Summary: Hearing Screening

Iceland

Produced as part of Work Package 4

Date: 2019-06-05

Allison Mackey & Inger Uhlén
Karolinska Institutet, Stockholm Sweden

Hearing screening representative for Iceland: Ingibjorg Hinriksdottir, Chief Physician at The National Hearing and Speech Institute of Iceland

Disclaimer: This is a summary report representing the responses from a screening expert working within hearing care services of the country or region reported. This report is the product of professional research conducted for the EUSCREEN study and does not represent conclusions made by the authors. It is not meant to represent the position or opinions of the EUSCREEN study or its Partners. Efforts were made to cross-check the information supplied; however, not all information supplied is fully verified by the authors.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 733352

Table of Contents

List of Tables

1. Glossary of Terms: Hearing Screening

Abnormal test result	A test result where a normal "pass" response could not be detected under good conditions. The result on screening equipment may indicate "no response," "fail," or "refer."
Attendance rate	The proportion of all those invited for screening that are tested and receive a result, • Invited for screening includes all those that are offered the screening test. • Tested and receive a result could be a "pass" or "fail". Attendance rate provides information on the willingness of families to participate in screening.
Attendance rate in first year of life	See definition of **Attendance rate.** The calculation cut-off is after one year of life.
Compliance with referral (percentage)	The percentage of those who are referred from screening to a diagnostic assessment that actually attend the first diagnostic assessment. Percentage of compliance provides information on the willingness of families to attend the diagnostic assessment after referral from screening.
Coverage	The proportion of those eligible for screening that are tested and receive a result within a specific time. • Eligible for screening includes those within the population that are covered under the screening or health care program. • Tested and receive a result could be a "pass" or "refer to diagnostic assessment". • Specific time can be defined, such as 1 month after birth, 3 months after birth, etc. Coverage provides information on the overall effectiveness and timeliness of a complete screening programme. Factors such as being offered screening, willingness to participate, missed screening, ability to complete the screen, and ability to document the screening results will influence the coverage.
Coverage in first year of life	See definition of **Coverage.** The specific time is pre-defined as within the first year of life. In other words, the coverage is the proportion of those eligible for screening that complete the screening sequence to a final result within the first year of life.
False negatives	The percentage of infants/children with a hearing loss (defined by the target condition) that receive a result of "pass" during screening.

	Example: If 100 infants with hearing loss are screened, and 1 infant passes the screening, the percentage of false negatives is 1%.
False positives	The percentage of infants/children with normal hearing that receive a result of "fail" from the final screening test. Example: If 100 infants with normal hearing are screened, and 3 infants fail the screening and are referred for diagnostic assessment, the percentage of false positives is 3%.
Guidelines	Recommendations or instructions provided by an authoritative body on the practice of screening in the country or region.
Hearing screening professional	A person qualified to perform hearing screening, according to the practice in your country or region.
Inconclusive test result	A test result where a normal "pass" response could not be detected due to poor test conditions.
Invited for screening	Offered screening.
Outcome of hearing screening	An indication of the effectiveness or performance of screening, such as a measurement of coverage rate, referral rate, number of infants detected, etc.
Permanent hearing loss	A hearing impairment that is *not* due to a temporary or transient condition such as middle ear fluid. Permanent hearing loss can be either sensorineural or permanent conductive.
Positive predictive value	The percentage of infants/children referred from screening who have a confirmed hearing loss, as described by your protocol or guideline and indicated in the **Target Condition** (see definition). For example, if 100 babies are referred from screening for diagnostic assessment and 90 have normal hearing while 10 have a confirmed hearing loss, the positive predictive value would be 10%.
Preschool or (pre)school children	All children between 3-6 years of age.
Preschool or (pre)school screening	Screening that takes place during the time children are between 3-6 years of age. This refers to *any* hearing screening during this age. The location of the screening is irrelevant to the definition.

