation of the visual evoked potentials in the diagnosis and prognosis of amblyopia in children. *Kaohsiung Journal Of Medical Sciences* 1987; 3: 222-233. (S)

Sun, B.C., Li, R.D., Zhang, X.L., Zou, L.H., Li, L., and Yan, S. Picture test cards for vision of the Chinese preschool children. *Chin.Med.J.Engl.* 1984; 97(11): 791-794. (T)

Swan, K.C. Accommodative esotropia long range follow-up. *Ophthalmology.* 1983; 90(10): 1141-1145.(D)

Tanlamai, T. and Goss, D.A. Prevalence of monocular amblyopia among anisometropes. *Am.J.Optom.Physiol.Opt.* 1979; 56(11): 704-715. (S)

Tatarinov, S.A., Dubovskaia, L.A., Kovalevskii, E.I., Fil'Chikova, L.I., and Matveev, S.G. Comparative assessment of visual acuity in preschoolers. *Oftalmol.Zh.* 1988; (7): 387-390. (T)

Taylor, D. Screening? *Trans. Opthalmol. Soc. UK* 1985; 104: 637-640. (D)

Thompson, C. and Drasdo, N. Clinical experience with preferential looking acuity tests in infants and young children. *Ophthalmic & Physiological Optics* 1988; 8: 309-321. (T)

Thores, A. and Philion, J. A preschool screening program on central Vancouver Island: a two-year follow-up. *Can.J.Public Health* 1974; 65(5): 385-387. (This relates to a general programme, of which vision screening was one part, & lacks detail)

Timberlake, G.T., Mainster, M.A., and Schepens, C.L. Automated clinical visual acuity testing. *Am.J.Ophthalmol.* 1980; 90(3): 369-373. (T)

Timmerman, G.J. The results of penalization therapy. *Doc.Ophthalmol.* 1977; 42(2): 385-390. (D)

Tokunaga, R., Yoshimura, K., Ueda, K., Ueki, Y., and Inomata, H. Vision screening of preschool children in municipal nursery schools (22 facilities). *Folia Ophthalmologica Japonica* 1988; 39: 314-318. (D)

Tomlinson, E Martinez, D The measurement of visual acuity- Comparison of Teller acuity cards with Snellen and MBL results. *American Orthoptic Journal.* 1996; 38: 130-134. (T)

Tommila, V. and Nordman, E. Late results of pleoptic treatment. *Br.J.Ophthalmol.* 1969; 53(11): 769-772. (S)

Tredici, T.D. and Von Noorden, G.K. The Pulfrich effect in anisometropic amblyopia and strabismus. *Am.J.Ophthalmol.* 1984; 98(4): 499-503. (T)

Tumanian, S.A., Bogdanov, O.V., Mikhailenok, E.L., Movsisiants, S.A., and Drozdov, O.A. The use of the procedures of functional biocontrol in the combined treatment of amblyopia. *Vestn.Oftalmol.* 1993; 109(4): 11-13. (D)

Uemura, Y. and Katsumi, O. Form-vision deprivation amblyopia and strabismic amblyopia. *Graefe'S Archive For Clinical And Experimental Ophthalmology* 1988; 226: 193-196. (D)

US Dept Health, E.,And Welfare Monocular Visual Acuity Of Persons 4-74 Years, United States - 1971-1972. Data from the National Health Survey.Anonymous Rockville,Md: 1977. (S)

US Preventive Services Task Force 'Screening for Visual Impairment' in Guide to Clinical Preventive Services - Report of the US Preventive Services Task Force (Second Edition).Anonymous Baltimore, Philadelphia, Hong Kong, London, Munich, Sydney, Tokyo:Williams & Williams. 1996; 373-382. (D)

Vaccari, G., Passani, E., and Barca, L. Treatment of functional amblyopia by the technique of adjusting and observation according to Berrondo: Considerations on results obtained in 20 cases. *Bollettino Di Oculistica* 1985; 63: 769-776. (D)

Van Der Torren, K. Treatment of amblyopia in strongly anisometropic eyes. *Documenta Ophthalmologica* 1985; 59: 99-104. (D)

Vereecken, E.P. and Brabant, P. Prognosis for vision in amblyopia after the loss of the good eye. *Arch.Ophthalmol.* 1984; 102(2): 220-224. (D)

