



**Summary: Hearing Screening
Belgium (Wallonia-Brussels Federation)**

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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	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: <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	Infants who are <i>not</i> 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 Belgium, hearing screening is organized regionally, with regions Wallonia-Brussels Federation, Flanders, and the German-speaking community each organizing and running a separate program.

This report contains information corresponding to hearing screening the Wallonia-Brussels Federation (WBF) region of Belgium.

3.1. General

The WBF region of Belgium has a total area of around 17 000 km² (Fédération Wallonie-Bruxelles, 2016) with a population of 4 571 072 in 2015 (Fédération Wallonie-Bruxelles, 2016). In Belgium, it is regulation that each birth be registered in a national database. The number of births in WBF was 57 500 infants in 2015 (Fédération Wallonie-Bruxelles, 2016).

The World Bank income classification categorizes Belgium as a high-income country (World Health Organization, 2015). The gross domestic product (GDP) was €395 262 million in Belgium as a country and estimated to be €156 091 million for WBF in 2013. With a population of 4 526 142 in 2013 (Fédération Wallonie-Bruxelles, 2016), this equates to an estimated €34 486 per capita for the region.

From the World Health Organization (WHO) Global Health Expenditure Database, health expenditure in Belgium in 2015 was 4228 USD or €3618 per capita (World Health Organization, 2018).

Data from the WHO indicates a child mortality rate (under age 5) in Belgium of 4 per 1000 in 2013 (World Health Organization, 2015), and data from the Euro-Peristat Perinatal Health Report indicates infant mortality rates (at or after 22 weeks to one-year of age) in 2010 as 4.8 and 3.1 per 1000 births in Brussels and Wallonia, respectively (Alexander, et al., 2010). Data acquired from the 2016 United Nations Demographic Yearbook indicates an infant mortality rate of 3.3 per 1000 for the country of Belgium in 2015 (United Nations Statistics Division, 2016).

3.2. Neonatal hearing screening

In WBF, neonatal hearing screening is conducted universally, with all well babies within the region having access to hearing screening, though screening is not obligatory for parents. The universal program was implemented and officially launched in November 2006 as part of the Preventive Child Health Care screening system, and it is funded through the province/region as well as by the parents. The same protocol is used throughout the region for well babies.

Infants with risk factors for hearing impairment are referred directly to a diagnostic evaluation.

3.3. Preschool hearing screening

There is no preschool hearing screening in the WBF.

4. Guidelines & Quality Control

A regional guideline and protocol exist for neonatal hearing screening in the Wallonia-Brussels Federation of Belgium (Communauté française de Belgique, 2015).

The content of the neonatal hearing screening guidelines was developed by a group of experts. ENT physicians, pediatricians, public health individuals in coordination with the coordinating agency of the neonatal hearing screening program decided on the content.

Since its initiation in 2007, the guidelines on hearing screening have not been revised. The document has only had administrative updates since its publication. If required in the future, a group of experts would be responsible for decisions on revisions.

The role of quality monitoring is assumed by the neonatal hearing screening coordinating agency. Data are collected on the screening process, such as date of test and results of screening. Currently, depending on the hospital, data is either sent electronically (50% of hospitals) or by paper (50%). In the future, all screening data will be transferred electronically.

Annual reports of neonatal hearing screening results in WBF are available online (www.depistagenenatal.be). Furthermore, the effectiveness of neonatal hearing screening WBF was investigated as part of a PhD thesis (Vos, 2016).



5. Process: Screening, Diagnosis, Intervention

5.1. Neonatal hearing screening

In WBF, well-baby screening occurs in the maternity unit at hospitals. There is a total of 45 hospitals with maternity wards in the WBF. Participation in the WBF neonatal screening programme is voluntary. Two maternity hospitals do not participate in the programme, and instead organize their own screening protocol.

Approximately 99.2 to 99.5% of children are born in a hospital or maternity clinic, and approximately 0.4 to 0.5% of births occur at home. The average stay in the maternity hospital after birth is 2-3 days as of a new reform in 2016/2017 (Van Leeux, Leroy, Englert, & Zhang, 2017; Leroy, Van Leeuw, Englert, & Zhang, 2017).