Prevalence	The number or percentage of individuals with a specific disease or condition. Prevalence can either be expressed as a percentage, proportion, or as the value per 1000 individuals within the same demographic.
Programme	An organized system for screening, which could be based nationally, regionally or locally.
Protocol	Documented procedure or sequence for screening, which could include which tests are performed, when tests are performed, procedures for passing and referring, and so forth.
Quality assurance	A method for checking and ensuring that screening is functioning adequately and meeting set goals and benchmarks.
Referral criteria	A pre-determined cut-off boundary for when an infant/child should be re-tested or seen for a diagnostic assessment. For example, referral criteria may be "no response" at 35 dB nHL.
Risk babies / Babies at-risk	All infants that are considered to be at-risk or have risk-factors for hearing loss according to the screening programme. Two common risk factors are admission to the neonatal-intensive care unit (NICU) or born prematurely. However, other risk factors for hearing loss may also be indicated in the screening programme.
Sensitivity	The percentage of infants/children with hearing loss that are identified via the screening program. For example, if 100 babies with hearing loss are tested, and 98 of these babies are referred for diagnostic assessment while 2 pass the screening, the sensitivity is 98%.
Specificity	The percentage of infants/children with normal hearing that pass the screening. For example, if 100 babies with normal hearing are tested, and 10 of these babies are referred for diagnostic assessment and 90 pass the screening, the specificity is 90%.
Target condition	The hearing loss condition you are aiming to detect via your screening programme. This includes: • The laterality of the condition, whether the program aims to detect both unilateral and bilateral hearing loss or just bilateral hearing loss. • The severity of the condition, whether the program aims to detect hearing loss ≥ 30 dB HL, ≥ 35 dB HL, ≥ 40 dB HL or ≥ 45 dB HL
Well, healthy babies	Infants who are *not* admitted into the NICU or born prematurely. Well, healthy babies may or may not have additional risk factors for hearing loss, according to the procedures indicated in the specific screening programme.

2. Abbreviations

ABR – auditory brainstem response

aABR – automatic auditory brainstem response

ANSD – auditory neuropathy spectrum disorder

ASSR – auditory steady-state response

CI – cochlear implant

CMV – cytomegalovirus

dB HL – decibel hearing level

dB nHL – decibel normalized hearing level

dB SNR – decibel signal-to-noise ratio

DPOAE – distortion product otoacoustic emissions

HA – hearing aid

NICU – neonatal intensive care unit

OAE – otoacoustic emissions

TEOAE – transient-evoked otoacoustic emissions

3. Background

In Iceland, hearing screening is performed nationally and also organized nationally. The following report contains information with regards to hearing screening in the entire country of Iceland.

3.1. General

The total country of Iceland has an area of 103 000 km^2 with a population of 348 450 as of January 1, 2018 (Statistics Iceland, 2018).

In Iceland, all births are registered. The number of live births in Iceland in 2017 was 4071 (Statistics Iceland, 2018).

The World Bank income classification categorizes Iceland as a high-income country (The World Bank, 2018). The gross domestic product (GDP) in 2015 was €41 928 per capita (Statistics Iceland, 2018).

From the World Health Organization (WHO) Global Health Expenditure Database, health expenditure for Iceland in 2015 was 4282 USD or €3733 per capita (World Health Organization (WHO), 2018).

An infant mortality rate of 2.1 per 1000 is reported for Iceland for 2015 (Statistics Iceland, 2018). The United Nations does not provide infant mortality rates due to low number of infants born per year (United Nations Statistics Division, 2016).

3.2. Neonatal hearing screening

In the country of Iceland, neonatal hearing screening is conducted universally, with all babies in the country having access to hearing screening, though screening is not obligatory for parents. The universal program for well babies was first implemented in 2007, and by 2009, neonatal hearing screening was available across the country. Screening for at-risk infants began much earlier in 1982. Neonatal hearing screening is embedded in the Preventive Child Health Care screening system. Screening is organized and coordinated through the National Hearing and Speech Institute. The institute is part of the Icelandic health care system financed by the government.

In Iceland, the same hearing screening protocol is followed across the country.

3.3. Preschool hearing screening

In Iceland, preschool hearing screening is not performed.

4. Guidelines & Quality Control

National guidelines for hearing screening exist in Iceland.

