Summary: Hearing Screening

Bosnia and Herzegovina (Tuzla Canton)

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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	The proportion of all those invited for screening that are tested and receive a result, • Invited for screening includes all those that are offered the screening test. • Tested and receive a result could be a "pass" or "fail". Attendance rate provides information on the willingness of families to participate in screening.
Attendance rate in first year of life	See definition of **Attendance rate.** The calculation cut-off is after one year of life.
Compliance with referral (percentage)	The percentage of those who are referred from screening to a diagnostic assessment that actually attend the first diagnostic assessment. Percentage of compliance provides information on the willingness of families to attend the diagnostic assessment after referral from screening.
Coverage	The proportion of those eligible for screening that are tested and receive a result within a specific time. • Eligible for screening includes those within the population that are covered under the screening or health care program. • Tested and receive a result could be a "pass" or "refer to diagnostic assessment". • Specific time can be defined, such as 1 month after birth, 3 months after birth, etc. Coverage provides information on the overall effectiveness and timeliness of a complete screening programme. Factors such as being offered screening, willingness to participate, missed screening, ability to complete the screen, and ability to document the screening results will influence the coverage.
Coverage in first year of life	See definition of **Coverage.** The specific time is pre-defined as within the first year of life. In other words, the coverage is the proportion of those eligible for screening that complete the screening sequence to a final result within the first year of life.
False negatives	The percentage of infants/children with a hearing loss (defined by the target condition) that receive a result of "pass" during screening.

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

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

2. Abbreviations

ABR – auditory brainstem response

aABR – automatic auditory brainstem response

ANSD – auditory neuropathy spectrum disorder

ASSR – auditory steady-state response

CI – cochlear implant

CMV – cytomegalovirus

dB HL – decibel hearing level

dB nHL – decibel normalized hearing level

dB SNR – decibel signal-to-noise ratio

DPOAE – distortion product otoacoustic emissions

HA – hearing aid

NICU – neonatal intensive care unit

OAE – otoacoustic emissions

TEOAE – transient-evoked otoacoustic emissions

3. Background

In Bosnia and Herzegovina, hearing screening is organized and implemented regionally.

The following report contains information with regards to hearing screening in the Tuzla Canton of Bosnia.

3.1. General

Bosnia and Herzegovina comprises two autonomous regions: The Federation of Bosnia and Herzegovina and the Republika Srpska (Serb Republic), plus a third region, the Brčko District. The Federation of Bosnia and Herzegovina is made up of 10 cantons, or member states, each with its own Ministry of Health, Law of Health and maternity wards. Tuzla Canton is the most populous of the 10 cantons in the country with 10 maternity wards.

Tuzla Canton has a total area of 2 664 km^2 (Vlada Tuzlanskog kantona, 2018) and a population of 477 278 as of the 2013 census (Agency for Statistics of Bosnia and Herzegovina, 2013) In Tuzla Canton, each birth is registered. In 2016, the number of live births was 30 183 in all of Bosnia and Herzegovina and 3727 in Tuzla Canton (Agency for Statistics of Bosnia and Herzegovina, 2018).

The World Bank income classification categorizes Bosnia and Herzegovina as an upper-middle income country. It was classified as a lower-middle-income country prior to 2010 (The World Bank, 2018). The gross domestic product (GDP) is €4 571 per capita as of 2017 (Agency for Statistics of Bosnia and Herzegovina, 2018).

From the World Health Organization (WHO) Global Health Expenditure Database, health expenditure in Bosnia and Herzegovina in 2015 was 431 USD or €378 per capita (World Health Organization, 2018).

Data acquired from the 2016 United Nations Demographic Yearbook indicate an infant mortality rate of 4.8 per 1000 for the country of Bosnia and Herzegovina in 2014 (United Nations Statistics Division, 2016).

3.2. Neonatal hearing screening

Only some cantons in Bosnia and Herzegovina have implemented neonatal hearing screening, such as Tuzla canton, Sarajevo, and Livno. Universal hearing screening is not carried out across the entire country.

In Tuzla Canton, neonatal hearing screening is conducted universally, with all babies in the region having access to hearing screening, though screening is not obligatory for parents. The hearing screening programme for at-risk babies was first implemented in 2001, and for well, healthy babies it was implemented in 2009. 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 health insurance and through the municipalities.

Across Tuzla Canton, there are differences in the location and timing of screening. Specifically, out of the three hospitals in Tuzla Canton, one hospital (General Hospital Gračanica) performs OAE screening in the maternity ward. In the two other hospitals, screening is not performed in the maternity ward, but parents are instead invited to hearing screening at the Audiology department.

3.3. Preschool hearing screening

In Tuzla Canton, preschool hearing screening is not performed.

