Title: EU-wide inventory of current paediatric vision and hearing screening programmes

Frea Sloot[1], MD, Hans L.J. Hoeve[2], MD, PhD, Marlou L.A. de Kroon[3], MD, PhD, André Goedegebure[2], PhD, MSc, Jill Carlton[4], PhD, MMedSci, BMedSci, Helen J. Griffiths[5], PhD, BSc (Hons), DBO, Huibert Jan Simonsz[1], MD, PhD, for the EUS€REEN study group[6]

Affiliations: [1]Department of Ophthalmology, Erasmus University Medical Center Rotterdam, the Netherlands; [2]Department of Otorhinolaryngology, Erasmus University Medical Center Rotterdam, the Netherlands, [3]Department of Public Health, Erasmus University Medical Center Rotterdam, the Netherlands, [4]Health Economics and Decision Science (HEDS), School of Health and Related Research (ScHARR), University of Sheffield, United Kingdom, [5]Academic Unit of Ophthalmology & Orthoptics, University of Sheffield, United Kingdom, [6]Members of the EUS€REEN study group are listed in Appendix A.

Address correspondence to: Frea Sloot, Department of Ophthalmology, Faculty Ee-1607 Erasmus MC, PO box 2040, 3000 CA Rotterdam, the Netherlands. Phone: +31 107043275. E-mail: f.sloot@erasmusmc.nl

Short title: EU vision and hearing screening inventory

Abbreviations: EU - European Union; VA - Visual acuity; OAE - otoacoustic emission; ABR - auditory brainstem response; UNHS - Universal new-born hearing screening

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Hans L.J. Hoeve conceptualized and designed the study, coordinated data collection, carried out the initial analyses, drafted the initial manuscript, revised the manuscript and approved the final manuscript as submitted.

Marlou de Kroon coordinated data collection, critically reviewed and revised the manuscript, and approved the final manuscript as submitted.

André Goedegebure designed the study, drafted the initial manuscript, critically reviewed and revised the manuscript and approved the final manuscript as submitted.

Jill Carlton coordinated data collection, critically reviewed and revised the manuscript, and approved the final manuscript as submitted.

Helen Griffiths coordinated data collection, critically reviewed and revised the manuscript, and approved the final manuscript as submitted.

Huibert Jan Simonsz conceptualized and designed the study, critically reviewed and revised the manuscript, and approved the final manuscript as submitted.

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ABSTRACT

Background: We examined the diversity in paediatric vision and hearing screening programmes in Europe.

Methods: Themes relevant for comparison of screening programmes were derived from literature and used to compile three questionnaires on vision, hearing and public-health screening. Tests used, professions involved, age and frequency of testing seem to influence sensitivity, specificity and costs most. Questionnaires were sent to ophthalmologists, orthoptists, otolaryngologists and audiologists involved in paediatric screening in all EU full-member, candidate and associate states. Answers were cross-checked.

Results: Thirty-nine countries participated; 35 have a vision screening programme, 33 a nation-wide neonatal hearing screening programme. Visual acuity (VA) is measured in 35 countries, in 71% more than once. First measurement of VA varies from three to seven years of age, but is usually before the age of five. At age three and four picture charts, including Lea Hyvarinen are used most, in children over four Tumbling-E and Snellen. As first hearing screening test otoacoustic emission (OAE) is used most in healthy neonates, and auditory brainstem response (ABR) in premature newborns. The majority of hearing testing programmes are staged; children are referred after one to four abnormal tests. Vision screening is performed mostly by paediatricians, ophthalmologists or nurses. Funding is mostly by health insurance or state. Coverage was reported as >95% in half of countries, but reporting was often not first-hand.

Conclusion: Largest differences were found in VA charts used (12), professions involved in vision screening (10), number of hearing screening tests before referral (1-4) and funding sources (8).

INTRODUCTION

The sensory functions of a child play a key role in intellectual and social development during early childhood. Vision or hearing impairment therefore affects both personal and societal health of children. There is robust evidence that earlier detection of a visual or hearing deficit results in an improved outcome.[1-4] Therefore, vision and hearing screening programmes have been introduced world-wide. Although the programmes are based on the same general principles, they still vary both within and across EU countries, regarding tests used, age of testing, frequency of testing, professions involved in screening, referral procedure, funding and coverage. These differences between screening programmes can result in health inequities. No screening or screening with little population coverage can result in delayed provision of the correct treatment and increased disease burden. Too abundant screening can result in inappropriate interventions and increased costs for health care systems.

Vision screening and subsequent treatment has reduced the occurrence of insufficiently detected and treated amblyopia.[5] In the Netherlands, the age that amblyopia is detected is nowadays more than two years earlier than in the seventies.[6] Early screening for hearing impairment has led to early intervention and improved outcome.[2,7] Early detection of hearing disorders and timely intervention such as cochlear implantation or hearing aid largely prevents delayed language development,[1] which also results in improved general developmental outcome at 3 to 5 years of age.[3]

In spite of the increased consciousness world-wide that vision and hearing screening is effective, there are differences in implementation between countries. Neugebauer et al. did a survey of existing vision screening programmes in 190 countries via their ministries of health and found that screening was often state funded, visual acuity (VA) was always tested and within the EU screening was predominantly voluntary.[8] Matta and Silbert assessed differences

in paediatric vision screening programmes through an e-mail survey to members of the International Orthoptic Association (IOA). Ninety-eight percent of their 18 responsive representatives indicated that a vision screening programme was in place in their country; in 44% this was a national programme. Screening was performed by a wide range of professionals.[9]

Bubbico et al. reported an overview of implemented universal new-born hearing screening (UNHS) programmes in 24 European countries dating from the period 2004-2006. In several countries UNHS programmes were successfully introduced reaching more than 95% of all neonates, but in many other countries programmes were recently introduced or were only partially functioning.[10] Reports on experiences with national neonatal hearing screening programmes concern issues on implementation, test procedures, type of tests, coverage, detected cases of hearing loss and costs.[11-19]

The cost-effectiveness of screening programmes has been the subject of several reports. In a report by Carlton et al.,[20] following the Health Technology Assessment (HTA) report by Snowdon and Stewart-Brown,[21] the cost-effectiveness of vision screening up to the age of 4-5 years was re-examined. They concluded that, based on the accepted value of a Quality-adjusted life year (QALY), the cost-effectiveness of screening for amblyopia depends on the long-term utility effects of unilateral vision loss and that there is currently no sustainable evidence of utility loss that would render any form of screening likely to be cost-effective.[20] Keren et al. concluded that universal new-born hearing screening (UNHS) in general has the potential for long-term cost savings compared with selective hearing screening and no screening.[22] Burke et al found that the cost-effectiveness of hearing screening depended mainly on the cost of the screening intervention per patient and on the prevalence of hearing loss in the population.[23]

The purpose of this study was to make an inventory of population-based vision and hearing screening programmes for children in Europe. It is known that differences exist, but to what extent is unknown. It is necessary to gain more insight into these differences. This problem is in particular relevant for EU countries that currently have no screening programme in place: for new EU member states that want to implement vision and hearing screening, there is uncertainty about which screening protocol to adapt. If large differences are found in population-wide vision and hearing screening in children in all EU countries, further study on the relative costs and effectiveness of the different approaches to screening is necessary.