The content of hearing screening programme was decided on by the National Hearing and Speech Institute, where certain employees take care of the neonatal hearing screening programme. The hearing division is made up of a medical doctor, an audiologist and an audiologist assistant. The content of the screening programme was changed in 2009 when neonatal hearing screening was included nationally and in 2012 when preschool hearing screening was terminated. The revision/review process is performed every 2 years through a meeting of National Hearing and Speech Institute. The revision process is funded through the state.

Quality assurance of hearing screening programmes is not imposed by the government; however, information is collected about hearing screening outcomes through a collection of results at the National Hearing and Speech Institute. At this time, data are aggregated for well babies only. Data for at-risk infants are collected, but not sent to the National Hearing and Speech Institute.

Data are collected at the National Hearing and Speech Institute for well and at-risk babies combined; however, it is not indicated whether reports are regularly produced from these collected data. Research has been performed on hearing screening in Iceland apart from auditing, though not on a regular basis. A cost-effectiveness study has not been performed.

5. Process: Screening, Diagnosis, Intervention

5.1. Neonatal hearing screening

Well-babies are screened in the hospital or at Child Health Care Centres, and at-risk babies are screened in the hospital/NICU. Well-baby families are invited to participate in neonatal screening as a part of the general preventive health care for newborns infants. Families of infants at-risk are invited for screening directly in person in the hospital. The staff of the National Hearing and Speech Institute and the staff at the maternity ward invite families to participate. Around 80-90% of infants are born in maternity hospitals. The average length of stay is not indicated.

It is roughly estimated that neonatal hearing screening for well-babies should be completed before 2-4 weeks of age, though this age may vary for infants born in rural areas. For at-risk infants, it is roughly estimated that screening should be completed by 8-12 weeks of age.

Data are unavailable regarding the percentage of infants screened with the at-risk protocol. At-risk infants are defined as those with a family history of hearing loss, a syndrome associated with hearing impairment, postnatal infections (e.g, CMV, asphyxia, intracranial hemorrhage, IPPV/ECMO), prematurity, NICU stay > 48 hours, or hyperbilirubinemia.

The prevalence of CMV infections and meningitis among neonates is registered when detected. In 2016, one neonate was diagnosed with CMV. This infant showed normal hearing.

The target condition for screening well babies is bilateral or unilateral hearing loss > 30 dB HL, and the target condition for screening at-risk babies is a bilateral or unilateral hearing loss > 30 dB HL as well as auditory neuropathy.

5.2. Neonatal diagnostic assessment

The diagnostic assessment should be performed by 12 weeks of age.

5.3. Preschool hearing screening

Preschool hearing screening is not performed in Iceland.

5.4. Intervention approach

In Iceland, treatment options available include grommets, hearing aids, bone conductive devices and cochlear implants. Infants are fitted with hearing aids from <6 months of age and cochlear implants from 6-12 months of age.

The hearing aid fitting criteria Iceland is a bilateral hearing loss of >20-25 dB HL depending on the frequencies or a unilateral hearing loss of 25-30 dB HL, depending on the frequencies of hearing loss.

6. Protocols

Hearing screening protocols are described for neonatal hearing screening (well and at-risk) as well as for preschool hearing screening when applicable.

- The Test performed is the screening technique used
- The Age of the child is indicated in hours, days, months or years
- Referral criteria may be the lack of an OAE response at specified frequencies, a response-waveform repeatability constant, the absence of an aABR response at a specified intensity, or an absent behavioural response at a specified intensity. Referral criteria may be defined within a protocol or limited based on the device used.
- The Device is the screening device used.
- Unilateral Referrals indicates whether children are referred if only one ear fails screening.
- The Location is where the screening takes place

6.1. Neonatal hearing screening (well)

TEOAE tests are performed every day at the two biggest maternity hospitals, and organized tours are made to the rural areas 2 to 4 times per year to test the infants born in the smaller villages. The screening process for well babies in Iceland is described in Table 1, whereby a 3-step OAE-OAE-aABR protocol is in place.

Table 1: Screening process for well babies in Iceland.

