



## **Summary: Hearing Screening**

**Israel**

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**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.

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## 1. Glossary of Terms: Hearing Screening

<b>Abnormal test result</b>	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.”
<b>Attendance rate</b>	<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"> <li>• <u>Invited for screening</u> includes all those that are offered the screening test.</li> <li>• <u>Tested and receive a result</u> could be a “pass” or “fail”.</li> </ul> <p>Attendance rate provides information on the willingness of families to participate in screening.</p>
<b>Attendance rate in first year of life</b>	<p>See definition of <b>Attendance rate</b>.</p> <p>The calculation cut-off is after <u>one year of life</u>.</p>
<b>Compliance with referral (percentage)</b>	<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>
<b>Coverage</b>	<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"> <li>• <u>Eligible for screening</u> includes those within the population that are covered under the screening or health care program.</li> <li>• <u>Tested and receive a result</u> could be a “pass” or “refer to diagnostic assessment”.</li> <li>• <u>Specific time</u> can be defined, such as 1 month after birth, 3 months after birth, etc.</li> </ul> <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>
<b>Coverage in first year of life</b>	<p>See definition of <b>Coverage</b>.</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>
<b>False negatives</b>	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%.
<b>False positives</b>	<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>
<b>Guidelines</b>	Recommendations or instructions provided by an authoritative body on the practice of screening in the country or region.
<b>Hearing screening professional</b>	A person qualified to perform hearing screening, according to the practice in your country or region.
<b>Inconclusive test result</b>	A test result where a normal “pass” response could not be detected due to poor test conditions.
<b>Invited for screening</b>	Offered screening.
<b>Outcome of hearing screening</b>	An indication of the effectiveness or performance of screening, such as a measurement of coverage rate, referral rate, number of infants detected, etc.
<b>Permanent hearing loss</b>	<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>
<b>Positive predictive value</b>	<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 <b>Target Condition</b> (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>
<b>Preschool or (pre)school children</b>	All children between 3-6 years of age.
<b>Preschool or (pre)school screening</b>	<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>



<b>Prevalence</b>	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.
<b>Programme</b>	An organized system for screening, which could be based nationally, regionally or locally.
<b>Protocol</b>	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.
<b>Quality assurance</b>	A method for checking and ensuring that screening is functioning adequately and meeting set goals and benchmarks.
<b>Referral criteria</b>	<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>
<b>Risk babies / Babies at-risk</b>	<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>
<b>Sensitivity</b>	<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>
<b>Specificity</b>	<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>
<b>Target condition</b>	<p>The hearing loss condition you are aiming to detect via your screening programme. This includes:</p> <ul style="list-style-type: none"> <li>• The <u>laterality of the condition</u>, whether the program aims to detect both unilateral and bilateral hearing loss or just bilateral hearing loss.</li> <li>• The <u>severity of the condition</u>, whether the program aims to detect hearing loss <math>\geq 30</math> dB HL, <math>\geq 35</math> dB HL, <math>\geq 40</math> dB HL or <math>\geq 45</math> dB HL</li> </ul>
<b>Well, healthy babies</b>	<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 Israel, hearing screening is performed nationally and also organized nationally. The following report contains information with regards to hearing screening in the entire country of Israel.

#### 3.1. General

The country of Israel has a total area of 20 770 km<sup>2</sup> and a population of 8 654 900 as of February 2017 (The State of Israel, 2018). In Israel, each birth is registered and infants are assigned an ID number. The number of live births in Israel was 181 351 in 2016.

The World Bank income classification categorizes Israel as a high-income country (The World Bank, 2018). The gross domestic product (GDP) was € 30 888 per capita in 2016 (The State of Israel, 2018).

From the World Health Organization (WHO) Global Health Expenditure Database, health expenditure in Israel in 2015 was 2 756 USD or €2 378 per capita (World Health Organization, 2018).

Infant mortality rate in the country of Israel was 3.1 per 1000 in 2015 (United Nations Statistics Division, 2016; The State of Israel, 2018).

#### 3.2. Neonatal hearing screening

In Israel, 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 1997 locally in some hospitals, and by 2010, neonatal hearing screening was implemented nationally in all hospitals. Screening for at-risk infants began much earlier in around 1985 when premature infants were followed after discharge and underwent a hearing screen. However, pre-discharge objective screening for-risk infants also began nationally in 2010.

Neonatal hearing screening is not embedded in the Preventive Child Health Care screening performed in the well child care centres. It is embedded in the funds for births provided by the state. The National Social Security Institute distributes these funds to the maternity hospitals to cover hospital costs for performing neonatal hearing screening on all infants, including both at-risk and well-baby screening.