METHODS

Items relevant for comparison of screening programmes were derived from literature, in particular from five major cost-effectiveness analyses.[20, 21,23-25] The following main domains were used to formulate vision (Q1) and hearing (Q2) screening questionnaires:

- Type of tests, like visual acuity chart or hearing screening device (OAE, aABR) used
- Professions involved in screening, like nurses, orthoptists or doctors
- Funding, for example by state or health insurance
- Coverage, percentage of screened children

Questions were formulated in a focus group and asked in a multiple-choice format with room for extra comments and multiple answers (Q1, Q2). All forms of screening for vision or hearing problems were included (e.g. inspection of the eyes was also counted as form of vision screening). To get a broader perspective of screening systems a short public-health questionnaire (Q3) was developed through extrapolation of the vision and hearing questionnaires. This very concise public-health questionnaire was only intended to provide background information on screening and screening systems in all countries.

In all EU full member states (28), candidate states (5), potential candidate state Albania and associated states Israel, Moldova, Norway and Switzerland a paediatric ophthalmologist, orthoptist, otolaryngologist, audiologist and screening professional were approached to fill out the questionnaires regarding screening in their own country. These representatives were selected based on their involvement in paediatric vision and hearing screening. Existing connections were used to find the most appropriate persons to fill out the questionnaires. Where a representative could not be identified, new connections were asked to recommend representatives in neighbouring countries or colleagues involved in vision or hearing

screening in their own country. Public-health representatives were found by approaching Ministries of health and via recommendation of the vision and hearing representatives.

Firstly questions about screening tests, age and frequency of screening were included in our questionnaire. Different tests can be used to screen for one disorder, but screening programmes can also focus on more than one disorder. Two-stage or multiple-stage testing improves the specificity of the screening, but makes the screening more expensive. The higher specificity however can reduce costs in diagnostics during follow-up.[23,26]

Secondly questions about the choice of professions involved in screening were included because this influences the quality and costs of screening. Screening tests with a higher sensitivity and specificity might require higher educated personnel. This will lead to an increase in costs of screening due to longer education and higher salary costs. This increase in costs should be balanced with the increase in sensitivity and specificity.

Thirdly, funding is an important issue in screening. Funding can be provided by the state, regions, municipalities, Health insurances, parents and/or charity. the choice of funding agencies will influence the equity of screening, competitiveness, costs, coverage and cost-effectiveness.

Finally questions about coverage were included because the participation frequency of a screening programme is crucial for its effectiveness, and to make screening worthwhile from a population point of view. Low coverage can lead to delayed provision of the correct treatment and increased disease burden. If screening is free of charge or obligatory, coverage will be higher. Acceptable participation frequencies can be reached by incorporating the screening into an already existing system with a high participation rate, e.g. vaccination programmes or school start.

Questionnaires were distributed via e-mail from December 2013 until April 2014. Clinicians involved in population based screening were sought and their answers were cross-checked with the answers given by the general screening professionals. In case of ambiguities the questionnaires were returned to both the clinician and the screening professional and they were asked to contact each other and send us the agreed corrections. Overviews of the questionnaire answers were made and these were circulated three times to all representatives. All representatives were asked to review and correct any errors in the overviews for their own country and for neighbouring countries. The overviews were also presented to and checked by external experts, who areinvolved first-hand in vision and hearing screening.

RESULTS

In all 39 countries (including 2 separate regions in Belgium), representatives were found.

Vision representatives were found in 36, hearing representatives in 38 and public-health representatives in 23 countries (Table 1).

Table 1. Eligible countries (**EU status**: A = associated state, C = Candidate, M = full member, P.C. = potential candidate).

Country	**EU status**	**Vision**	**Hearing**	**Public**
Albania	P.C.	-	+	+
Austria	M.	+	+	-
Belgium Flanders	M.	+	+	+
Belgium Wallonia	M.	+	+	-
Bulgaria	M.	+	+	+
Croatia	M.	+	+	+
Cyprus	M.	+	+	-
Czech Republic	M.	+	+	+
Denmark	M.	+	+	-
Estonia	M.	+	+	-
Finland	M.	+	+	+
France	M.	+	+	+
Germany	M.	+	+	+
Greece	M.	+	+	+
Hungary	M.	+	+	+
Iceland	C.	+	+	+
Ireland	M.	+	+	-
Israel	A.	+	+	+
Italy	M.	+	+	-
Latvia	M.	+	+	-
Lithuania	M.	+	+	-
Luxembourg	M.	+	+	-
Macedonia	C.	-	-	+
Malta	M.	+	+	+
Moldova	A.	-	+	-
Montenegro	C.	+	+	+
Netherlands	M.	+	+	+
Norway	A.	+	+	-
Poland	M.	+	+	-
Portugal	M.	+	+	+
Romania	M.	+	+	-
Serbia	C.	+	+	+
Slovakia	M.	+	+	-
Slovenia	M.	+	+	+
Spain	M.	+	+	+
Sweden	M.	+	+	+
Switzerland	A.	+	+	-
Turkey	C.	+	+	+
United Kingdom	M.	+	+	+

Vision

Information on vision screening programmes was obtained from 36 countries including two regions in Belgium (Flanders and Wallonia). No information could be obtained from Albania, Macedonia and Moldova. Thirty-five countries have a vision screening programme in place. In Belgium, Bulgaria, Estonia, France, Romania, Spain and Switzerland this is a regional programme. In several countries with a national vision screening programme in place, regional differences in screening protocols do exist.

