

Universal **NEWBORN SCREENING** Implementation Guidance

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Hearing impairment

Eye abnormalities

Newborn hyperbilirubinaemia at discharge

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Universal newborn screening: Implementation guidance

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Universal **NEWBORN** SCREENING

Implementation Guidance

FOR-



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It is a matter of pride that our WHO South-Asia Region, during the last decade, achieved the highest reduction in the number of deaths of under-5 children compared to all other WHO regions. The regional under-5 mortality rate declined by 45%, against a global reduction of 26%. However, there is more to be done.

The three most common causes of death in under-5 children are preterm birth complications, intrapartum-related events, and birth defects. Between 2000 and 2021, the contribution of birth defects to child mortality unfortunately increased in our Region from 4% to 11%, compared to a global increase from 4.6% to 8%.

In 2022, WHO released the updated guideline on postnatal care for mothers and newborns, with new recommendations on universal newborn screening for three conditions – eye abnormalities, hearing impairment and neonatal hyperbilirubinaemia. If not detected early and managed adequately, these conditions can have serious implications on a child's overall development. They can result in delayed motor and language skills, and impaired emotional, social and cognitive development. The consequences are potentially lifelong.

The handbook has been developed through a consultative process with technical experts from Member States, and provides guidance on planning and implementation of the universal newborn screening programme in health facilities using simple tests. It provides standard operating procedures, as well as specifications for the equipment and management of a baby with a positive screening test.

Additionally, videos are provided to demonstrate the procedure of screening newborns using these simple screening tests. Integration of these tests within the existing system can enhance the health system capacity for early detection and management of these conditions. It is equally important to ensure that these screening tests are supported by effective systems for referral, diagnosis, management and follow-up.

I need not remind us that our Region is committed to achieving the 2030 Sustainable Development Goal targets for maternal, newborn and child mortality.

It is with that goal in mind that I urge all our Member States and stakeholders to adopt, internalize and use the implementation guidance for introducing, conducting and monitoring these three screening tests for all newborns before hospital discharge.

We owe the next generation our collective actions to standardize these screening practices, to achieve the SDG targets - and, most importantly, to meet the needs of every newborn, everywhere.

Ms Saima Wazed Regional Director WHO South-East Asia



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We would like to express our deep appreciation to all the contributors, experts, partners, and reviewers who played a vital role in the development of the document and training videos.

Abbreviations

AABR	automated auditory brainstem response
ABR	auditory brainstem response
АМС	annual maintenance contract
BIND	bilirubin induced neurological dysfunction
CI	confidence interval
СМС	comprehensive maintenance contract
dB	decibel
D	dioptre
ENT	ear, nose and throat
GDG	guideline development group
G6PD	glucose 6 phosphate deficiency
JCIH	Joint Committee on Infant Hearing
LMP	last menstrual period
NICE	National Institute for Health and Clinical Excellence
NICU	neonatal intensive care unit
OAE	otoacoustic emission
PBHL	Permanent bilateral hearing loss
ΡΤΑ	pure-tone audiometry
PVL	periventricular leucomalacia
NES	newborn eye screening
Rh	Rhesus blood group
SEARO	South East Asia Regional Office
тсв	trans cutaneous bilirubin
TEOAE	transient evoked otoacoustic emission
TSB	total serum bilirubin
UNES	universal newborn eye screening
UNHS	universal newborn hearing screening
WHO	World Health Organization



CHAPTER 01

Introduction

n 2022, the World Health Organization (WHO) released updated postnatal care guidelines "Recommendations on maternal and newborn care for a positive postnatal experience". For the first time, WHO addressed the aspects of discharge readiness, discharge preparation, and universal screening of newborns as part of the updated guidance.

THREE NEW RECOMMENDATIONS FOR UNIVERSAL SCREENING TO ENSURE OPTIMAL HEALTH AND WELL-BEING OF ALL NEWBORNS



Currently, most Member States in the Region are performing screening tests only for high-risk newborns e.g., preterm or requiring special or intensive newborn care due to any other reason.