Test	Age	Referral criteria	Device	Unilateral Referrals?	Location
OAE1	<5 days (older in rural areas)	8x peaks of alternating-signs	Accuscreen	Yes	Maternity hospital / Child Health Care Centre
OAE2	≤ 10 days			Yes	Maternity hospital / Hearing Clinic
aABR	≤ 4 weeks (bilateral referral) ≤ 12 weeks (unilateral referral)	35 dB nHL		Yes	Hearing Clinic

6.2. Neonatal hearing screening (at-risk)

The protocol for testing at-risk infants is described below, whereby a 2-step TEOAE+aABR - aABR protocol is in place. Specifically, the first step is a combined OAE and aABR, and the second step is an aABR at lower intensity. The same protocol is followed across the country for at-risk infants; however, a personal family-centred approach is taken in rural areas to ensure contact is maintained.

Table 2: Screening process for at-risk babies in Iceland.

Test	Age	Referral criteria	Device	Unilateral Referrals?	Location
TEOAE +aABR	36-42 weeks gestation	8x peaks of alternating-signs 45 dB nHL	Accuscreen	Yes	NICU / Maternity hospital
aABR		35 dB nHL		Yes	

6.3. Preschool hearing screening

Not applicable.

7. Professionals

7.1. Neonatal hearing screening (well)

Screening for well babies is performed by nurses, midwives, audiologists or specially trained health care employees. There is accredited training for hearing screening staff. The training is offered and accredited through The National Hearing and Speech Institute, however, data are unavailable regarding the length of this training.

7.2. Neonatal hearing screening (at-risk)

Screening for at-risk infants is performed by the same professionals performing screening for well-infants.

7.3. Preschool hearing screening

Not applicable

8. Results: Neonatal Hearing Screening

8.1. Coverage and attendance rates

The coverage rate in Iceland for all babies from 2016 was calculated to be 92.6%, which is the total percentage of infants that have completed all stages of the screening (Hinriksdottir, 2017).

The number of infants that missed being *offered* screening is not specified, and therefore, attendance rate is not indicated.

8.2. Referral rates

Data are unavailable for pass and referral rates for each stage of the screening process.

In total, the referral rate to a diagnostic assessment after the screening process was 1.2% in 2016 for well-babies (Hinriksdottir, 2017).

8.3. Diagnostic assessment attendance

Data are unavailable regarding the compliance rate for a diagnostic assessment after neonatal hearing screening, but it is described as an exception if parents do not show up.

8.4. Prevalence / Diagnosis

The prevalence rate values of permanent hearing loss among neonates in Iceland are presented in Table 3.

There were 4 neonates in total diagnosed with hearing loss in 2016, two with bilateral hearing loss over 80 dB HL, one with unilateral hearing loss and one with mild HL (Hinriksdottir, 2017). Therefore, there are very few children with hearing loss in Iceland, which should be accounted for when interpreting prevalence rate figures.

Table 3: Prevalence of permanent hearing loss among all neonates in Iceland (per 1000; Hinriksdottir, 2017).

	Bilateral		Unilateral	
	≥ 40 dB	≥ 80 dB	≥ 40 dB	≥ 80 dB
Prevalence of permanent hearing loss among neonates (2016 data)	0.5	0.5	0.25	

The prevalence rate values of permanent hearing loss among pre-school aged children in Iceland are presented in Table 4.

Table 4: Prevalence of permanent hearing loss among preschool-age children in Iceland (per 1000; Hinriksdottir, 2017).

	Bilateral			Unilateral		
	≥ 25 dB	≥ 40 dB	≥ 80 dB	≥ 25 dB	≥ 40 dB	≥ 80 dB
Prevalence of permanent hearing loss among pre-school age children (2011-2016 data)	0.62	0.5	0.27	0.54	0.54	0.08

The prevalence values of permanent hearing loss among children in Iceland without having been screened in 2016 are presented in Table 5.

Table 5: Percentage of children diagnosed with permanent hearing loss in Iceland without being screened (%; Hinriksdottir, 2017).

	Bilateral		Unilateral	
	≥ 40 dB	≥ 80 dB	≥ 40 dB	≥ 80 dB
Percentage of children diagnosed without being screened (2016 data)	0	0	0.025	0

The prevalence of bilateral auditory neuropathy for both well-babies and NICU-babies was estimated to be 0 in Iceland.

