



## **Summary: Hearing Screening England (South East London)**

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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 the United Kingdom, hearing screening is performed nationally and organized nationally. The following report contains information with regards to childhood hearing screening across England and includes data corresponding to the region of South East London.

#### 3.1. General

The region of South East London (SEL) contains six London boroughs and has a total area of 348.88 km<sup>2</sup> with a population of 1,793,600 as of mid-2016 (Office for National Statistics, 2017).

In the U.K., all births are registered in the maternity ward when issuing an NHS number. The number of live births in the U.K. in 2016 was 774,835, and there are approximately 26,000 live births per year in SEL (Office for National Statistics, 2017).

The World Bank income classification categorizes the U.K. as a high-income country (The World Bank, 2018). The gross domestic product (GDP) in 2015 was £29 670 per capita in the U.K. or €33 275 (Office for National Statistics, 2018).

From the World Health Organization (WHO) Global Health Expenditure Database, health expenditure for the U.K. in 2015 was 3498 USD or €3480 per capita (World Health Organization (WHO), 2018).

An infant mortality rate of 3.9 per 1000 is reported for the U.K. in 2015 (United Nations Statistics Division, 2016; Office of National Statistics, 2018). The infant mortality rate in 2015 varies from 3.4 to 4.8 across the six London boroughs making up the region of SEL (Office for National Statistics, 2018).

#### 3.2. Neonatal hearing screening

In the United Kingdom, neonatal hearing screening is conducted universally, with all babies in the country having access to hearing screening, though participation is not obligatory for parents. Hearing screening for well and at-risk babies started and was fully implemented across England in 2006. Neonatal hearing screening is funded by the state and embedded in the Preventive Child Health Care screening system (Public Health England, 2017). Neonatal hearing screening is organized by the national Newborn Hearing Screening Programmes.

In the South-East London (SEL) region, hearing screening is offered to all infants born in one of the SEL maternity hospitals or if the general practitioner's office lies within the SEL region and the infant was not screened in the maternity hospital.

National guidelines are available from Public Health England as is a screening protocol that is used across the country. The same protocol is followed across England for performing hearing screening (Public Health England, 2017).

#### 3.3. Preschool hearing screening

School-entry screening currently exists in England only in regions where a programme was in effect prior to the 2015 neonatal hearing screening guidelines. For some regions, school-entry screening has been in effect since 1955; however, since 2015 it has been advised that no new school-entry hearing screening programmes be implemented. School entry screening is funded by parents, companies, and the state, though it is not embedded in Preventive Child Health Care.



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

There are national guidelines for hearing screening in England.

The content of the general hearing screening programme was decided on by Public Health England (NHS England), and has not been changed since implementation. While there is no set time for when reviews are made, the national Newborn Hearing Screening Programme (NHSP) is reviewed regularly through discussions with the national screening committee and revisions to the programme are performed when necessary. Public Health England decides on and funds revisions.

Quality assurance of the neonatal hearing screening programme is imposed by the government. Quality assurance is performed via national and local reporting and checks and audits within the NHSP. These procedures assure the quality of antenatal and newborn screening, as well as manage safety and reduce risk. Information is collected directly via the national NHSP Patient Management System (Smart4Hearing, formerly ESP), supported by Northgate. Through Smart4Hearing, national and local performance reports are generated on a monthly, quarterly and annual basis, which describe NHSP performance, highlights, activity, outcomes and data quality.

There have been a number of studies published on the hearing screening programme in the U.K., including studies measuring the effectiveness of NHSP (e.g., Uus & Bamford, 2006).



## 5. Process: Screening, Diagnosis, Intervention

### 5.1. Neonatal hearing screening

Well-babies are screened in the hospital, child health care centres, or in outpatient clinics (e.g., general practitioner's office) within the National Health Service. At-risk infants may also be screened in the NICU. The percentage of infants born in a maternity hospital in the U.K. is unknown. It is roughly estimated that the length of stay in the hospital after delivery is 4 hours (minimum) to one day. Parents/caregivers of eligible well and at-risk babies are invited to participate in neonatal hearing screening directly in the maternity hospital. For infants screened in the outpatient clinic, parents/caregivers are invited to participate by phone when an appointment is booked. Appointments are then confirmed via email or letter. For areas without a phone-based booking service, a letter is sent to the parents inviting them to participate by booking an appointment time (SEL NHSP local managers and Head of service, 2017).

