



Summary: Hearing Screening

Greece

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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	<p>The proportion of all those <u>invited for screening</u> that are <u>tested and receive a result</u>,</p> <ul style="list-style-type: none"> • <u>Invited for screening</u> includes all those that are offered the screening test. • <u>Tested and receive a result</u> could be a “pass” or “fail”. <p>Attendance rate provides information on the willingness of families to participate in screening.</p>
Attendance rate in first year of life	<p>See definition of Attendance rate.</p> <p>The calculation cut-off is after <u>one year of life</u>.</p>
Compliance with referral (percentage)	<p>The percentage of those who are <u>referred from screening</u> to a diagnostic assessment that actually <u>attend</u> the first diagnostic assessment.</p> <p>Percentage of compliance provides information on the willingness of families to attend the diagnostic assessment after referral from screening.</p>
Coverage	<p>The proportion of those <u>eligible for screening</u> that are <u>tested and receive a result</u> within a <u>specific time</u>.</p> <ul style="list-style-type: none"> • <u>Eligible for screening</u> includes those within the population that are covered under the screening or health care program. • <u>Tested and receive a result</u> could be a “pass” or “refer to diagnostic assessment”. • <u>Specific time</u> can be defined, such as 1 month after birth, 3 months after birth, etc. <p>Coverage provides information on the overall effectiveness and timeliness of a complete screening programme.</p> <p>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.</p>
Coverage in first year of life	<p>See definition of Coverage.</p> <p>The <u>specific time</u> is pre-defined as within the first year of life.</p> <p>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.</p>
False negatives	The percentage of <u>infants/children with a hearing loss</u> (defined by the target condition) that <u>receive a result of “pass”</u> 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	<p>The percentage of <u>infants/children with normal hearing</u> that <u>receive a result of “fail”</u> from the final screening test.</p> <p>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%.</p>
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	<p>A hearing impairment that is <i>not</i> due to a temporary or transient condition such as middle ear fluid.</p> <p>Permanent hearing loss can be either sensorineural or permanent conductive.</p>
Positive predictive value	<p>The percentage of infants/children referred from screening who have a confirmed <u>hearing loss</u>, as described by your protocol or guideline and indicated in the Target Condition (see definition).</p> <p>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%.</p>
Preschool or (pre)school children	All children between 3-6 years of age.
Preschool or (pre)school screening	<p>Screening that takes place during the time children are between 3-6 years of age.</p> <p>This refers to <i>any</i> hearing screening during this age. The location of the screening is irrelevant to the definition.</p>



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	<p>A pre-determined cut-off boundary for when an infant/child should be re-tested or seen for a diagnostic assessment.</p> <p>For example, referral criteria may be “no response” at 35 dB nHL.</p>
Risk babies / Babies at-risk	<p>All infants that are considered to be at-risk or have risk factors for hearing loss according to the screening programme.</p> <p>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.</p>
Sensitivity	<p>The percentage of infants/children with hearing loss that are identified via the screening program.</p> <p>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%.</p>
Specificity	<p>The percentage of infants/children with normal hearing that pass the screening.</p> <p>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%.</p>
Target condition	<p>The hearing loss condition you are aiming to detect via your screening programme. This includes:</p> <ul style="list-style-type: none"> • The <u>laterality of the condition</u>, whether the program aims to detect both unilateral and bilateral hearing loss or just bilateral hearing loss. • The <u>severity of the condition</u>, whether the program aims to detect hearing loss ≥ 30 dB HL, ≥ 35 dB HL, ≥ 40 dB HL or ≥ 45 dB HL
Well, healthy babies	<p>Infants who are <i>not</i> admitted into the NICU or born prematurely.</p> <p>Well, healthy babies may or may not have additional risk factors for hearing loss, according to the procedures indicated in the specific screening programme.</p>



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 Greece, hearing screening is organized and implemented locally.

The following report contains information with regards to hearing screening in the entire country of Greece. The details of the hearing screening protocol and the data provided are specific to Attikon University Hospital in Athens.