VerLee, D.L. and Iacobucci, I. Pleoptics versus occlusion of the sound eye in the management of strabismic amblyopia with eccentric fixation. *Am.J.Ophthalmol.* 1967; 63(2): 244-250. (D)

Vinding, T., Gregersen, E., Jensen, A., and Rindziunski, E. Prevalence of amblyopia in old people without previous screening and treatment. An evaluation of the present prophylactic procedures among children in Denmark. *Acta Ophthalmol.Copenh.* 1991; 69(6): 796-798. (S)

Vital-Durand, F. and Ayzac, L. Tackling amblyopia in human infants. *Eye* 1996; 10: 239-244. (S)

Vitale Brovarone, F., Fea, A., Chiado Piat, L., Porro, G., Ponzetto, M., and Cortassa, F. Preferential looking techniques yield important information in strabismic amblyopia follow-up. *Documenta Ophthalmologica* 1996; 83: 307-312. (T)

Voller, J. and Griffiths, P. Inconsistency of stereo-acuity results using the Frisby stereotest. *B Orthoptic J* 1988; 45. (T)

Von Noorden, G.K. Chronic vision problems of school-age children. *Journal of School Health* 1976; 46(6): 334-337. (S)

Von Noorden, G.K. Idiopathic amblyopia. *American Journal Of Ophthalmology* 1985; 100: 214-217. (D)

Von Noorden, G.K. and Attiah, F. Alternating penalization in the prevention of amblyopia recurrence. *American Journal Of Ophthalmology* 1987; 102: 473-475. (D)

Von Noorden, G.K., Avilla, C., Sidikaro, Y., and Laroche, R. Latent nystagmus and strabismic amblyopia. *American Journal Of Ophthalmology* 1987; 103: 87-89. (D)

Von Noorden, G.K. and Avilla, C.W. Refractive accommodative esotropia: a surgical problem? *Int.Ophthalmol.* 1992; 16(1): 45-48. (S)

Von Noorden, G.K. and Milam, J.B. Penalization in the treatment of amblyopia. *Am.J.Ophthalmol.* 1979; 88(3 Pt 1): 511-518. (D)

Von, Noorden, GK Amblyopia- A multidisciplinary approach. *Investigative Ophthalmology and Visual Science* 1985; 26(12): 1704-1716. (D)

Wali, N., Leguire, L.E., Rogers, G.L., and Bremer, D.L. CSF interocular interactions in childhood amblyopia. *Optometry And Vision Science* 1991; 68: 81-87. (D)

Walraven, J. Amblyopia screening with random-dot stereograms. *Am.J.Ophthalmol.* 1975; 80(5): 893-900. (T)

Walraven, J. and Janzen, P. TNO stereopsis test as an aid to the prevention of amblyopia. *Ophthalmic Physiol.Opt.* 1993; 13(4): 350-356. (T)

Wang, Z. An observation on the curative effect of child amblyopia by the composite amblyopia cure apparatus. *Journal Of China Medical University* 1990; 19: 376-379. (D)

Wasserman, R.C., Croft, C.A., and Brotherton, S.E. Preschool vision screening in pediatric practice: A study from the Pediatric Research in Office Settings (PROS) Network. *Pediatrics* 1993; 89: 834-838. (S)

Watson, P.G. and Banks, R.V. Theory and practice in the treatment of amblyopia. *B Orthoptic J* 1981; 38. (D)

Watson, P.G., Banks, R.V., Campbell, F.W., and Hess, R.F. Clinical assessment of a new treatment for amblyopia. *Trans.Ophthalmol.Soc.U.K.* 1978; 98(2): 201-208. (D)

Watson, P.G., Sanac, A.S., and Pickering, M.S. A comparison of various methods of treatment of amblyopia. A block study. *Trans.Ophthalmol.Soc.U.K.* 1985; 104(3): 319-328. (D)

Weatherhead, R.G. Use of the Arden grating test for screening. *Br.J.Ophthalmol.* 1980; 64(8): 591-596. (T)

Werner, D.B. Amblyopia treatment in children ages six through eight. *Trans.Pa.Acad.Ophthalmol.Otolaryngol.* 1982; 35(1): 31-35. (D)

Wick, B., Meguire, G., and O'Neal, M.R. Evaluation of a non-professional visual screening method. *Am.J.Optom.Physiol.Opt.* 1975; 52(9): 607-613. (S & O)