Hearing screening should be completed as soon as possible. A key performance indicator (KPI) of the NHSP measures the percentage of neonatal hearing screening for well babies completed before 4 weeks of age; however, hearing screened should be completed before 3 months corrected age. For at-risk babies, screening should be completed after 34 weeks gestational age and before 52 weeks gestational age. In circumstances where the health of the infant is a limiting factor, screening may be performed up to 64 weeks gestation (Public Health England, 2017; Public Health England, 2016).

Hearing screening is contraindicated among children with bacterial meningitis, atresia and microtia. These children are referred directly for a diagnostic assessment. Infants admitted to the NICU for a minimum of 48 hours are tested with a different protocol compared to the well-baby protocol (Public Health England, 2016). Data collected across South East London from 2006 through 2016 shows that 5.3% of infants are screened according to the NICU protocol (McCall, 2018).

An audit of a pilot of screening pathways for congenital CMV was performed in Evelina London Children's Hospital from 2014-2016. Across the 24-month pilot, 177 infants with ABRs suggesting sensorineural hearing loss were screened for congenital, and a total of 9 cases were confirmed (Martinez-Alier, et al., 2017).

From the NHS England Laboratory, there were a total of 34 confirmed cases of invasive meningococcal infection among infants under 1 year of age from January to March 2018. There were an additional 34 cases among children 1 to 4 years of age, 18 cases among children 5 to 9 years of age and 4 cases among children 10 to 14 years of age across the same time period (Public Health England, 2018).

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

### 5.2. Neonatal diagnostic assessment

The diagnostic assessment after neonatal hearing screening referral should be completed by 44 weeks of gestational age, or 4 weeks after the completion of the screening.

### 5.3. Preschool hearing screening

In places where school-entry hearing screening is performed, the screening takes place in the kindergartens or schools. Schools wishing to conduct preschool or school-entry hearing screening

contact the Paediatric Audiology Service, and an audiologist from the Paediatric Audiology Service visits the school to conduct screening. The target condition for preschool hearing screening is a hearing loss of 30 dB HL or worse at 1, 2 and 4 kHz or 35 dB HL or worse at 500 Hz (CYPAC, 2017).

In SEL, 3 schools in the Southwerk sub-region approached the Paediatric Audiology Service in 2018.

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

In the U.K., treatment options available include grommets, hearing aids, bone conductive devices, and cochlear implants. Infants are fitted with hearing aids within 4-6 weeks of confirmation of PCHI, regardless of age. Infants are fitted with cochlear implants from 6 months of age or older (National Institute for Health Care and Excellence, 2009).

The local fitting protocol in SEL is that hearing aids are fit on both unilateral and bilateral hearing losses of mild to profound severity. There is not set pre-tone average criteria, but instead, hearing aids are determined suitable based on the individual and configuration 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)

The process for neonatal hearing screening for well babies is summarized in Table 1. There are two models of well-baby hearing screening in England.

The majority of neonatal hearing screening follows the hospital model, whereby a 3-step OAE - OAE - aABR protocol is in effect. The first OAE is performed in the maternity hospital after birth. If the infant does not pass the first OAE test, rescreening occurs 5 hours later. If the infant is discharged from the maternity hospital before rescreening, an OAE is scheduled in an outpatient clinic as soon as possible and no later than 3 months of age. If the infant does not pass the second OAE, an aABR is performed. If the infant does not pass the aABR, a referral to the ENT department for a diagnostic assessment is made (Public Health England, 2017).

Infants that miss the initial screen in the maternity ward or are born outside of a maternity hospital are screened according to the community model. A 2-step OAE-aABR protocol is in performed in outpatient clinics. For these cases, the OAE is performed once. If the infant does not pass the OAE, an aABR is administered (Public Health England, 2017).

Table 1: Process for neonatal hearing screening for well, healthy infants in England (Public Health England, 2017; Public Health England, 2016).

Test	Age	Referral criteria	Device	Unilateral Referrals?	Location
OAE1	<24 hours or older (10 days in outpatient clinics)	Various	Accuscreen (SEL) / Various (NHSP)	Yes	Maternity hospital / Outpatient clinic
OAE2	5 hours after initial screen (no later than 3 months)			Yes	Maternity hospital / Outpatient clinic
aABR	< 4-5 weeks* (no later than 3 months)	40 dB nHL		Yes	Maternity hospital / Outpatient clinic

\*Final screening should be completed by 4 weeks of age for the hospital model or by 5 weeks of age for the community model.