3.1. General

The country of Greece has a total area of 131 960 km² and a population of 10 816 286 according to the 2011 census (Hellenic Statistical Authority, 2014). In Greece, each birth is registered with the government. The number of live births in Greece was 94 134 in 2013 (Hellenic Statistical Authority, 2016)

The World Bank income classification categorizes Greece as a high-income country (The World Bank, 2018). The gross domestic product (GDP) is €16 475 per capita as of 2013 (Hellenic Statistical Authority, 2016)

From the World Health Organization (WHO) Global Health Expenditure Database, health expenditure in Greece in 2015 was 1505 USD or € 1287 per capita (World Health Organization, 2018).

Data acquired from the 2016 United Nations Demographic Yearbook indicate an infant mortality rate of 4.0 and 4.2 per 1000 for the country of Greece in 2015 and 2016, respectively (United Nations Statistics Division, 2016).

3.2. Neonatal hearing screening

Only some hospitals in Greece have implemented universal neonatal hearing screening. Universal hearing screening is not carried out across the entire country. Neonatal hearing screening is also not carried out on all at-risk or NICU infants.

The year that hearing screening for well and at-risk babies was first implemented is dependent on the hospital. In one local hospital, screening for well and at-risk babies was first implemented in 2008. As indicated, it is not yet implemented across the entire country. Neonatal hearing screening is not embedded in the Preventive Child Health Care screening system. Screening is funded through parents and through research funding. Some research articles in other hospitals should hearing screening being implemented some years earlier (Korres, Balatsouras, Nikolopoulos, Korres, & Ferekidis, 2006; Korres, et al., 2005).

Hospitals across Greece use the different protocols for screening well and at-risk babies. There are no national or regional protocols. Only local protocols are available.

3.3. Preschool hearing screening

In Greece, preschool hearing screening is not performed. Paediatricians may roughly estimate a child's hearing around preschool age.



4. Guidelines & Quality Control

National guidelines for hearing screening exist in Greece, consisting of a 60-page document; however, these guidelines were never implemented due to financial reasons.

The content of hearing screening programme was decided on by the Ministry of Health through an appointed committee of professionals. As indicated, the committee wrote national guidelines; however, these guidelines were never implemented into clinical practice. Therefore, a universal neonatal hearing screening programme has not yet been implemented. Each hospital decides whether it will implement neonatal screening and follow or change the guidelines.

In some hospitals, outcomes of hearing screening are collected in local databases; however, quality assurance of hearing screening programmes is not imposed in Greece.

Annual reports are not available in Greece. Some studies have been performed on neonatal hearing screening and its effectiveness in Greece (Korres, Balatsouras, Nikolopoulos, Korres, & Ferekidis, 2006; Korres, et al., 2005; Korres, et al., 2008; Nikolopoulos, 2015; Papacharalampous, Nikolopoulos, Davilis, Xenellis, & Korres, 2011; Tzanakakis, et al., 2016; Vlastarakos & Kalampalikis, 2015).



5. Process: Screening, Diagnosis, Intervention

5.1. Neonatal hearing screening

Well babies and at-risk babies are screened in the hospital, where the average length of stay is estimated to be 3 days (2-5 days). It is roughly estimated that more than 90% of births take place at the maternity hospital, while less than 10% of births take place at home. Families of well and at-risk infants are invited to participate in neonatal screening directly in person while in the hospital by the doctor or staff at the delivery hospital.

It is roughly estimated that neonatal hearing screening for well and at-risk infants should be completed before 6 months of age. Typically, infants that fail initial screening are rescreened at 3-5 months of age, depending on the hospital's local protocol.

The target condition for screening well babies is a bilateral or unilateral hearing loss of greater than 40 dB HL, and the target condition for screening at-risk babies is a bilateral or unilateral hearing loss of greater than 40 dB HL.

At Attikon University Hospital, at-risk infants are defined as infants admitted to the NICU and those with risk factors for hearing loss according to the international guidelines (e.g., family history of hearing loss, stigmata, etc). All parents in the maternity ward are asked if the child meets the criteria for being at risk for hearing loss, and if so, these children are screened with the at-risk protocol. Data are unavailable regarding how many infants are screened with the at-risk protocol.

The prevalence of CMV infections and meningitis among neonates is not known.

5.2. Neonatal diagnostic assessment

The diagnostic assessment tests performed after neonatal hearing screening referral are tympanometry, ABR and ASSR. Well infants and at-risk infants should have their diagnostic assessment completed by 6 months of age.