Tests infant and preverbal screening

Infant screening (age 0-4 months) included inspection, fixation, red reflex testing, Hirschberg test, Bruckner test, Cover test, pupillary reflexes and motility. Most countries perform a combination of two or more of these tests. In Bulgaria, Greece and Poland no screening is performed at this age. In Germany only inspection of the eyes is performed. In Ireland, Montenegro and Spain inspection of the eyes is combined with red reflex testing. In Cyprus, Italy, Lithuania and Malta only red reflex testing is done. In Latvia this is combined with motility testing. Preverbal screening (age 6-30 months) includes the same tests. At this age screening is not performed in eight countries. In most other countries a combination of two or more tests is performed.

Visual acuity measurements

In all countries visual acuity (VA) is tested, but the age of the first measurement varies between three and seven years of age. In a third of countries VA is tested once, one third twice and in one third more than two times. Thus in most countries VA measurements are repeated at an older age. In children age four years and younger the most common used VA charts are picture charts and the Lea Hyvarinen chart, above four years Tumbling E and Snellen are most often used.

Personnel and referral

Screening is mostly performed by paediatricians, ophthalmologist and/or nurses. In all countries children are referred to the ophthalmologist for further examination, except for Latvia, where children are referred to the General Practitioner (GP), the UK where children may also be referred to joint orthoptic and optometry clinics or optometrists, Malta where children are referred to either the orthoptist or optometrist and the Netherlands where children are mostly referred via the GP to an orthoptist or ophthalmologist, but sometimes directly to an orthoptist, ophthalmologist, optometrist or optician.

Funding

In most countries vision screening is free of charge for parents, except for the Czech Republic, Malta, Switzerland and Turkey. Funding is in 33% (partially) provided by the Health Insurance and in 53% (partially) by the State. Parents and charity pay (part of the) screening in the Czech Republic, Latvia, Romania, Slovakia, Spain and Turkey.

Coverage

Coverage varied from just starting (Estonia, Portugal, Turkey) to more than 95% in Austria, Czech Republic, Denmark, Finland, Flanders, Germany, Hungary, Iceland, Luxembourg, the Netherlands, Norway, Serbia, Slovenia, Sweden and parts of the UK. Coverage of different testing moments varied within countries: the number of children screened varied, dependent on the age that the screening test was carried out. The highest coverage percentage was regarded as coverage for each particular country.

Data is presented in more detail in table 2 and Map 1.

Table 2. Vision screening programmes in 36 European countries. **Scope** = scope of vision screening programme (nat = nation-wide, loc = local), **Personnel:** (ophth = ophthalmologist, ped = paediatrician, school = school physician, YHC = youth health care physician, orth = orthoptist, optom = optometrist, GP = general practitioner, optic = optician, assist = practice assistant), **Pres.** = preschool screening(screening before school age, school age varies across countries), **Chart and age** = visual acuity chart and age of testing (Pict = Picture chart, Lea = Lea Hyvarinen Chart (picture) C = Landolt C, E = Tumbling E, KM = Konstantin Moutakis, Sher = Sheridan Gardiner, Snel = Snellen), **Auto.** = autorefraction/ photorefraction, **Also** = testing of stereopsis and/or colour vision, **Funding =** (Insur = health insurance, Munic = Municipalities, Par = parents), **Cov.** = Coverage.

Country	Scope	Personnel	0-4mo	6-30mo	Pres.	Chart and age	Auto.	Also	Funding	Cov. (%)
Austria	nat	Ophth, ped, school	+	+	+	Lea 3; 4; 5; 6	-	stereo	insur, state	>95
Belgium (Fl)		YHC, nurse	+	+	+	Pict 3½, HOTV 4½	+	both	region	>95
Belgium (W)	nat	Orth, ped, other	+	+	+	Snel 3½; 6	+	-	region	>40
Bulgaria	loc	GP	-	+	-	Pict, E 7	-	colour	insur	
Croatia	nat	Ophth, ped, school	+	+	+	Pict, Lea 4, E 6; 6½	-	-	insur, state	>90
Cyprus	nat	School	+	-	-	Snel 6½; 7	-	-	state	>80
Czech rep	nat	Ophth, orth, ped, YHC, optom, other	+	+	+	Pict; Lea 3, E 5, Snel 7; 9; 11; 13; 15	Loc.	colour	insur, par region	>95
Denmark	nat	Nurse, school, GP	+	+	+	Pict 3; 4; 5; 6	-	-	region	>95
Estonia	loc	Ophth, ped	+	+	+	Lea 3, Lea; Snellen 6	-	-	insur	start
Finland	nat	Nurse, school, GP	+	+	+	Lea 3; 4; 5½	-	-	state, munic	>95
France	loc	Orth, ped, nurse, school	+	+	+	Pict 4	-	-	insur, region	>80
Germany	nat	Ped	+	+	+	Lea; HOTV 3	-	-	insur	>95
Greece	nat	Ophth	-	-	+	Snel 5½	-	both	state	>60
Hungary	nat	Ped, nurse, school	+	+	+	Pict 6	Loc.	both	insur, state	>95
Iceland	nat	Ped, nurse	+	+	+	Lea; HOTV 4, HOTV; Snel 6	-	stereo	state	>95
Ireland	nat	School	+	+	-	Snel 5½	-	-	state	>80
Israel	nat	Ped, nurse	+	+	+	Pict 3; 6	-	-	state	>80
Italy	nat	Ped	+	-	+	Snel (3); 6	-	-	region	>80
Latvia	nat	Ophth, ped	+	+	+	Cardiff 1, Pict; E 3, E; numbers 6½	-	stereo	state, par	>60
Lithuania	nat	Ophth, ped	+	+	+	Pict; E; Snel 6; 6½; 7	+	-	state	
Luxembourg	nat	Orth, ped, nurse	+	+	+	Pict; E 3½, 4½, 5½, 6½	+	both	insur, state	>95
Malta	nat	Orth, nurse, optom, school	+	+	-	Snel 3, Sher 5½	-	stereo	state	>80
Montenegro	nat	Ped, nurse	+	+	+	Snel 5½	-	-	state	
Netherlands	nat	YHC, nurse	+	+	+	Pict 3, Lea; C 4	-	-	munic	>95
Norway	nat	Nurse, GP, school	+	+	+	Lea 4, Sher 6	-	-	munic	>95
Poland	nat	Ped, GP	-	+	+	Pict 4, Snel 6	-	-	state	>80
Portugal	nat	GP	+	-	+	Sher 4, E 5; E; C 5½; 6	-	-	state	start
Romania	loc	Ophth	+	-	+	Pict 3, Snel 4; 5	Loc.	-	state, charity	>80
Serbia	nat	Ophth, ped	+	+	+	Snel 6½	-	both	state	>95
Slovakia	nat	Ophth, orth, ped	+	+	+	Pict 3, Lea; E; C; Snel, 5; 6	-	both	par, insur	>90
Slovenia	nat	Ped, school	+	+	+	Pict 3; 5 Snel 6; 7	-	-	insur	>95
Spain	loc	Ped, ophth, optom	+	-	+	Pict 4, Snel 4½; 5	-	stereo	par, state	
Sweden	nat	Nurse	+	-	-	HOTV 4, KM 6	-	-	region	>95
Switzerland	loc	Ophth, orth, ped, nurse, optic, school, GP	+	+	+	Pict 4, Lea; E 4½; 5, 5½	-	stereo	insur	>80
Turkey	start	Ophth	+	+	-	E 5	-	-	par	start
UK	nat	Orth, nurse, assist	+	-	-	Sonksen; Keeler 4; 5	-	-	region	>95