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

The screening process for at-risk (NICU) infants is described in Table 2. A combined OAE+aABR protocol is in effect whereby both OAE and aABR are performed.

If the infant does not pass the aABR, a referral is made to diagnostic audiology, regardless of the results of the OAE. If the infant passes aABR but does not pass OAE, the infant is not immediately referred to diagnostic, but may be referred for follow-up at 7-9 months of age. This depends on the presence of risk factors and whether the infant did not pass OAE in one or both ears.

Table 2: Process for neonatal hearing screening for at-risk infants in England (Public Health England, 2017; Public Health England, 2016).

Test	Age	Referral criteria	Unilateral Referrals?	Location
OAE + aABR	34-52 weeks gestation (depending on health of infant)	40 dB nHL	Yes	Maternity hospital / NICU / Outpatient clinic

\*The aABR must pass in order for the infant to be discharged from the screening programme. Results of the OAE are used for determining whether surveillance at 7-9 months of age is warranted.

### 6.3. Preschool hearing screening

In places that perform screening, hearing screening is performed in kindergarten schools at 5 years of age. Children are conditioned to the task at higher intensities, and then pure-tone audiometry screening is performed at 25 dB HL at 1-4 kHz and 30 dB HL at 500 Hz. If thresholds are greater than screening levels a referral is then made to the diagnostic audiology services.

Table 3: Process for preschool hearing screening in England (CYPAC, 2017).

Test	Age	Referral criteria	Unilateral Referrals?	Location
Pure-tone screening	5 years	Threshold 25 dB HL (1-4 kHz) Threshold 30 dB HL (500 Hz)	Yes	Kindergarten schools



## **7. Professionals**

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

Neonatal hearing screening is performed by NHSP trained screeners or may be performed by health visitors if screened in an outpatient clinic. NHSP trained screeners are registered nurses, or individuals that have received a diploma in population health screening, with a focus on newborn hearing, and have met the subsequent training and examination requirements under the NHSP (Public Health England, 2016).

Health visitors are nurses or midwives that have additional training in paediatric public/community health.

Subsequent training includes an e-learning programme, local training programmes such as safeguarding and infection control, on-site practical training, and monitored practice. An exam, the observed structural clinical examination (OSCE) is typically required for final certification as a NHSP screener (Public Health England, 2016).

The length of training varies as NHSP trained screeners come from various backgrounds. A diploma in population health screening takes approximately 12-18 months. The OSCE is expected to be administered within 3 months of starting employment as a NHSP screeners (Public Health England, 2016).

Training of certain protocols are regularly updated, and the performance of NHSP trained screeners is monitored on a regular basis (SEL NHSP local managers and Head of service, 2017).

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

Screening for at-risk (NICU) infants is also performed by NHSP trained screeners or health visitors. See 5.1 for details on NHSP screeners and training requirements.

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

Screening for preschool-age children is performed by audiologists of the Pediatric Audiology Service (CYPAC, 2017).

## 8. Results: Neonatal Hearing Screening

### 8.1. Coverage and attendance rates

The information provided corresponds to data collected in the South East London (SEL) region. The coverage rate is defined by the NHSP as the percentage of eligible infants born who completed screening before 4/5 weeks of age (depending on if the infant follows the hospital model or community model; SEL NHSP, 2017a, 2017b, 2017c; 2017d).

An eligible infant includes any live infant born during the reporting period whose mother is registered with a GP within the NHS network or was born into a region covered by an NHSP site or NHS network (Public Health England, 2016).

The coverage rate for the SEL region for 2016 was 98.5% (SEL NHSP, 2017a, 2017b, 2017c; 2017d). The number of children missed being *offered* screening is not indicated, and therefore, the attendance rate cannot be calculated for the initial screen.

### 8.2. Referral rates

The referral rates for neonatal hearing screening of well, healthy infants are presented below in Table 4. Rates are presented for data collected across SEL from April-December 2016 (SEL NHSP, 2017a, 2017b, 2017c).

**Table 4:** Referral rates for neonatal hearing screening (well-babies) in South East London, England (SEL NHSP, 2017a, 2017b, 2017c; 2017d).