All babies that are screened are done so using the well-baby protocol. As indicated, babies at-risk are not screened but referred directly for diagnostic assessment. Well-baby screening should ideally be completed before the infant is discharged from the hospital. If hearing screening cannot be completed by discharge, an appointment is booked before 15 days of age; however, in some cases where this is not possible, a 4-week maximum benchmark age is tolerated by protocol (Communauté française de Belgique, 2015).

The target condition for screening is not specified in the protocol for well babies, nor is the target condition for at-risk babies.

At-risk babies are defined as those with a family history of hereditary hearing loss, consanguinity to the first degree, in utero infections including CMV, toxoplasmosis, herpes, rubella, and syphilis), drug or alcohol poisoning during pregnancy, an APGAR score of 0-6 at 5 minutes or gestational age < weeks and/or low birth weight (<1500g), NICU stay \geq 5 days, newborn ototoxic medication, exchange transfusion, assisted ventilation, head or neck abnormalities, syndrome including hearing loss, neurological diseases or endocrine diseases. These may include babies in both the well-baby and NICU units (Communauté française de Belgique, 2015).

In 2015, a total of 787 infants were born prematurely (< 37 weeks) in WBF (Van Leeux, Leroy, Englert, & Zhang, 2017; Leroy, Van Leeuw, Englert, & Zhang, 2017). The prevalence of CMV infection is unknown. This information is not collected and registered; on the other hand, risk factor data are collected. CMV has been reported as a risk factor in 213 out of 506 000 neonates (Vos, Lavenne, Oumourgh, & Levêque, 2017).

The prevalence of meningitis is not collected, but instead all neurological diseases combined are reported in the neonatal hearing screening program.

Neonates with at least one risk factor for hearing loss account for 9% of total births, including both well infants and infants admitted the NICU (Vos, Lavenne, Oumourgh, & Levêque, 2017).

5.2. Neonatal diagnostic assessment

The diagnostic assessment tests vary across the WBF. While it is recommended that at least an ABR is performed, other diagnostic tests performed may include otoscopy, OAEs, and impedance measurements.

The diagnostic assessment of well-babies should be performed within 15 days from hearing screening referral (Communauté française de Belgique, 2015). Recall letters are sent by the coordinating agency in cases where infants are lost to follow up after referral or infants who were not screened, or by the hospitals for the 3rd recall or in cases where data transmission is performed via paper.

All at-risk babies are referred directly for a diagnostic assessment during their stay in the hospital / maternity ward. The diagnostic test may be performed while the infant is in the hospital or via a scheduled appointment. Medical professionals may phone the parents or send a letter with the scheduled day and time of consultation. The test takes place in the hospital in the NICU or the ENT clinic. This diagnostic test should be completed by 2-8 weeks after birth or by 1-month of age, corrected. (Communauté française de Belgique, 2015).

5.3. Preschool hearing screening

Not applicable.

5.4. Intervention approach

In WBF, treatment options available include grommets, hearing aids, bone conductive devices, cochlear implants, and more. The age at which children are fitted with hearing aids or cochlear implants are not reported, as this depends on individual trajectory of care and age at which hearing loss is diagnosed (Vos, Senterre, Boutsen, Lagasse, & Levêque, 2018).

Fitting guidelines for hearing aids are not published in guidelines, but international recommendations are followed. WBF criteria for hearing aid fitting depend on the child's hearing loss, personal situation, other disabilities, etc.

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 screening process for well babies is indicated in Table 1. In WBF, a two-step OAE protocol is performed when necessary before discharge. Infants that fail the second OAE at discharge are referred for a diagnostic assessment (Communauté française de Belgique, 2015).

Table 1: Screening process for well babies in Belgium (WBF).

Test	Age	Referral criteria	Device	Unilateral Referrals?	Location
OAE1	24-72 hours	8x peaks of alternating-signs	Accuscreen*	Yes	Maternity hospital
OAE2	+1 day after OAE1 (before discharge)			Yes	Maternity hospital

*While the Accuscreen device by Madsen is widely used across WBF, some hospitals use the EchoScreen by Natus, which has a bimodal statistical algorithm, or Echocheck by Otodynamics.