Hearing

Information on neonatal hearing screening (NHS) programmes was obtained from 38 countries including two regions: Flanders and Wallonia in Belgium. No information could be obtained from Macedonia.

Nation-wide universal NHS programmes are present in 33 out of 38 countries. Malta has a nation-wide selective screening programme only for infants from neonatal and paediatric IC units. In Bulgaria, Moldova and Serbia local selective screening programmes for risk groups (premature new-borns) exist. Albania had for a few years a pilot nation-wide universal screening programme, which was discontinued due to lack of funds.

Tests

The most widely used audiometric test is otoacoustic emission (OAE). Flanders has used automated auditory brainstem response (aABR) in all neonates, but in 2013 measurement of aABR plus auditory steady state responses (ASSR) were introduced. Some regions in Denmark, Estonia, France, Germany, Spain and Sweden use aABR, OAE or both in the same infant as first test in well babies. In nearly all programmes both ears are tested. Exceptions are Finland and Switzerland where one or two ears are tested depending on the institution or the presence of risk factors. Testing is not staged in five countries, two-staged in 13 countries, three-staged in 19 countries and 4-staged in one country. aABR is used as final stage in the majority of countries. In risk groups such as premature new-borns, most programmes use aABR or a combination of OAE and aABR, but in eight countries OAE only is used. In Wallonia (Belgium) all premature infants undergo full ABR.

A hearing test in pre-school or early school age children is in less than half of the countries a regular part of health screening programmes in children.

Referral

Neonates who do not pass the test are in most countries referred to a combined audiology / ear, nose, throat (ENT) institution, in some countries to an audiologist and in a few countries to an ENT specialist.

Funding

In most countries the government or health insurance finances the neonatal hearing screening programme. Other reported funding includes hospital, parents and private funds.

Coverage

Universal NHS programmes have a coverage of an estimated 10-50% in Romania, 50-95% in nine countries, and more than 95% in 23 other countries. Malta has a nation-wide selective screening programme with a good coverage, whereas Bulgaria, Moldova and Serbia have local selective screening programmes, with a low coverage. Albania had for a few years a pilot nation-wide universal screening programme with a low coverage.

Data is presented in more detail in table 3 and Map 2.

Table 3. Overview of neonatal hearing screening programmes in 38 European countries. **Scope** = scope of hearing screening programme (nat = nation-wide, loc = local, past = pilot from 2004-2008), **Strat =** screening strategy (all = all neonates, select = only neonates at risk e.g. prematures), **Test =** test used for well babies in the programme (first test when staged)(test a or test b = both tests are used in the programme, test a + test b = both tests are used in one neonate), **St =** stages (number of tests before referral), **last test** = test before referral if staged, **ears =** ears tested (both or only the first ear with a pass), **test risk group** = test used in neonates at risk (first test when staged), **refer =** referred to ENT, audiological institution or a combination (both), **funding = (**insur = health insurance**,** hosp = hospital, par = parents, NGO = non-government organization, int. project = international project), **Cov** = **coverage** (infants screened / infants meant to be screened x 100), **child**: standard hearing test in screening programme at child age.

Country	Scope	Strat	Test	St	Last test	Ears	Test risk group	Refer	Funding	Cov (%)	Child
Albania	past	all	OAE	3	full ABR	2	OAE	ENT	private	<10	-
Austria	nat	all	OAE	3	aABR	2	OAE	audio	state	>95	-
Belgium (Fl)	nat	all	aABR+ ASSR	2	aABR	2	aABR + ASSR	audio	state	>95	
Belgium (W)	nat	all	OAE	2	full ABR	2	full ABR	both	par, state	90	-
Bulgaria	loc	select	OAE	2	aABR	2	aABR	both	private, hosp	25	
Croatia	nat	all	OAE	3	aABR	2	aABR	both	insur	>95	-
Cyprus	nat	all	OAE	3	aABR	2	aABR	audio	NGO	>95	+
Czech rep	nat	all	OAE	1		2	OAE	ENT	insur	>50	
Denmark	nat	all	OAE or aABR	2	aABR	2	OAE+aABR	audio	state	>95	+
Estonia	nat	all	OAE or aABR	3	aABR	2	OAE	both	insur	>95	+
Finland	nat	all	OAE	2	OAE	1/2	aABR	both	state	>95	+
France	nat	all	OAE or aABR	3	aABR or full ABR	2	aABR	both	state	>50	+
Germany	nat	all	OAE or aABR	2	aABR	2	aABR	both	insur	>95	+
Greece	nat	all	OAE	1		2	aABR	both	par	>50	+
Hungary	nat	all	OAE	2	OAE	2	aABR	both	insur, state	>50	+
Iceland	nat	all	OAE	3	aABR	2	OAE	both	state	>50	-
Ireland	nat	all	OAE	2	aABR	2	OAE+aABR	audio	state	>95	-
Israel	nat	all	OAE	3	aABR	2	OAE+aABR	audio	state	>95	+
Italy	nat	all	OAE	3	aABR	2	OAE+aABR	both	hosp	70	
Latvia	nat	all	OAE	3	ABR	2	aABR and/or other	both	state	>95	+
Lithuania	nat	all	OAE	3	aABR	2	OAE+aABR	both	insur	50-90	-
Luxembourg	nat	all	OAE	2	OAE	2	aABR	ENT	state	>95	+
Malta	nat	select	OAE	1		2	aABR	both	state	>95	
Moldova	loc	select	OAE	2	aABR	2	OAE	both	int. project	>50	-
Montenegro	nat	all	OAE	4	aABR	2	aABR	both	state	>95	-
Netherlands	nat	all	OAE	3	aABR	2	aABR	audio	state	>95	+
Norway	nat	all	OAE	3	aABR or full ABR	2	aABR	both	state	>95	
Poland	nat	all	OAE	2	OAE	2	OAE	both	insur	>95	-
Portugal	nat	all	OAE	3	aABR	2	aABR	both	hosp	>95	-
Romania	nat	all	OAE	2	aABR	2	OAE+aABR	both	state	>10	-
Serbia	loc	select	OAE	1		2	OAE	both	hosp	25	+
Slovenia	nat	all	OAE	3	aABR	2	aABR	both	insur	>95	-
Slovakia	nat	all	OAE	2	OAE	2	aABR	both	insur, state	>95	
Spain	nat	all	OAE or OAE+aABR	3	aABR	2	aABR or OAE+aABR	audio	state	>95	-
Sweden	nat	all	OAE or aABR	3	aABR or full ABR	2	OAE+aABR or aABR	both	state	>95	+
Switzerland	nat	all	OAE	1		1/2	OAE or aABR	both	hosp	>95	+
Turkey	nat	all	OAE	3	aABR	2	aABR	both	state	90	
UK	nat	all	OAE	3	aABR	2	aABR	audio	state	>95	+