Test	Referral Rate
OAE1	22.2%
OAE2	

Referral rates assume a 100% attendance rate at each step.

The final referral rate to a diagnostic assessment for all babies was 2.09% from April through December 2016 (SEL NHSP, 2017a, 2017b, 2017c). Prior to 2015, information from all records dating back to 2005 indicate a final referral rate of 2.02%, with a referral rate of 1.70% for well infants and a referral rate of 7.31% for NICU infants (McCall, 2018).

### 8.3. Diagnostic assessment attendance

Out of the infants referred from neonatal hearing screening, 96% attended a diagnostic assessment within the required time period (i.e., 4 weeks after referral from screening or 44 weeks gestational age; (SEL NHSP, 2017a, 2017b, 2017c). It is not indicated whether the remaining percentage of infants attended a diagnostic assessment outside of the required time frame.

### 8.4. Prevalence / Diagnosis

**Table 5:** Prevalence rate (per 1000) of permanent hearing loss among neonates in South East London region (McCall, 2016 departmental PCHI statistics, 2018)

	Bilateral		Unilateral	
	≥ 40 dB HL	≥ 80 dB HL	≥ 40 dB HL	≥ 80 dB HL
SEL region (2017)	1.0	0.3	0.6	0.1

Table 6: Number of cases (prevalence) of permanent hearing loss among children 0-5 years of age in South East London region (McCall, 2016 Practice Navigator Audiology Patient Management System, 2018).

	Bilateral			Unilateral		
	≥ 25 dB	≥ 40 dB	≥ 80 dB	≥ 25 dB	≥ 40 dB	≥ 80 dB
	HL	HL	HL	HL	HL	HL
SEL region (2017)	46	31	10	17	13	3

There are 5 cases of ANSD reported in SEL region. Two infants were identified as NICU (at-risk) infants, two infants were well babies, and one was not identified until the age of 3 years (McCall, 2016 Practice Navigator Audiology Patient Management System, 2018).

Out of the total children diagnosed with permanent hearing loss in 2016, a percentage was referred from a non-NHSP source (Table 7). It is not indicated whether these children were missed NHSP, had progressive loss, or passed screening.

Table 7: Percentage of children diagnosed with hearing loss out of the total number of children diagnosed in each category (McCall, 2016 departmental PCHI statistics, 2018).

	Bilateral		Unilateral	
	≥ 40 dB HL	≥ 80 dB HL	≥ 40 dB HL	≥ 80 dB HL
Referred from non-NHSP source	16	1	3	1
Total number diagnosed	140	16	16	16
% of those diagnosed from non-NHSP source	11%	6%	19%	6%

### 8.5. Treatment success

In SEL region, 49 out of the 83 children diagnosed with hearing loss were fitted with hearing aids in 2016 (McCall, 2016 departmental PCHI statistics, 2018). It is unknown how many children per year are fitted with cochlear implants; however, according to Consortium for Research into Deaf Education, 3350 children have at least one cochlear implant as of 2016, which makes up 7% of the total deaf population in England (Consortium for Research into Deaf Education (CRIDE), 2017).

### 8.6. Screening evaluation

Actual data on the sensitivity or specificity of neonatal hearing screening are not available, and neither are data on false positives, false negatives, or the positive predictive value.

However, some estimations were provided. A positive predictive value of a refer result was estimated at 20% for well infants (CYPAC, 2018). For well infants, sensitivity of the OAE screen was estimated to be close to 100% and specificity was estimated to be 90-95% (Public Health England, 2017).

Data are not available for at-risk (NICU) infants.



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

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

In the U.K., preschool hearing screening coverage is low. In SEL, three schools carried out preschool hearing screening in 2018, where a total of 87 children 5 years of age were screened (CYPAC, 2018).

In places where preschool hearing screening is performed, attendance rate is 99% as the screening is performed in school by an audiologist.

### **9.2. Referral rates**

The final referral rate to a diagnostic assessment after preschool hearing screening is not available.

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

The compliance rate to a diagnostic assessment after preschool hearing screening is not available.

### **9.4. Screening evaluation**

Data unavailable.



## 10. Costs: Neonatal Hearing Screening

Financing of neonatal hearing screening (NHSP) in the U.K. is organized by the state. Screening is free of charge for parents. There is no financial reward when parents attend hearing screening, nor is there a penalty for those who do not attend hearing screening.