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

#### 3.3. Preschool hearing screening

In Israel, there is no preschool hearing screening. Hearing screening performed in first grade at the age of 6 years.

First-grade hearing screening began in Israel around the 1970s. Unlike neonatal hearing screening, first-grade screening is embedded in the general Preventive Child Health Care system. Hearing screening, as part of the total school health services programme, is funded by the state.

The same hearing screening protocol is followed across the country for the first-grade hearing screening.



## **4. Guidelines & Quality Control**

National guidelines for hearing screening exists in Israel (Ministry of Health, 2018).

The content of hearing screening programme was decided on by Public Health Service with expert consultation. Revised directives were published in the beginning of 2018. The basic programme remains the same; however, revisions were made regarding the definition of high-risk infants as well as pass criteria for high-risk infants. There are no set criteria for performing revisions; however, in practice, the content of the programme is planned for revision every 7-10 years. The Public Health Service along with the National Audiologist Supervisor and expert consultants are responsible for revising the programme. Once updated guidelines are issued, training and conference sessions would be held to publicize the new recommendations.

Quality assurance of hearing screening programmes is imposed by the government. Referral rate data are calculated across hospital sites, and site visits are made to hospitals and schools. While follow-up data are not routinely collected, national surveys of age of diagnosis and entry to rehabilitation are performed, collecting information across rehabilitation units.

Annual reports are not available in Israel.

Research has been performed on hearing screening in Israel apart from auditing.



## 5. Process: Screening, Diagnosis, Intervention

### 5.1. Neonatal hearing screening

Well babies are screened in the maternity hospital, and at-risk babies are screened in the hospital nursery or a quiet room near the NICU. It is estimated that 99% of infants are born in hospitals each year and less than 1% are born at home. The minimum stay in the maternity hospital is typically 48 hours after birth, with the exception of two busy hospitals that can discharge by 36 hours. Well-baby families and families of infants at-risk are invited for screening directly in person, as screening is part of the discharge process from the hospitals.

There is no set age for when neonatal hearing screening should be completed in Israel, with the exception that screening for well and at-risk infants should be completed before discharge (i.e., in 48 hours) from the hospital.

The target condition for screening for well and at-risk babies is not specifically indicated in protocol; however, typical target condition for neonatal screening for both groups of infants is a unilateral or bilateral hearing loss of  $\geq 40$  dB HL.

There is a definition of high-risk infants that determines which infants are screened with the high-risk protocol, an aABR in addition to an OAE. Approximately 5% of infants are screened with the at-risk screening protocol, though this figure varies. At-risk infants are defined as those with a family history of permanent hearing loss, the presence of a syndrome associated with hearing loss, 5 or more days in the NICU; or bilirubin levels necessitating exchange transfusion.

Furthermore, infants with risk factors are followed-up regardless of the results of the hearing screening performed in the hospital. These risk factors include those tested with the high-risk protocol and additional risk factors. There are no established deadlines regarding when this follow-up examination should occur or the percentage of infants that are followed up.

With regards to the prevalence of CMV, a study by Barkai et al. (2014) found that 56 of 9824 infants (0.56%) had a positive saliva assay. Of these, 47 were confirmed with urine rt-PCR and culture and one with confirmed maternal sero-conversion during pregnancy. Screening of CMV is not universally performed in Israel; however, it is suggested that that all infants with failed hearing screening should be tested for CMV.

### 5.2. Neonatal diagnostic assessment

Infants are referred to a diagnostic centre after neonatal hearing screening referral. Well, healthy infants without risk factor may either undergo a rescreening examination including both OAE and aABR or a full diagnostic assessment, including a clinical ABR. Infants at-risk must have a full diagnostic assessment after hearing screening referral.

There is no set protocol for testing performed during the diagnostic appointment. Confirmation of hearing impairment should be performed by 3 months of age for all babies.

### 5.3. Preschool hearing screening

Six-year old hearing screening is performed in schools (first-grade) in Israel. Children are invited to participate by the school health service provider via a letter sent to families.

The target condition for first-grade screening is a unilateral or bilateral hearing loss of  $\geq 25$  dB HL.



#### **5.4. Intervention approach**

In Israel, 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 or older.

The hearing aid fitting criteria Israel is a bilateral or unilateral hearing loss of greater than 20 dB HL average hearing threshold across a 4-frequency pure-tone threshold of 500, 1000, 2000 and 4000 Hz.