Public-health

Extra information on public-health screening programmes was obtained from 23 countries including one region in Belgium (Flanders).

All 23 countries have a public health screening programme in place, but in Albania, Belgium and Spain this is a regional programme. In the Netherlands and Sweden there is a combination of national and regional programmes in place. Almost all countries have a programme for all children, except for Albania where there is only selective screening available. Screening is not free of charge in Albania, Bulgaria and Czech Republic and is obligatory in Bulgaria, Flanders, Greece, Hungary and Turkey.

Tests

Weight, height and head circumference are measured in all countries, cardiac function in all but Albania, lung function in all but Albania and Flanders, vision in all but Albania and Turkey, hearing in all but Albania and Malta, motor skills in all but Czech Republic and the UK, speech and language development in all but Albania, Bulgaria, Czech Republic and the UK, cognitive development in all but Albania, Czech Republic, Flanders and the UK and psychosocial development is screened in all countries but Albania, Bulgaria, Czech Republic, Flanders, Germany, Israel, Sweden and the UK.

Referral, funding and coverage

Referral is most often to a specialist. Funding is provided mostly by the government or health insurance. Coverage is above 80% in all countries, except Albania.

Data is presented in more detail in table 4 and Map 3.

Table 4. Public health screening programmes in 23 European countries. **Scope** = public-health screening programme (nat = nation-wide, loc = local), **All** = screening programme for all children, **WHH** = weight, height and head circumference, **Cog** = cognitive development, **Psycho** = psychosocial aspects, **Funding** (insur = Health Insurance, par = parents, munic = Municipalities) **Cov** = Coverage)

Country	**Scope**	**All**	**Vision**	**Hearing**	**WHH**	**Heart**	**Lung**	**Motor**	**Speech**	**Cog**	**Psycho**	**Funding**	**Cov (%)**
Albania	loc	-	-	-	+	-	-	+	-	-	-	state, par	>10
Belgium (Fl)	nat	+	+	+	+	+	-	+	+	-	-	state	>95
Bulgaria	nat	+	+	+	+	+	+	+	-	+	-	state, insur	>95
Croatia	nat	+	+	+	+	+	+	+	+	+	+	insur	>95
Czech rep	nat	+	+	+	+	+	+	-	-	-	-	insur	>80
Finland	nat	+	+	+	+	+	+	+	+	+	+	state, munic	>95
France	nat	+	+	+	+	+	+	+	+	+	+	state	>95
Germany	nat	+	+	+	+	+	+	+	+	+	-	insur	>80
Greece	nat	+	+	+	+	+	+	+	+	+	+	state, par	
Hungary	nat	+	+	+	+	+	+	+	+	+		state	>95
Iceland	nat	+	+	+	+	+	+	+	+	+	+	state	>95
Israel	nat	+	+	+	+	+	+	+	+	+	-	state	>95
Macedonia	nat	+	+	+	+	+	+	+	+	+	+	state, insur	>95
Malta	nat	+	+	-	+	+	+	+	+	+	+	state	>95
Montenegro	nat	+	+	+	+	+	+	+	+	+	+	insur	>95
Netherlands	nat	+	+	+	+	+	+	+	+	+	+	state, munic	>95
Portugal	nat	+	+	+	+	+	+	+	+	+	+	state	>95
Serbia	nat	+	+	+	+	+	+	+	+	+	+	insur	>80
Slovenia	nat	+	+	+	+	+	+	+	+	+	+	insur	>95
Spain	loc	+	+	+	+	+	+	+	+	+	+	state	>95
Sweden	nat	+	+	+	+	+	+	+	+	+	-		>95
Turkey	nat	+	-	+	+	+	+	+	+	+	+	state	>95
UK	nat	+	+	+	+	+	+	-	-	-	-	state	

Questionnaire answer check

Several changes were made based on the first round of questionnaire answers. The following changes in hearing screening data were made: for Belgium (Flanders) the ASSR was added as test for neonates at risk. For Finland "testing one ear" was changed to "testing one ear or both ears". For France "testing one ear and testing both ears" was changed to "always testing both ears". For Italy coverage of "> 95%" was changed to "70%". For Malta selective screening, and not population-wide screening, was confirmed. For Poland "non-staged screening" was changed in "staged screening". For Israel, Italy, Lithuania and Switzerland "only aABR testing" for neonates at risk was corrected to "OAE and/or aABR".