6.2. Neonatal hearing screening (at-risk)

All infants considered at risk are referred directly for audiological diagnostic assessment.

6.3. Preschool hearing screening

Not applicable.

7. Professionals

7.1. Neonatal hearing screening (well)

Screening is performed by midwives or nurses. Sometimes screening is performed by audiologists, speech therapists, or assistant nurses. There is no formal training for screening staff or accreditation required.

A non-mandatory half- to full-day session is held once every 3-5 years to discuss elements of hearing screening, including the programme, operation, results, risk factors, etc; however, this session is not intended for training on the use and operation of screening equipment (Communauté française de Belgique, 2015).

7.2. Neonatal hearing screening (at-risk)

Screening is not performed. Audiologists or specialized nurses perform the diagnostic test bilaterally. As a legal requirement, the test results must be analyzed by an ENT or neurophysiologist.

7.3. Preschool hearing screening

Not applicable.

8. Results: Neonatal Hearing Screening

8.1. Coverage and attendance rates

In WBF, coverage rate is defined as the percentage of eligible well infants that receive the first screening test. Eligible infants do not include infants whose parents choose to be screened elsewhere such as within the Flemish newborn screening programme or parents that refuse screening. In many cases, infants may be born in WBF but are covered within the Flemish programme.

The coverage rate for neonatal hearing screening for well babies was 95% in 2016. It is reported that 0.2% of parents refused the first screening step in 2016 (Vos, Lavenne, Oumourgh, & Levêque, 2017); therefore, the calculated coverage rate for the first screening step (including refusals) would equal 94.7%.

Attendance rate is defined as the number of infants screened out of the number that are offered screening. The number of infants that *missed being offered* screening is not specified, and therefore attendance rate for the first screening step is not known. Attendance rate for the second step of screening is reported from 2016, whereby 87.4% of well infants who were referred from the first screening step attended the second step of screening (Vos, Lavenne, Oumourgh, & Levêque, 2017).

8.2. Referral rates

Referral rates for each step of the 2-step OAE screening for well babies are indicated in Table 2. Note that the referral rates for each step assume 100% attendance. Actual attendance rates for each step are presented in section 8.1 (above).

Table 2: Referral rates for each step of the neonatal hearing screening protocol (well babies) in Belgium (WBF) (Vos, Lavenne, Oumourgh, & Levêque, 2017)

Test	Referral Rate
OAE1	15.3%
OAE2	23.5%

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

The total referral rate for well babies from the 2-step screening process to diagnostic evaluation is 3%. This figure, calculated from the total number of infants referred from step 2 out of all infants screened in the step 1, does not account for infants lost between the two steps of the screening process (12.6%).

8.3. Diagnostic assessment attendance

Among the referred well-baby newborns, the initial compliance rate to a diagnostic examination was 72.1% in 2016: however, not all infants that attended the initial diagnostic exam received a confirm diagnosis. In fact, 65.9% of infants referred from screening received a final conclusive diagnostic assessment in 2016 (Vos, Lavenne, Oumourgh, & Levêque, 2017).

For at-risk babies, 100% are referred for a diagnostic assessment. The compliance rate for the diagnostic assessment was 91.3% in 2016 (Vos, Lavenne, Oumourgh, & Levêque, 2017).

8.4. Prevalence / Diagnosis

Hearing loss prevalence data are collected in the WBF but lack accuracy in the database.

8.5. Treatment success

The number of children fit with hearing aids or cochlear implants in WBF after neonatal hearing screening is unmonitored by the WBF neonatal hearing screening programme.

8.6. Screening evaluation

It is difficult to accurately evaluate a screening system given overall limitations of hearing loss confirmation. The figures presented are roughly estimated.

The percentage of false negatives (percentage of babies who pass screening out of all who have hearing impairment) is unmonitored. The percentage of false positives (percentage of babies who fail screening out of all those with normal hearing) is roughly estimated to be 2.7%. The positive predictive value of a refer result in one or two ears in well babies is roughly estimated to be 10%.