## 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)

The neonatal hearing screening programme in Israel for well babies described includes two or three screening tests before discharge from the maternity hospital. The first test (OAE) is performed at least 24 hours after birth, and the second test (aABR) is performed before discharge for infants that do not pass the OAE. As indicated, it is roughly estimated that discharge is at least 48 hours after birth for most hospitals, with the exception of two busy hospitals where discharge may be after 36 hours. There is variation across hospitals as to when the OAE test is performed, and whether it is repeated at a later time before attempting aABR.

**Table 1:** Screening process for well babies in Israel.

Test	Age	Referral criteria	Device	Unilateral Referrals?	Location
OAE*	24-72 hours	Various	Various	Yes	Maternity hospital
aABR	Before discharge	Various		Yes	Maternity hospital

\*OAE can either be DPOAE or TEOAE and conducted one or two times before aABR is performed.

### 6.2. Neonatal hearing screening (at-risk)

The neonatal hearing screening programme in Israel for at-risk babies is described in Table 2. Both OAE and aABR are performed on infants considered at-risk. Prior to a 2018 revision to protocol, only the results of the aABR determined a referral to diagnostic assessment. The current protocol requires a passing result for both OAE and aABR screening, or a referral to a diagnostic assessment is warranted.

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

Test	Age	Referral criteria	Device	Unilateral Referrals?	Location
OAE +aABR	Before discharge (usually 36 weeks gestation)	Various	Various	Yes	Quiet room near NICU / Nursery

### 6.3. Preschool hearing screening

**Table 3:** Screening process for first-grade children in Israel.

Test	Age	Referral criteria	Location
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Pure-tone sweep	6-years	25 dB HL at 500 Hz & 20 dB HL at 1, 2 and 4 kHz	School
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## **7. Professionals**

### **7.1. Neonatal hearing screening (well)**

OAE screening for well babies is performed by medical technicians, audiologists or specially trained employees; aABR screening is performed by audiologists or medical technicians in the maternity hospitals.

There is a recommended syllabus and 2-day on-the-job supervision for training new hearing screening staff; however, training is not formally accredited. An online training manual is currently in progress.

### **7.2. Neonatal hearing screening (at-risk)**

Screening for at-risk infants is performed by medical technicians or audiologists.

### **7.3. Preschool hearing screening**

Screening first-grade children is performed by nurses or audiologists.

## 8. Results: Neonatal Hearing Screening

### 8.1. Coverage and attendance rates

Based on aggregate data reported by hospitals to the Ministry of Health, the coverage rate in Israel for well babies was 99% in 2016 and 98.9% in 2017. These data are accumulated by aggregate hospital reports from maternity hospitals, and indicate the percentage of infants born in Israel that complete all tests required under the screening protocol.

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

For at-risk infants, 99% were offered neonatal hearing screening 2016.

### 8.2. Referral rates

Referral rates for each stage of the screening process for well babies is presented below in Table 4.

**Table 4:** Referral rates for neonatal hearing screening (well babies) in Israel (2017)

Test	Referral Rate
OAE*	4.3%
aABR	54.8% <sup>†</sup>

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

\*OAE referral rate data are cumulative from either one or two OAEs. There is variation in when OAEs are performed and repeated. All tests, however, are performed before discharge.

<sup>†</sup> This figure is inaccurate for well infants as some hospitals combined well-infant and at-risk-infant data for aABR.

In total, the referral rate to a diagnostic assessment after the screening process was 2.4% (2015) for all babies.

### 8.3. Diagnostic assessment attendance

According to a telephone survey of parents of well infants who fail screening, approximately 81% complied with a referral to further evaluation from the maternity hospital (diagnostic assessment or rescreening in some cases).

### 8.4. Prevalence / Diagnosis

The prevalence values of permanent hearing loss among neonates in Israel are presented in Table 5 according to the National Social Security Institute (2014) and a study by Attias and colleagues (2006). Prevalence from the National Social Security Institute are derived from the number of reported infants that are eligible for benefits under the regulations of having a bilateral hearing loss > 40 dB HL.

**Table 5:** Prevalence of permanent hearing loss among neonates in Israel.

	Bilateral		Unilateral	
	≥ 40 dB HL	≥ 80 dB HL	≥ 40 dB HL	≥ 80 dB HL
National Social Security Institute (2014)	0.64			
Attias et al. (2006) – all hearing loss	2.3		2.5	
Attias et al. (2006) – sensorineural hearing loss	1.5		0.95	



Data on the prevalence of bilateral auditory neuropathy for both well babies and NICU-babies are unavailable in Israel.