Vision screening data was revised: for Austria funding was changed from "health insurance" to "health insurance and state". For Belgium (Flanders) personnel was changed from "nurse" to "nurse and youth health care physician", testing of stereopsis and colour vision was added and VA chart was changed from "Landolt C" to "Pictures and HOTV". For Croatia VA chart was changed from "only Tumbling E" to "Pictures, Lea and Tubling E". For Czech Republic Pictures and Lea chart were added. For Denmark the "Snellen chart" was changed to "Pictures" and coverage was changed from ">80%" to ">95%". For Iceland Snellen chart was added. For Israel coverage was changed from ">95%" to ">80%". For Italy funding was changed from "state" to "regions". For Latvia "Picture chart and Tumbling E" was corrected to "Cardiff, Pictures, Tumbling E and numbers". For Norway the Sheridan Gardiner chart was added. For Slovenia autorefraction was corrected as in Slovenia autorefraction is only performed in ophthalmology clinics for referred children and not for screening. For Sweden the Konstantin Moutakis chart was added. For the UK funding was corrected from "state" to "regions", and personnel were changed from "orthoptist, optician and optometrist" to "orthoptist, nurse and practice assistant".

DISCUSSION

This study assessed population-based vision and hearing screening programmes in all EU countries. We showed that large differences exist in paediatric population-based vision and hearing screening programmes throughout the EU. Large differences were found in tests used, age and frequency of testing. First measurement of VA varies from three to seven years of age, but in most countries it is measured before the age of five. In children age three and four picture charts, including Lea Hyvarinen are used most, in children over four Tumbling E and Snellen. Vision screening is performed mostly by paediatricians, ophthalmologists or nurses. As first hearing screening test, otoacoustic emission (OAE) is used most in healthy neonates and auditory brainstem response (ABR) in premature newborns. The majority of hearing testing programmes are staged. Children are referred after one, two, three or four abnormal tests. Funding is by health insurance, state, regions, municipalities, charity, hospital, parents or private funding. A high coverage is reached in most countries for both vision and hearing screening.

Our study was limited by the difficulty in obtaining referenced or first-hand data sources from respondents. We have where possible tried to maintain the quality of our data by involving clinicians who were involved in population based screening, and cross-checking their answers with the answers given by the general screening professionals. It was most difficult to get accurate information on funding and coverage, while information on tests, personnel and age was easier to obtain. The percentage of coverage may have been overestimated by the country representatives

Screening of vision and hearing deficits has similarities, but also differences. An essential difference between vision and hearing screening is that objective tests are available for hearing screening at a very early age, enabling screening directly after birth. This probably is the reason for the more uniform approach and higher coverage that was reported for hearing screening as compared to vision screening. As we assumed that the personnel operating the screening apparatus at the hospital or during home visits would be a technician, we did not ask the profession explicitly. There are only two tests for hearing screening available; OAE and aABR. The major difference in hearing screening is primarily the number of screening stages before referral. Multiple stage screening is more expensive, but results in a larger specificity, which reduces the number of false referrals to specialized and expensive audiological care centres.[23,26] Two or three stages of screening before referral is most frequently used, with mostly OAE as first test and aABR as last test. Boshuizen et al. calculated that three stages is preferable in terms of cost-effectiveness, but this is not based on combined use of OAE and aABR.[26] A hearing test in pre-school or early school-age children has the potential to discover hearing loss acquired during the years after birth, which occurs more rarely. These tests have been abolished in many countries in Europe.

In our opinion the large diversity in screening programmes may have resulted from the fact that these programmes arose piecemeal prior to the reporting of any robust evidence on effectiveness and cost-effectiveness to guide protocol design or implementation. Another reason could be that in addition most of the preventive health care programmes are government funded and, therefore, competition is lower than in curative health-care. Careful assessment is needed of the influence of the kind of funding (e.g. state, health insurance or municipalities) on the efficiency of screening.

The large differences found in population-wide vision and hearing screening in children in all EU countries necessitate further study on the relative costs and effectiveness of the different approaches to screening. For instance 12 different VA charts are used, 10 professions are involved in vision screening, one to four hearing screening tests take place before referral and eight funding sources are involved. The large number of screening tests used in vision screening should be compared. Efficiency of screening (i.e. sensitivity and specificity per euro) should be calculated for screening performed by different screening professions.

We plan to extend the questionnaire and include data sources in a much larger and more detailed questionnaire. The EUS€REEN study group, an EU-wide consortium (appendix), is currently preparing a Europe-wide study to compare and optimise the cost-effectiveness of vision and hearing screening and give country-specific advice in all candidate, associate and full EU-member states.