4. Guidelines & Quality Control

Guidelines and a protocol for hearing screening do not exist in Tuzla Canton. There are no official protocols or guidelines. The Joint Committee of Infant Hearing (2007) document is used as guidance.

The content of hearing screening programme was decided on by ENT specialists. The content of the programme has not changed since hearing screening implementation; however, changes have been made due to device failure. Specifically, in 2009, all hospitals performed neonatal hearing screening in the maternity ward. However, in two of three hospitals, device failure has caused the location of screening to move from the maternity ward to the Audiology department in Tuzla. Since then, parents are provided written information about neonatal hearing screening in the delivery ward, inviting them to the Audiology department to have their newborn's hearing screened free of charge.

Quality assurance of hearing screening programmes is not imposed by the government, nor is it performed in Tuzla Canton; however, data on the number of newborns screened are collected, sent monthly to the Audiology department in the ENT clinic at the University Clinical Center Tuzla. Data are also available from the Audiology department, as newborns born in two of three hospitals are screened directly in the Audiology department.

Reports are available for screening Tuzla Canton, including data collected from April 2009 to December 2010 and from December 2010 to March 2017. From these data, studies have been performed on neonatal hearing screening and its effectiveness in Tuzla Canton. Studies have also been performed on hearing screening in other parts of Bosnia and Herzegovina (Pirić, 2018; Sarajlić, 2013; Hrncic, 2018; Vranjes, et al., 2012).

5. Process: Screening, Diagnosis, Intervention

5.1. Neonatal hearing screening

Well-babies and at-risk babies are mostly screened in the Audiology department in Tuzla. Infants born in one hospital in Tuzla Canton are screened in the maternity hospital, where the maximum length of stay is estimated to be 2 days. It is roughly estimated that 1-2% of births take place at home. Families of well infants are typically invited to participate in neonatal screening via a letter. Families of at-risk infants are invited to participate directly in person in the hospital

Neonatal hearing screening for well babies should be completed before 6 months of age, and by 6-12 months of age for at-risk infants.

The target condition for screening well babies is a bilateral or unilateral hearing loss of greater than 30 dB HL, and the target condition for screening at-risk babies is a bilateral or unilateral hearing loss of greater than 25 dB HL.

In Tuzla Canton, at-risk infants are defined based on the list created by the Joint Committee on Infant Hearing (2007); however, there is no difference in protocol between well and at-risk infant. Data are unavailable regarding how many infants meet the listed risk-factor criteria (Joint Committee on Infant Hearing, 2007).

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

5.2. Neonatal diagnostic assessment

The diagnostic assessment test performed after neonatal hearing screening referral is a clinical ABR. Well infants should have their diagnostic assessment completed by 6 months of age, and at-risk infants should have their diagnostic assessment completed by 80 weeks, corrected.

5.3. Preschool hearing screening

Not applicable.

5.4. Intervention approach

In Tuzla Canton, treatment options available include grommets, hearing aids, and cochlear implants. Infants are fitted with hearing aids or cochlear implants from 6-12 months of age or older.

The hearing aid fitting criteria in Tuzla Canton is a hearing loss > 40% according to the Fowler-Sabine scale (a frequency-weighting algorithm to estimate hearing handicap).

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)

There are two to three steps to the newborn hearing screening protocol for well babies in Tuzla Canton. Tables 1 and 2 describe the different protocols used in Tuzla Canton. In one hospital, initial OAE screening is performed in the maternity ward. A possible third step is sometimes performed at the age of 4 months. In the other two hospitals, screening devices are not available in the maternity wards. Instead, parents are invited for screening at the Audiology unit. For these infants, screening takes place around the age of 2 months. For infants that fail the first OAE, a rescreening occurs 1 to 2 months later.

Table 1: Screening process for well babies in Tuzla Canton (hospital 1).

Test	Age	Referral Criteria	Device	Unilateral Referrals?	Location
OAE1	24-72 hours	Not indicated	Not indicated	Yes	Maternity ward
OAE2	1-2 months	Not indicated	Not indicated	Yes	Audiology dept.
*OAE3**	*4 months*	*Not indicated*	*Not indicated*	Yes	*Audiology dept.*

*Infants are *sometimes* invited back for a third OAE at 4 months of age before being referred for a clinical ABR.

Table 2: Screening process for well babies in Tuzla Canton (hospitals 2 & 3).

Test	Age	Referral Criteria	Device	Unilateral Referrals?	Location
OAE1	2 months	Not indicated	Not indicated	Yes	Audiology dept
OAE2	3-4 months	Not indicated	Not indicated	Yes	Audiology dept.