#### **8.5. Treatment success**

In Israel, it is unknown how many infants with neonatal hearing impairment are fitted with hearing aids per year. In 2014, 103 infants were fitted with cochlear implants.

#### **8.6. Screening evaluation**

Data are unavailable regarding the false positives, false negatives, sensitivity or specificity of neonatal hearing screening in Israel. Data are also unavailable regarding the positive predictive value of a refer result.



## **9. Results: Preschool Hearing Screening**

### **9.1. Coverage and attendance rates**

In Israel, the coverage of first-grade hearing screening was 96.8% according to an audit performed in 2015.

### **9.2. Referral rates**

The referral rate of first-grade hearing screening was 7.9%, which does not include an additional 0.37% of children with known hearing loss and thus excluded from screening. This figure, however, does not represent the overall prevalence rate among 6-year old children, as children attending special education were not included in this calculation.

### **9.3. Diagnostic assessment attendance**

According to parent reports, 76.9% indicated that they attended a physician's examination after referral from first-grade hearing screening; however, not all children received a diagnostic audiological examination after consultation with a physician (Telephone follow-up survey, 2015).

### **9.4. Prevalence / Diagnosis**

After first-grade hearing screening, 0.012% of children were diagnosed with permanent hearing loss and fitted with hearing devices (Telephone follow-up survey, 2015). This figure does not include the children who were previously identified with a permanent hearing loss and receiving intervention.

### **9.5. Screening evaluation**

Data are unavailable regarding the false positives, false negatives, sensitivity or specificity of first-grade hearing screening.



## 10. Costs: Neonatal Hearing Screening

Neonatal hearing screening in Israel is free of charge for parents. There is no financial reward when parents attend hearing screening.

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

### 10.1. Screening costs

In Israel, funds of 42 NIS (€9.86) per infant screened were allocated in 2010 to cover costs of neonatal hearing screening for both well and at-risk babies. Considering the change in index since 2010, this is estimated to be equivalent to 45 NIS (€10.56) today. While these are the funds allocated to the screening programme, it is unknown whether these funds completely cover the entire cost.

### 10.2. Equipment costs

Information on equipment costs or associated costs to maintain equipment is unavailable.

### 10.3. Staff costs

The salary of a professional performing hearing screening is not provided. In total, there are approximately 75-100 hearing screening professionals in Israel. The cost of training hearing screening professionals is not provided.

### 10.4. Diagnostic costs

The cost for a diagnostic assessment is not indicated. It is a service provided under the national health insurance.

### 10.5. Amplification costs

In Israel, all children are treated for hearing loss, except when children of deaf parents refuse cochlear implants or delay treatment for their children.

The cost of each hearing aid is reimbursed by the government to 6000 NIS for each aid (each ear), with a 25% co-pay agreement. Therefore, the hearing aid costs are around 8000 NIS (€1878) for each ear. Until the age of 6, hearing aids are replaced every 3 years and then ever 4 years until age 18. This does not include the costs associated with clinical follow-up and consultations. These costs are covered by the National Health Insurance and include periodic evaluation and retesting.

In addition to hearing aids, the government subsidizes the cost of FM equipment to 8000 NIS with 25% co-pay. Therefore, the total cost of an FM device is 10 000 NIS (€2347).

The initial cost of fitting a cochlear implant is 1893+730 NIS (€611) for pre-surgical evaluation and 16 976 NIS (€3984) for the surgery. The cost of the implant itself is 23 364 NIS or €5518.

### 10.6. Social costs

Approximately 5000 children (ages 3-21) with hearing loss are enrolled in the school system. Children with hearing impairment qualify under the special education law, which includes children in special schools and receiving support in mainstream schools.

In Israel, there are 16 special education schools for the deaf.



For young children, 75% attend mainstream nursery schools/kindergartens, 20% attend special nursery schools/kindergartens connected to a mainstream setting, and 5% attend special education schools.

Up until the 9<sup>th</sup> grade, deaf and hard-of-hearing children in mainstream education receive additional support, either in school or in a separate setting. High school children receive 3-8 hours per week of special education, according to their individual requirements.



## **11. Costs: Preschool Hearing Screening**

### **11.1. Screening costs**

The cost of first-grade screening is embedded to the total costs for the school health service program and cannot be indicated separately.

### **11.2. Equipment costs**

Not applicable.

### **11.3. Staff costs**

Not applicable.



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