APPENDIX A

EUS€REEN consortium: EU vision:
Austria: Langmann A; Lindner S; Gaugl H (Medical University Graz), Belgium Flanders: ten Tusscher M (University Clinic Brussel), Guérin C; Hoppenbrouwers K, van Lammeren M (University Leuven), Boelaert K (Kind en gezin, Brussel), Godts D (University Hospital Antwerp), Belgium Wallonia: Paris V (CHU de Liège), Bauwens A (Bastogne), Bulgaria: Stateva D (Medical University Pleven), Croatia: Petrinovic-Doresic J; Bjelos M (University Eye Clinic University Hospital "Sveti Duh", Zagreb), Novak-Stroligo M (Clinical Hospital Rijeka), Alpeza-Dunato Z (Rijeka University Hospital Center), Cyprus: Gavrielides Michaeloudes M, Czech Republic: Dostálek M (Center of Paediatric Ophthalmology, BINOCULAR s.r.o. Litomysl & Masaryk's University, Brno), Zobanova A (Prague), Jerabkova A, Denmark: Hesgaard H, Welinder LG (Aalborg University Hospital), Sandfeld L (University of Copenhagen, Roskilde Hospital), Larsen S (Squinting Eyes, Copenhagen), Estonia: Levin M (Ida-Tallinn Central Hospital), Klett A; Somma K (Tallinn), Ismagilova S, Finland: Hyvärinen L (Developmental Neuropsychology, University of Helsinki), France: Thouvenin D (Purpan University Hospital, Toulouse), Coursager K, Germany: Elflein H; Pitz S (University Hospital, Johannes Gutenberg-University, Mainz), Lenk-Schaefer M (Nürnberg), Van-Waveren M (Tübingen), Greece: Ziakas NG (Aristotle University Thessaloniki), Polychroniadis Scouros S (Hygeia Hospital Athens), Hungary: Knezy K; Nemeth J (Semmelweis University, Budapest), Soproni A (Anna Soproni's Private Eye Clinic Budapest), Facskó A; Berkes S (University of Szeged), Iceland: Gudmundsdottir E (Landspitalinn, University of Iceland, Reykjavik), Ireland: McCreery K (Blackrock Clinic, Dublin), Israel: Morad Y (Assaf Harofeh Medical Center, Tel Aviv University, Zrifin), Ancri O (Goldschleger Eye Institute, Sheba Medical Center, Sackler Faculty of Medicine, Tel Aviv University), Italy: Nucci P; Serafino M; Lembo A (University Hospital San Giuseppe, Milan), Bottin D (Hospital of Bolzano), Latvia: Valeina S (Riga Children's University Hospital), Lithuania: Misevice A (Clinic of Ophthalmology, Kaunas University of Medicine), Asoklis RS (ENT and Eye Clinic, Vilnius, Lithuania), Luxembourg: Planata-Bogdan B (Service Orthoptique et Pléoptique, Esch-sur-Alzette), Malta: Francalanza M (Mater Dei Hospital, Malta) MJ Gouder, Montenegro: Jovovic N; Pojuzina N (Children's Hospital, Podgorica), Netherlands: Sjoerdsma T (Municipal Health Service, Amsterdam), van Rijn R (VU University Medical Center, Amsterdam), Norway: Osnes-Ringen O, Moe M (Center for Eye Research, Oslo University Hospital), Poland: Bakunowicz-Lazarczyk A (Medical University of Bialystok), Portugal: Reich-d'Almeida F (Faculty of Medical Sciences New University Lisbon), Marques Neves C (Centro Hospitalar de Lisboa Norte, Lisbon), Reich d' Almeida I, Oliveira M, Romania: Vladutiu C *(Clinica Oftalmologică Cluj*-Napoca), Serbia: Stankovic B; Djokić V (University of Belgrade Clinical Center of Serbia), Slovakia: Gerinec A (Klinika Detskej Oftalmológie DFNsP-LF UK, Bratislava), Slovenia: Stirn Kranjc B (University Medical Centre, Ljubljana), Spain: Gomez-de-Liano Sanchez R (Hospital Clínico San Carlos, Madrid), Rajmil L; Prats B (Catalan Agency for Health Quality and Assessment), Sweden: Nilsson J (Institute of Neuroscience and Physiology, The Sahlgrenska Academy, University Gothenburg), Flodin S (The Sahlgrenska Academy, University Gothenburg), Switzerland: Landau K (University of Zurich), Sturm V (Kantonhospital St. Gallen), Zuber C (Cabinet orthoptie Neuchâtel et La Chaux-de-Fonds), Glauser V, Turkey: Atilla H (Ankara University), UK: Horwood AM (University of Reading), Williams C (University of Bristol), Shea S (Orthoptic Department, North West Wales NHS Trust, Ysbyty Gwynedd, Bangor), Griffiths H; J Carlton (University of Sheffield).

EUS€REEN consortium: EU hearing:
Albania: Birkena Qirjazi, (University of Medicine of Tirana), Austria: Markus Gugatschka, (Medical university Graz), Belgium Flanders: Luc Stappaerts (Kind en Gezin, Brussels), Belgium Wallonia: Bénédicte Vos (Centre d'Epidémiologie Périnatale-School of Public Health/Université libre de Bruxelles, Brussels), Bulgaria: Mario Milkov (St. Petka Eye and Ear Clinic, Varna), Croatia: Marko Velepic (Rijeka University Hospital Center, Rijeka), Cyprus: Chryssoula Thodi (European University Cyprus, UNHS Programmeme), Czech Rep: Josef Syka (Czech Academy of Science, Prague), Denmark: Therese Ovesen (Aarhus University Hospital), Estonia: Liina Luht (East Tallinn Central Hospital), Finland: Riina Niemensivu; Antii Aarnisalo (Helsinki University Hospital), France: Françoise Denoyelle (Hopital Necker-Enfants Malades, Paris), Germany: Annerose Keilmann (Johannes Gutenberg-Universität Mainz), Katrin Neumann (Ruhr-University Bochum), Greece: Thomas Nikolopoulos (Athens University School of Medicine), Hungary: Zsolt Beke (Sanct Rokus Hospital, Baja), Iceland: Ingibjörg Hinriksdóttir (National Hearing and Speech Institute of Iceland, Símí), Ireland: Ann O'Connor (RCSI Surgery, Dublin),Israel: Lisa Rubin (Public Health Service, Ministry of Health, Jerusalem), Italy: Patrizia Trevisi; Alessandro Martini (University of Padova), Ferdinando Grandori, (Institute of Biomedical Engineering, Milan), Latvia: Sandra Kušķe (Latvia Children Hearing center), Lithuania: Eugenijus Lesinskas (University Hospital Santariskiu Clinics, Vilnius), Luxembourg: Jean Marc Hild (Services Audiophonologiques, Strassen), Malta: Anthony Fenech, (Mater Dei Hospital, Msida), Moldova: Anghelina Chiaburu (Republican Center of Audiology, Chisinau), Montenegro: Ognjen Jovicevic, (Institute for Children's disease, Clinical Center of Montenegro, Podgorica), Norway: Karl Nordfalk; Sverre Medbø (Universitetssykehus, Oslo), Poland: Witold Szyfter, Grażyna Greczka (*University of Medical Sciences, Poznań*), Portugal: Luisa Monteiro (Lisbon), Romania: Madalina Georgescu, (University of Medicine and Pharmacy, Bucharest),Serbia: Snezana Andric Filipovic (Clinical Center of Serbia, Clinic of ENT and Maxillofacial Surgery, Belgrade), Slovakia: Gabriela Pavlovcinova, Milan Profant (University Hospital Bratislava), Slovenia: Saba Battelino; Irena Hocevar Boletezar (University Medical Center, Ljubljana), Spain: Faustino Núñez-Batalla (Hospital Universitario Central de Asturias), Oviedo Javier Cervera (Hospital Infantil Universitario Niño Jesús, Madrid), Sweden: Inger Uhlén, (Karolinska University Hospital, Stockholm), Switzerland: Dorothe Veraguth, (University Hospital Zürich), Turkey: Huban Atilla (University Ankara), UK: Gwen Carr; Adrian Davis; Adam Bruderer (UCL Ear Institute, London), Tony Sirimanna, (Great Ormond Street Hospital for Children, London)