Wick, B., O'Neal, M., and Ricker, P. Comparison of vision screening by lay and professional personnel. *Am.J.Optom.Physiol.Opt.* 1976; 53(9 Pt 1): 474-478. (S & O)

Wick, B., Wingard, M., Cotter, S., and Scheiman, M. Anisometropic amblyopia: Is the patient ever too old to treat? *Optometry And Vision Science* 1992; 69: 866-878. (D)

Williams, S., Simpson, A., and Silva, P.A. Stereoacuity levels and vision problems in children from 7 to 11 years. *Ophthalmic Physiol.Opt.* 1988; 8(4): 386-389. (S)

Willshaw, H.E. and Keenan, J. Strabismus surgery in children: The prospects for binocular single vision. *Eye* 1991; 5: 338-343. (D)

Willshaw, H. and Johnson, F. Penalization as the primary treatment of strabismic amblyopia. *British Orthoptic Journal* 1979; 36. (D)

Wong, D. and Plumb, A. Computer automated visual acuity testing for visual screening. *Trans.Ophthalmol.Soc.U.K.* 1986; 105(4): 498-503. (S)

Wong, S.G. Comparison of vision screening performed by optometrists and nurses. *Am.J.Optom.Physiol.Opt.* 1978; 55(6): 384-389. (S)

Woodhouse, J.M., Adoh, T.O., and Compton, P. Pre-school visual acuity screening: the cardiff acuity test. 1996 (unpublished). (T)

Wortham, C. The increase in hypermetropia in children. *British Orthoptic Journal.* 1978; 35. (No good for natural history as some wore spectacles).

Wright, K.W., Edelman, P.M., Walonker, F., and Yiu, S. Reliability of fixation preference testing in diagnosing amblyopia. *Archives Of Ophthalmology* 1986; 104: 549-553. (T)

Wright, K.W., Walonker, F., and Edelman, P. 10-Diopter fixation test for amblyopia. *Arch.Ophthalmol.* 1981; 99(7): 1242-1246. (T)

Wright, M.C., Colville, D.J., and Oberklaid, F. Is community screening for amblyopia possible, or appropriate? *Archives of Disease in Childhood* 1995; 73: 192-195. (D)

Wright, K.W., Bruce Lyle, L. Augmented surgery for esotropia associated with high hypermetropia. *Journal of Pediatric Ophthalmology and Strabismus* 1993; 30(3): 167-170. (S & D)

Yamamoto, S., Seguchi, Y., Sakai, Y., and Nakatsuka, K. Two cases of cyclic esotropia. *Folia Ophthalmologica Japonica* 1991; 41: 92-96. (D)

Yazawa, K., Suga, J., Wakita, S., Sumitomo, M., and Uemura, Y. The Tokyo Metropolitan Home Vision Screening Program for amblyopia in 3-year-old children. *Am.J.Ophthalmol.* 1992; 114(4): 416-419. (O)

Young, D.A., McKee, M.C., Coffey, B., Cool, S., Roth, N., and Yolton, R.L. Comparison of Snellen letter and Vistech grating charts as refraction targets. *J.Am.Optom.Assoc.* 1988; 59(5): 364-371. (T)

Zang, Y.F., Guo, J.Q., and Liu, J.Q. Occlusion therapy for amblyopia and stereopsis. *Chinese Medical Journal* 1991; 101: 719-722. (D)

Zanoni, D. and Rosenbaum, A.L. A new method for evaluating distance stereo acuity. *J.Pediatr.Ophthalmol.Strabismus* 1991; 28(5): 255-260. (T)

Zehetmayer, M., Stangler Zuschrott, E., and Schemper, M. Prolonged preoperative prismatic treatment in alternating convergent squint. *Acta Ophthalmologica* 1994; 72: 103-109. (S & D)

Zehetmayer, M., Stangler Zuschrott, E., and Schneider, B. Influence of existing retinal correspondence on the results of squint operations in alternating convergent strabism. *Documenta Ophthalmologica* 1996; 88: 127-139. (D)

Zibrandtsen, P., Rindziunski, E., and Gregersen, E. Ten years follow-up of surgery for intermittent exotropia. *Acta Ophthalmol.Copenh.* 1986; 64(4): 374-378. (D)

Zurcher, B. and Lang, J. Reading capacity in cases of 'cured' strabismic amblyopia. *Trans. Opth, Soc. UK* 1980; 100: 501-503. (D)