5.3. Preschool hearing screening

Preschool hearing screening is not performed, but hearing status is estimated at the discretion of the pediatrician. There are no reliable tests performed.

5.4. Intervention approach

In Greece, treatment options available include grommets, hearing aids, bone conductive devices, and cochlear implants. Infants are fitted with hearing aids from 6-12 months of age and cochlear implants from 11-12 months of age. The average age of cochlear implantation is 2 years of age.

There are no fixed hearing aid fitting criteria in Greece.



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)

For well babies in Greece, there is no universal screening protocol. In Attikon University Hospital, 2-3 OAEs are performed for well-baby neonatal hearing screening. The first OAE takes place within 1-4 days after birth in the newborn units in the hospitals. For infants that fail the first OAE, a rescreening occurs at 1 month of age. Finally, infants that fail the 1-month rescreen return for a screening test with aABR and tympanometry at 3 months of age before being referred to full diagnostic assessment with ABR and ASSR.

Table 1: Screening process for well babies in Attikon University Hospital, Greece.

Test	Age	Referral criteria	Device	Unilateral Referrals?	Location
OAE1	24-72 hours	Not indicated	Not indicated	Yes	Maternity ward
OAE2	1 month	Not indicated	Not indicated	Yes	Hospital clinic
aABR + tymp	3 months	40 dB nHL		Yes	Hospital clinic

6.2. Neonatal hearing screening (at-risk)

The sequence for screening infants at-risk at Attikon University Hospital is described in Table 2. As described, all neonates in the NICU are screened with the at-risk protocol as well as well babies with risk factors for hearing loss. A combined OAE+aABR protocol is in effect, whereby all infants are screened with both tests. Infants in the NICU are screened directly with both tests, and those that do not pass the aABR screen are referred for a rescreen at 3-months of age. Well babies with risk factors are screened with OAE in the maternity ward, but are referred for aABR testing at 3-months of age, regardless of the OAE results. At this 3-month test, tympanometry is also performed.

Table 2: Screening process for at-risk babies in Attikon University Hospital, Greece.

Test	Age	Referral criteria	Unilateral Referrals?	Location
OAE (+aABR*)	4 days / before discharge	40 dB nHL	Yes	Hospital /NICU
aABR+tymp	3 months	40 dB nHL	Yes	Hospital clinic

*aABR is performed before discharge from the NICU. At-risk infants born in well-baby unit are referred for aABR at 3 months of age.



6.3. Preschool hearing screening

Not applicable.



7. Professionals

7.1. Neonatal hearing screening (well)

Screening for well babies is performed by paediatricians, midwives, nurses, specialist nurses, assistant nurses, ENT physicians, audiologists, audiologist assistants, or health care support workers. There is no specific training for hearing screeners in Greece.

7.2. Neonatal hearing screening (at-risk)

Screening for at-risk infants is performed by paediatricians, nurses, specialist nurses, ENT physicians, or audiologists.

7.3. Preschool hearing screening

Not applicable.



8. Results: Neonatal Hearing Screening

8.1. Coverage and attendance rates

The local coverage rate of neonatal hearing screening for well, healthy babies at Attikon University Hospital, is roughly estimated to be 80 to 90%. It is roughly estimated that 90 to 100% of local at-risk infants are invited for hearing screening (Nikolopoulos, 2017).

Across all of Greece, the coverage and attendance rate is roughly estimated to be 20 to 40%.

8.2. Referral rates

Pass and referral rates from neonatal screening are sourced from the local database at Attikon University Hospital.

Table 3: Referral rates for well, healthy neonates in Attikon University Hospital, Greece (Nikolopoulos, 2017).

Test	Referral Rate
Step 1 (OAE1)	13%
Step 2 (OAE2)	30%

Referral rates assume 100% attendance. Rates reflect the number of infants referred out of the number of infants screened at each step.

In total, the referral rate for well babies to a diagnostic assessment after the screening process is estimated to be approximately 5-15%, a rate that varies across the years (Nikolopoulos, 2017).

The referral rate for at-risk infants to a diagnostic assessment after the screening process is an estimated 20% (Nikolopoulos, 2017).