Cost analyses of neonatal hearing screening in U.K. have been attempted (Chorozoglou, Mahon, Pimperton, Worsfold, & Kennedy, 2018).

### 10.1. Screening costs

The total screening costs for the NHSP are not available, as there are many individual NHSP services in operation. The NHS England on behalf of Public Health commissions services to carry out hearing screening. In London, PAN London covers all NHS services operating across London, including the NHSP. It is therefore PAN London that sets tariffs for neonatal hearing screening per infant, including both well and at-risk infants. The PAN London tariff is £43.00 per screen.

The South East London Newborn Hearing Screening Programme was able to reduce this PAN London tariff due to contracts with Otometrics and negotiation of overhead charges. Therefore, the tariff for the SEL NHSP is £38.00 per screen, while the tariff for other NHSPs in London remain at 43.00 per screen.

This tariff covers all costs associated with neonatal hearing screening, including staff costs, equipment, maintenance, disposables, and overhead costs (location, electricity, and administration).

### 10.2. Equipment costs

*(Information extracted to protect commercially sensitive data)*

Note that these costs are covered under the tariffs noted in section 8.1.

### 10.3. Staff costs

There are 8 full-time equivalent professionals performing hearing screening for every 10 000 births according to the national NHSP. Other staff include an NHSP administrator and NHSP coordinator, in which 1 full-time equivalent staff is required in each roll for every 10 000 births (Public Health England, 2016). The NHSP in SEL has 17.14 full-time equivalent hearing screeners, 4.2 full-time equivalent senior screeners, 2.6 full-time equivalent administrators, and 2 full-time equivalent coordinators (SEL NHSP local managers and Head of service, 2017).

The annual salary for a NHSP hearing screener is £17,787 to £23,363 for fulltime employment (NHS Employers, 2018).

A diploma in population health screening, with a focus on newborn hearing (12-18 months), costs £1,200 (SEL NHSP, 2018).

Note that these costs are covered under the tariffs noted in section 8.1.

### 10.4. Diagnostic costs

The total cost of diagnostic confirmation is not indicated.

### 10.5. Amplification costs



In the U.K, all children with hearing loss are treated.

Data are unavailable regarding the yearly costs for hearing aid or cochlear implant treatment.

#### **10.6. Social costs**

In England, Educational Health Care Plans are issued by Local Authorities for each child with hearing impairment in order for the child to be placed in a special school or a Resource Base.

There are 334 schools in the U.K. for children with highest needs, including those with autism, communication difficulties, severe learning difficulties and challenging behaviour, those with social, emotional and mental health needs, and those with profound and multiple learning difficulties. Around 6000 children in total attend one of these schools (Consortium for Research into Deaf Education (CRIDE), 2017). The cost per child is roughly estimated to be £27 000 to £38 000 annually.

The number of special schools specifically for deaf or hard of hearing is not indicated; however, a total of 952 students attend one of these special schools, making up 2% of the total number of deaf or hard of hearing children in England (3% of excluding children over the age of 16; Consortium for Research into Deaf Education (CRIDE), 2017).

The large majority (78%) of children with hearing impairment attend mainstream schools. Depending on the needs of the child, they may be placed in a Resource Base within a mainstream school. In some cases, children's educational needs are met with input from a qualified Teacher of the Deaf from a Local Authority Peripatetic Hearing/Sensory Support Service. Based on the need of the child (i.e., weighting and resource banding criteria applied), children with hearing impairment have access to Teachers of the Deaf anywhere from a weekly to annually basis.

Resource Base provisions may include adapted classrooms for teaching hearing-impaired students (e.g., improved acoustics, special equipment), staff familiar with teaching strategies for hearing impaired students, support from a communication support worker, teaching assistant, or learning support assistant, and/or access to small group sessions. Special small group sessions make take place before and/or after regular school teaching sessions or replacing some or all school teaching lessons. There are 251 Resource Base provisions across England, and they may specialize in different approaches (e.g., aural approach or total communication approach).

All costs for mainstream, special education schools, and Resource Base provisions are unknown (Consortium for Research into Deaf Education (CRIDE), 2017).

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

### **11.1. Screening costs**

Total costs are not available. Not all schools provide hearing screening. The local tariff for school-entry (preschool) screening is £20 per child screened (CYPAC, 2017).

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