8.5. Treatment success

In Iceland, 2 children with neonatal hearing impairment were fitted with hearing aids and 1 child was fitted with cochlear implants in 2016 (Hinriksdottir, 2017). Because Iceland is a small country, there is large variation from year to year regarding the number of children diagnosed and fitted with amplification.

8.6. Screening evaluation

In Iceland, all babies that were born in 2015 and 2016 who were diagnosed with hearing loss were referred from neonatal hearing screening. The percentage of false positives after neonatal hearing screening is roughly estimated to be about 1%.

The positive predictive value of a refer result is unavailable. Data are unavailable for all other measures of screening evaluation.

9. Results: Preschool Hearing Screening

9.1. Coverage and attendance rates

Not applicable

9.2. Referral rates

Not applicable

9.3. Diagnostic assessment attendance

Not applicable.

9.4. Screening evaluation

Not applicable.

10. Costs: Neonatal Hearing Screening

Neonatal hearing screening in Iceland is free of charge for parents. There is no financial reward when parents attend hearing screening, and there is no penalty for those who do not attend hearing screening.

There has not been a cost effectiveness analysis completed in Iceland.

10.1. Screening costs

In Iceland, neonatal hearing screening for well-babies is calculated to cost €77 000 per year or €19 per infant screened. Data on the costs for screening at-risk babies are not available.

10.2. Equipment costs

The cost for OAE and aABR screening devices is not available. All the devices are imported from Denmark and the maintenance is done there. Data on the cost for disposables are not available.

10.3. Staff costs

The salary of a professional performing hearing screening is roughly estimated to be €60 200 per year. The wage per hour per person is roughly estimated to be around €30.

There are 8 hearing screening professionals in Iceland, including 2 audiologists, 2 audiologist assistants, 2 nurses and 2 midwives. The professionals are all part-time workers. It is roughly estimated that 1 to 1.5 full-time positions are required to perform the job of a hearing screener. This is roughly estimated (extrapolated) to be 24 hearing screening staff per million population. The cost of training hearing screening professionals is approximately €2000 per person.

10.4. Diagnostic costs

The cost for a diagnostic assessment is not available.

10.5. Amplification costs

In Iceland, all children are treated for hearing loss.

The initial cost for the first year of hearing aid treatment is estimated to €8000. Thereafter, the yearly costs for hearing aid treatment per patient per year is €4000 to €7500 including hearing aid renewal, audiologist consults, and speech-language pathologist consults. Children typically have their hearing aids replaced every three to four years.

The initial cost of fitting a cochlear implant is €70 000 for the first year and €8000 to €15,000 for subsequent years, including the replacement of the processor, consultations with the audiologist, and consultations with the speech-language pathologist. Children usually have two CIs. They can have the processor renewed every other year. The most common is that the children have the device for three to four years.

10.6. Social costs

In Iceland, there are classes available for deaf and hard-of-hearing children in one elementary school and one kindergarten; however, there are neither separate schools nor separate classes at the high school level available for deaf or hard of hearing students.

In mainstream schools, services are available to support children who are deaf or hard of hearing, including special teachers, sign language interpreters and classroom equipment. These costs are not included in annual hearing aid and cochlear implant costs; however, specific costs associated with special services are not indicated.

11. Costs: Preschool Hearing Screening

11.1. Screening costs

Not applicable.

11.2. Equipment costs

Not applicable.

11.3. Staff costs

Not applicable.

11.4. Diagnostic costs

Not applicable.

12. References

Hinriksdottir, I. (2017). *Personal communication.* Reykjavik: The National Hearing and Speech Institute of Iceland.

Statistics Iceland. (2018). *Statistical database*. Retrieved from Statistics Iceland: https://statice.is/

The World Bank. (2018). *World Bank GNI per capita Operational Guidelines & Analytical Classifications.* The World Bank.

United Nations Statistics Division. (2016). *Demographic Yearbook – 2016.* Department of Economic and Social Affairs. New York: United Nations.

World Health Organization (WHO). (2018). *Global Health Expenditure Database*. Retrieved from NHA Indicators: http://apps.who.int/nha/database/DataExplorerRegime.aspx)