6.2. Neonatal hearing screening (at-risk)

The sequence for screening infants at-risk is identical to the protocol for well, healthy infants. The only exception is that testing occurs when the health condition of the infant allows.

6.3. Preschool hearing screening

Not applicable.

7. Professionals

7.1. Neonatal hearing screening (well)

Screening for well babies in the neonatal ward is performed by nurses. Screening at the Audiology department is performed by a hearing rehabilitator. There is no specific training for hearing screeners in Tuzla Canton.

7.2. Neonatal hearing screening (at-risk)

Screening for at-risk infants is performed by nurses or a hearing rehabilitator, as described in section 7.1.

7.3. Preschool hearing screening

Not applicable

8. Results: Neonatal Hearing Screening

8.1. Coverage and attendance rates

The data on coverage and attendance rate is difficult to calculate in Tuzla Canton due to the change in programme situation and variation in how infants are invited for neonatal hearing screening. Therefore, one figure does not reflect the entire duration of the programme since its implementation in April 2009.

During initial implementation of neonatal hearing screening in Tuzla Canton in 2009, all three hospitals were tasked with performing screening in the maternity wards. Data collected from April 2009 to December 2010 showed a coverage rate of 38.7%. From December 2010 to March 2017, infants born in two maternity wards are invited to participate in screening at the Audiology department. Infants attend screening at the Audiology department around 2 months of age. The coverage rate from infants born in these two hospitals is 78.6% (Brkić, 2018; Pirić, 2018).

Theoretically, all infants are invited for screening; however, the number of infants that may have missed being offered screening is not indicated, and therefore the attendance rate is not known, though likely very similar to the coverage rate.

Data provided on attendance rates varied across the data collection studies and area. In Tuzla Canton, out of the infants that are referred from OAE1, the attendance rate to OAE2 was 27.1%. This means that out of the infants referred from OAE1 72.9% of did not attend rescreening and were lost (Brkić, 2018; Pirić, 2018).

However, findings from outside of Tuzla Canton shows other results. Vranjes et al. (2012) from Banja Luka reported a higher attendance rate (74.5%) to the OAE2 screen after OAE1 referral. Furthermore, Hrncic (2018) from the Cantonal Hospital Zenica, which has 3 OAE screening tests, reported that a total of 10.3% of children were lost to follow-up after OAE1 and OAE2 combined.

8.2. Referral rates

Referral rates for the neonatal screening are sourced from the Audiology department database at the University Clinical Center Tuzla (Brkić, 2018; Pirić, 2018). Referral rates for each step of OAE screening for well babies are indicated in Table 3 and represent the protocol indicated in Table 2.

Table 3: Referral rates for each step of the neonatal hearing screening protocol (well babies) in Tuzla Canton (Brkić, 2018; Pirić, 2018).

Test	Referral Rate
OAE1	9.46%
OAE2	13.8%

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 all babies after neonatal hearing screening is 0.35%; 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 steps of the screening process (Brkić, 2018; Pirić, 2018).

8.3. Diagnostic assessment attendance

The compliance rate to a diagnostic audiological evaluation after neonatal hearing screening is not indicated. From Banja Luka, 47% of infants referred from OAE2 attended the follow-up test, and 53% were lost to follow-up (Vranjes, et al., 2012).

8.4. Prevalence / Diagnosis

From the data provided by the Audiology department from December 2010 to March 2017, 67 children were identified with hearing loss after neonatal hearing screening. This can be calculated to an estimated total prevalence rate of 1.8 per 1000 (Brkić, 2018; Pirić, 2018). However, it must also be noted that this figure only accounts for the neonates screened in 2 out of 3 maternity hospitals in Tuzla Canton, and may be an underestimation due to the high drop-out rate between screening steps.

Rough estimates of the prevalence of permanent hearing loss among neonates in Tuzla Canton were made, as follows:

Bilateral, ≥ 40 dB HL: 3 per 1000
Bilateral ≥ 80 dB HL: 2-4 per 1000

Unilateral ≥ 40 dB HL: 40% of newborns with hearing loss
Unilateral ≥ 80 dB HL: 50% of newborns with hearing loss

The prevalence of bilateral auditory neuropathy in Tuzla Canton is not available.

8.5. Treatment success

In Tuzla Canton, there are 25 children fitted with hearing aids per year and 3 children fitted with cochlear implants. In Bosnia and Herzegovina, approximately 10 children are fitted per year with cochlear implants.

8.6. Screening evaluation

For neonatal hearing screening in Tuzla Canton, it is very difficult to calculate the sensitivity, specificity, false negatives, false positives, or positive predictive value.

Rough estimations were provided, including 5% for the percentage of false negatives and 4% for the percentage of false positives. The sensitivity is roughly estimated to be 95% and the specificity is roughly estimated to be 96-97%.