The sensitivity and specificity of neonatal hearing screening in well babies are not known, given that the number of false negative results are unknown and gold standard hearing loss confirmation is not applied.

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. Prevalence / Diagnosis

Not applicable

9.5. Treatment success

Not applicable

9.6. Screening evaluation

Not applicable

10. Costs: Neonatal Hearing Screening

Neonatal hearing screening in WBF is not 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.

There has not been a cost effectiveness analysis in the WBF.

10.1. Screening costs

The total annual budget for neonatal hearing screening is an estimated €437 000. This budget would cover an estimated cost of €150 000 for the coordinating agency, and €37 000 for data collection. The coordinating agency and data collection covers all infants, including those with risk factors. An estimated cost of €250 000 is for the hospitals. Hospitals receive €5 for each child tested from the Mother and Child Agency (Ministry) (Vos, Personal communication, 2018).

A fee is also billed to the parents. The cost to the parents is up to €10, indexed. The 2018 indexed amount is €11.50. This amount from the parents is transferred directly to the hospitals (Communauté française de Belgique, 2015; Vos, Personal communication, 2018).

10.2. Equipment costs

(Information extracted to protect commercially sensitive data)

The maintenance costs and disposable costs are also covered by the hospitals, and this cost is not known.

10.3. Staff costs

In WBF, the monthly salary for a nurse, specialized nurse, midwife, and audiologist ranges from €2220-2500 to €3160-4000 depending on years of experience. The hourly salary for screening professionals range from €13.2-15.5 to €19.2-24.3 depending on the years of experience (La Centrale Générale-FGTB, 2016).

In WBF, nurses and midwives have 4 years of education. Audiologists have 3 years of education and speech therapists have either 3 or 5 years. The annual cost for education in WBF is €5500-7900 per student paid by the region, plus an additional €835 paid by the student, in addition to the costs of books, etc. (€180 per year) (Fédération Wallonie-Bruxelles, 2012).

10.4. Diagnostic costs

The cost of diagnostic examination is sourced from the Nomenclature in Belgium (Social and Health Security / Insurance). The cost to parents for a diagnostic assessment is €20.75 for an ENT appointment and €95.65 for a technical exam, with ABR only. These costs may be reimbursable to the parents, depending on their economic status.

10.5. Amplification costs

All eligible children with hearing loss are treated.

The costs for the first year of hearing aid intervention, including device and consultation/rehabilitation costs, is unknown, though these costs would vary depending on the device. The costs for CI

intervention, including device and consultation/rehabilitation costs is unknown, though these costs would vary depending on the device. All costs would be fully reimbursed to the parents.

After the first year of intervention, costs for continued intervention are unknown, and there is no rule of how often devices should be replaced.

10.6. Social costs

In WBF, hearing impaired students may attend regular primary school or special schools for deaf children. There is a total of 13 schools for the deaf and hard of hearing in WBF. All 13 schools provide maternal and primary education, and 7 of these schools provide education up to the secondary-level. Additionally, there are childcare centers for deaf toddlers. Table 3 provides details on the age and number of students at each level of education (Fédération Wallonie-Bruxelles, 2018; Fédération Wallonie-Bruxelles, 2015)

Table 3: Schools for the deaf and hard of hearing in Belgium (WBF).

School	Student age (years)	Number of schools	Number of students
Maternal	3-6	13	181
Primary	6-12	13	462
Secondary	12-18	7	383

Special support or accommodation is provided to deaf children who attend a mainstream primary school. This support is financed by the WBF or by the hearing rehabilitation center, therein financed by the healthcare insurance or social security within the disabled policy / inclusion of disabled people.

In WBF, the cost per student for attendance in a special school for deaf children or for special support in mainstream schools is €15 100 per child. The cost per student without special accommodation in a regular primary school is €4238 (Fédération Wallonie-Bruxelles, 2014).

11. Costs: Preschool Hearing Screening

11.1. Screening costs

Not applicable.

11.2. Equipment costs

Not applicable.

11.3. Staff costs

Not applicable.

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