EUS€REEN consortium: EU Public health:
Albania: Qirjazi B (Faculty of Medicine, Science Medical University of Tirana), Belgium Flanders: Hoppenbrouwers K; Guérin C (KU University Leuven), Bulgaria: Georgieva L (Faculty of Public Health, Medical University, Sofia), Croatia: Rukavina T (University Rijeka School Medicine), Czech Republic: Bourek A (Masaryk University), Finland: Hietanen-Peltola M (The National Institute of Health and Welfare), France: Jégat C (Association Nationale pour l'Amélioration de la Vue Paris), Germany: Ottová-Jordan V(University Medical Center Hamburg-Eppendorf), Greece: Polychroniadis Scouros S (Hygeia Hospital Athens), Hungary: Kovacs A (Scientific Committee at Association of Primary Care Paediatricians), Iceland: Jónsdóttir LS (Directorate of Health), Israel: Morad Y (Department of Ophthalmology, Assaf Harofeh Medical Center, Tel Aviv University, Zrifin); Grotto I (Israel Ministry of Health), Malta: Farrugia Sant'Angelo V (Ministry for Health, Floriana, Malta), Macedonia: Memeti S (Institute of Public Health of the Republic of Macedonia), Montenegro: Mugosa B, (Institute of Public Health of Montenegro, Podgorica), Netherlands: Raat H (Department of Public Health, Erasmus Medical Center Rotterdam), Portugal: Gaspar T (Institute of Psychology and Educational Sciences, Lusiada University, Lisbon), Serbia: Zivkovic Sulovic M (Institute of public health of Serbia), Slovenia: Juricic M (University of Ljubljana, Medical Faculty), Spain: Rajmil L (Catalan Agency for Health Quality and Assessment), Sweden: Hjern A, (Karolinska Institutet), Turkey: Atilla H (Ankara University), UK: Dahlmann-Noor A (NIHR Biomedical Research Centre at Moorfields Eye Hospital and UCL Institute of Ophthalmology)

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APPENDIX B

Glossary:

aABR: automated Auditory Brainstem Response; detects responses in the brainstem after offering clicks of 35 or 40 dB via headphones.

Amblyopia (lazy eye): reduced vision, usually in one eye caused by abnormal visual experience in early childhood e.g. strabismus and refractive error.

Bruckner test: A direct ophthalmoscope is used in a darkened room and the red reflex in both eyes is assessed simultaneously at 0.6 to 0.9 metres. The colour and brightness of the red reflexes are compared. The colour is often more orange than red. The test is easy and quick to perform and can reliably detect media opacities. Strabismus and refractive error can also be detected, but with a lower sensitivity. Refractive error can give a yellow-white edge to a red reflex.

Hirschberg test: corneal light reflex test. The corneal light reflex test is performed to assess ocular alignment. The test is performed by shining a light into the child eyes from a distance and observing the reflections on the cornea with respect to the pupil. The location of the light reflexes should be symmetric.

OAE: Otoacoustic emissions; sounds produced by inner ear hair cells if the hearing threshold is better than 35 dB and picked up by a microphone in the ear canal.

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DATA SUPPLEMENT

Q1

in your country is there a:										
Public-health screening programme?	None	Regional	National	Employer-based	Other					
Eye screening programme?	None	Regional	National	Employer-based	Other					
Who pays for eye screening?	Parents	Health Insurance	Councils	Provinces-Regions	State	Parents employer	Companies		Charity	Other
Who does the eye screening?	Ophthalmologist	Orthoptist	Paediatrician	Youth health care physician	Nurse	Ophth practice assistant	Optometrist	Optician	School physician	Other:
Coverage among eligible children?	>95%	>90%	>80%	>60%	>40%	>20%	>10%	<10%	Just starting	Other:
Parents' secondary benefits:	Eye exam is free	Eye exam is cheap	Financial reward	During working hours	Condition for school entry	Free glasses	Obligatory			Other:
Infant eye-screening tests?	Inspection	Fixation	Red fundus reflex	Hirschberg	Brückner	Cover test	Pupillary reflexes	Motility		Other:
At approx	1 week	2 weeks	3 weeks	1 month	6 weeks	2 months	10 weeks	3 months	4 months	Other:
Preverbal eye-screening tests?	Inspection	Fixation	Red fundus reflex	Brückner	Pupillary reflexes	Motility	Hirschberg	Cover test		Other:
at approx	6 months	9 months	1 year	15 months	18 months	21 months	2 years	27 months	30 months	Other:
Autorefraction photoscreening at:	6 months	9 months	1 year	15 months	18 months	21 months	2 years	27 months	30 months	Other:
Preschool eye screening?	Inspection	Fixation	Red fundus reflex	Brückner	Pupillary reflexes	Motility	Hirschberg	Cover test		Other:
visual acuity measured with:	Picture chart	Lea Hyvarinen	HOTV	Tumbling E	Landolt C	Snellen	Also:	Stereopsis	Color vision	Other:
at approx	3 years	3,5 years	4 years	4,5 years	5 years	5,5 years	6 years	6,5 years	7 years	Other:
Positively screened children referred to:	General practitioner	Ophthalmologist	Orthoptist	Optician	Optometrist					Other:

Q2

In your country is there a:				
Public-health screening programme for children?	no	regional	national	other
Neonatal hearing screening programme (NHS)	no	regional	national	other
In what year approximately did the programme start?				
How is the NHS programme financed?	parents	hospital	government	health insurance
What % of neonates are actually screened?	>95%	>50%	>10%	<10%
Which test is used for NHS?	OAE	aABR	other	
Different test for neonates at risk, f.e. prematures?	no	aABR	other	
Are both ears tested?	one ear	both ears		
Is NHS staged?	no	OAE-aABR	OAE-OAE-aABR	other
Is NHS in your country	universal?	selective?		
What is the follow up if a neonate tests positive on NHS?	audiologic examination	ENT	combination	other

Q3

In your country is there a:										
Public-health screening programme for children?	no	national	regional							other
In what year did the programme start?										
General or selective screening	no screening	general	selective		risk groups					
Who pays for the screening programme?	parents	charity	hospital	government	health insurance					other
Parents' secondary benefits:	exam is free of charge	exam is cheap	financial reward	during working hours	obligatory					other
Coverage among eligible children?	>95%	>80%	>50%	>10%	<10%					
At what age is screening performed?										
Are the following tests performed	weight, height, head circumference	heart	lung	vision	hearing	motor skills	speech and language	cognitive development	Psycho social aspects	other
Who performs the screening?	doctors	paramedic	nurses	screening physician	school physician					other
Positively screened children are referred to:	GP	hospital	specialist	private clinics						other