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 Tuzla Canton 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.

There has not been a cost effectiveness analysis completed in Tuzla Canton.

10.1. Screening costs

The costs for neonatal hearing screening for both well and at-risk infants in Tuzla Canton is €75 per infant. With a birth rate of approximately 4000 infants per year, the total cost is around €30 000 per year.

10.2. Equipment costs

(*Information extracted to protect commercially sensitive data*)

Maintenance costs are roughly estimated to be €1 000 per year, and a device is roughly estimated to be replaced every two years. The cost for disposables is also roughly estimated to be €1 000 per year.

10.3. Staff costs

The salary of nurses in Tuzla Canton is roughly estimated to be €350 per month or €4200 annually. The salary for a hearing rehabilitator that perform hearing screening is roughly estimated to be €650 per month or €7 800 annually. The educational cost is roughly estimated to be €1000.

10.4. Diagnostic costs

The cost for a diagnostic assessment is not indicated.

10.5. Amplification costs

In Tuzla Canton, all children are treated for hearing loss.

For hearing aids, the cost for the first year is €1 500. Each visit to the ENT/hearing rehabilitator costs €200.

For cochlear implants, the initial costs are €27 000, plus €3 000 per year for consultation, rehabilitation, and fitting.

10.6. Social costs

A specialized school is available in Tuzla Canton, with a total of 20 children ages 6-15 years; however, only 6 have hearing loss. The cost per child for specialized school is €2 000 per year, while the cost for a child in mainstream school is €500 per year. It is estimated that children with hearing impairment that attend regular schools have access to extra teacher support, plus daily access to a hearing rehabilitator.

11. Costs: Preschool Hearing Screening

11.1. Screening costs

Not applicable.

11.2. Equipment costs

Not applicable.

11.3. Staff costs

Not applicable.

12. References

Agency for Statistics of Bosnia and Herzegovina. (2013, 12 30). *ENUMERATED PERSONS, HOUSEHOLDS AND DWELLINGS, 2013 CENSUS FIRST RESULTS, BY CANTONS OF THE FEDERATION OF BOSNIA AND HERZEGOVINA*. (Sector for Demography and Social Statistics) Retrieved from Popis 2013: http://dissemination.bhas.ba/PXWeb/pxweb/en/Census%202013%20-%20Popis%202013%20-%20Попис%202013/?tablelist=true&selection=Census 2013 - Popis 2013 - Попис 2013&rxid=929fac9f-6a40-4fd2-b33e-a9d871e791be

Agency for Statistics of Bosnia and Herzegovina. (2018). *DEMOGRAPHY AND SOCIAL STATISTICS*. Retrieved from Agency for Statistics: http://www.bhas.ba/?option=com_publikacija&id=1&lang=en

Agency for Statistics of Bosnia and Herzegovina. (2018). *ECONOMIC STATISTICS*. Retrieved from Agency for Statistics: http://www.bhas.ba/?option=com_publikacija&id=2&lang=en

Brkić, F. (2018). *Personal communication.* Tuzla: University Clinical Center Tuzla.

Hrncic, N. (2018, Feb). Identification of risk factors for hearing impairment in newborns: a hospital based study. *Med Glas (Zenica), 15*(1), 29-36.

Joint Committee on Infant Hearing. (2007). Year 2007 position statement: principles and guidelines for early hearing detection and intervention programs. *Pediatrics, 120*(4), 898-921.

Pirić, L. (2018). *The impact of the universal neonatal auditory screening program on the process of hearing and speech rehabilitation.* University of Tuzla, Medical faculty. Tuzla: University of Tuzla.

Sarajlić, Z. (2013). *Assessment of hearing impairment in newborns by screening test by evoked otoacoustic emission method.* University of Sarajevo, Medical faculty. Sarajevo: University of Sarajevo.

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

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

Vlada Tuzlanskog kantona. (2018). *PROSTORNO DEMOGRAFSKA OBILJEŽJA*. Retrieved from O KANTONU: http://www.vladatk.kim.ba/

Vranjes, D., Spremo, S., Travar, D., Aleksic, A., Novakovic, Z., Steva, N., . . . Stupar, Z. (2012). THE ROLE AND IMPORTANCE OF SCREENING PROCEDURES IN EARLY DIAGNOSTICS OF HEARING IMPAIRMENT. *Medicinski časopis, 6*(2), 71-76.

World Health Organization. (2018). *Global Health Expenditure Database*. (W. H. Organization, Producer) Retrieved 08 01, 2018, from NHA Indicators: http://apps.who.int/nha/database/DataExplorerRegime.aspx)