8.3. Diagnostic assessment attendance

The compliance rate to a diagnostic audiological evaluation after neonatal hearing screening is roughly estimated across all of Greece to be very low at less than 30%. The percentage of well, healthy infants that receive an audiological assessment after neonatal hearing screening referral is very low. The percentage of referred at-risk infants that receive an audiological evaluation after neonatal hearing screening referral is roughly estimated to be 40% across all of Greece.

8.4. Prevalence / Diagnosis

The prevalence of permanent hearing loss among both neonates and pre-school age children in Greece is roughly estimated (Nikolopoulos, 2017), as follows:

Bilateral, ≥ 40 dB HL: 5 per 1000

Bilateral ≥ 80 dB HL: 2 per 1000

The prevalence of hearing impairment among preschool-age children is unknown, but it is roughly estimated that prevalence rates remain approximately the same between the neonatal and preschool age because of the lack of hearing screening at preschool age and the inconsistencies in pediatrician assessments.



The percentage of infants diagnosed with permanent hearing loss after neonatal hearing screening is roughly estimated from data collected at Attikon University Hospital and personal communication from other hospitals.

Estimations are as follows (Nikolopoulos, 2017):

Bilateral ≥ 40 dB HL: 0.1% to 0.5% of newborns

Bilateral ≥ 80 dB HL: 0.1% of newborns

Data are unavailable regarding prevalence of bilateral auditory neuropathy in Greece.

8.5. Treatment success

In Greece, it is unknown how many children are fitted with hearing aids per year. It is roughly estimated that 70 children per year are fitted with cochlear implants.

8.6. Screening evaluation

For neonatal hearing screening in Greece, figures for screening evaluation are roughly estimated based on the screening programme at Attikon University Hospital and one additional private programme that made these data available (Nikolopoulos, 2017). The percentage of false negatives is roughly estimated to be $<10\%$ and the percentage of false positives is roughly estimated to be 10-20%.



9. Results: Preschool Hearing Screening

9.1. Coverage and attendance rates

It is roughly estimated that around 90-100% of preschool- or school-aged children have some type of hearing evaluation by pediatricians.

9.2. Referral rates

It is roughly estimated that 10-20% of preschool-aged children are referred for further evaluation.

9.3. Diagnostic assessment attendance

Unknown information.

9.4. Screening evaluation

Unknown information.



10. Costs: Neonatal Hearing Screening

Neonatal hearing screening in Greece is not 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 Greece.

10.1. Screening costs

Data on costs for neonatal hearing screening are unavailable.

10.2. Equipment costs

The cost of equipment for performing OAE is roughly estimated to be €2 000 to €3 000, the cost for aABR equipment is roughly estimated to be €4 000 to €5 000, and the cost for ASSR equipment is roughly estimated to be €20 000.

Maintenance costs are unknown, and there is no set schedule for maintenance or replacement, though yearly calibration cost for Attikon University Hospital's screening programme is approximately €300. The cost for disposables is also roughly estimated to be €2 per child for aABR disposables and €3 per child for OAE disposables, though plastic OAE tips are often sterilized and reused. It is roughly estimated that Attikon University Hospital spends a total of €700 per year on disposables for both aABR and OAE.

10.3. Staff costs

The salary of professionals that perform hearing screening is roughly estimated to be anywhere from €8 000 to €25 000. The educational cost for hearing screening professionals cannot be estimated.

10.4. Diagnostic costs

The cost for a diagnostic assessment is not indicated.

10.5. Amplification costs

In Greece, not all children are treated for hearing loss. Children may not be treated due to payment problems or capacity problems.

For hearing aids, the cost for the first year of intervention is roughly estimated to be €3000. The cost for subsequent years of intervention is unknown.

For cochlear implants, the cost for the first year of intervention is roughly estimated to be €28 000. The cost for subsequent years of intervention is unknown.

10.6. Social costs

In Greece, it is roughly estimated that there are 11 schools for deaf and hard of hearing. The cost per child for specialized school is unknown. It is roughly estimated that children with hearing impairment that attend regular schools sometimes have access special support.



11. Costs: Preschool Hearing Screening

11.1. Screening costs

Not known.

11.2. Equipment costs

Not known / not applicable.

11.3. Staff costs

Not known.



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