The recommendation on discharge criteria includes, besides physical examination, the skills of the woman to care for herself, competency of the parents and caregivers to provide care for the woman and the newborn in the home, and careseeking behaviour. Additionally, information provision, educational interventions, and counselling are recommended to strengthen preparation for discharge from the health facility to home after birth. While newborn examination before discharge is considered the standard of clinical care and

practiced in many countries, in most settings, the examination usually relies on clinical assessment/judgment, for example, visual assessment of jaundice by blanching of skin and subcutaneous tissue, external examination of eye using penlight /torchlight to examine external structures and observing the newborn's response to sound as a test of hearing, and not formal testing using a screening test.

The implementation of these new recommendations for universal screening in the Member States of the Region will require policy change and programmatic support, but even before that may be done, it will be important to assess the feasibility of integrating universal newborn screening as part of the existing national programmes.

Purpose of the handbook

The handbook is aimed to provide implementation guidance and support to the Member States in developing and implementing strategies and actions for the three recommendations on universal newborn screening. It provides standard operating procedures including the equipment needs for screening, specifications for the equipment, and management of a baby with a positive screening test. Additionally, videos are provided to demonstrate the procedure. This handbook along with the videos will help health care providers at all levels of care to conduct screening for all newborns and also support program managers in setting up the universal newborn screening program.

Use of the handbook

The implementation guidance for the three recommendations on universal newborn screening are provided in this handbook. Each guidance discusses the need and rationale, current status and perspectives, the screening tools, the equipment and supplies needed, and the specifications for the equipment. The document also provides a brief overview on the management and next steps if the screening test is positive. Algorithms and figures are presented for easy understanding. Videos can be accessed by scanning the QR code available on the back cover.

CHAPTER 02

Universal newborn screening for hearing impairment

Need and rationale

Severe or profound permanent bilateral hearing loss (PBHL) is a serious condition in newborns, with a prevalence of 1 to 1.5 per 1000 live births. In addition, 1 to 2 per 1000 newborns have bilateral mild to moderate hearing loss, or unilateral hearing loss of any degree. Causes of PBHL include intrauterine infections such as TORCH

FIGURE 1: CAUSES OF PERMANENT BILATERAL HEARING LOSS



(Toxoplasma, rubella, cytomegalovirus, herpes) congenital infections, genetic abnormalities and craniofacial problems. Approximately, 50% of newborns with PBHL have no identifiable risk factor.^(1,2)

It has been shown that infants who receive intervention before the age of 6 months have better school outcomes, and improved language and communication skills by 2–5 years.⁽⁵⁾ Hearing loss in newborns has serious implications in not only language but overall development, literacy, functioning in adulthood and quality of life.^(1,2,3) The first six months of life are crucial for the development of speech and language. Each month lag in diagnosis of hearing impairment accounts for a 0.17-month delay in receptive language and a 0.30-month lag in expressive language.⁽⁴⁾ Without early intervention, children with hearing loss will show irreversible deficit in communication, psychosocial skills and literacy and are more prone to academic underachievement, and problems in employment which cause psychological distress.⁽⁶⁾

Universal newborn hearing screening (UNHS) programmes are considered the standard of care in many countries.^(1,7) Without a screening programme, hearing deficit is typically identified with language delay by around 2 years of age compared with three months or younger in the screened population.⁽⁶⁾ Screening has reduced the age at which infants receive hearing aids, from 13–16 months to 5–7 months in developed countries.⁽⁸⁾ The need for this hearing screening and early intervention may be further disseminated and highlighted through advocacy meetings on World Hearing Day (3 March).

Current status and perspectives

It is estimated that nearly one third of the world's population, living mainly in high-income regions, is fully or almost fully covered by UNHS.^(9,10) The degree of implementation and coverage of such programmes varies substantially across the world. Screening coverage is also closely associated with average living standards and economic well-being.⁽¹¹⁾ The lack of relevant policies, human resources, equipment and financial resources for hearing screen are challenges very commonly faced in low- and middle-income countries. These challenges are further aggravated by low awareness about hearing loss and its associated stigma.

OAE and AABR are simple non-invasive 30-minute bedside tests.⁽¹⁾ A combination of protocols is often used with OAE or AABR and is repeated if infants are reported to have "failed" i.e not responded to the test. Both the tests have high sensitivity, specificity, and positive and

negative predictive values, used alone or in combination. A systematic review of 32 study populations in high-income countries (1,799,863 screened infants) has shown the pooled sensitivity as 89%–100%, specificity 92%–100%, positive predictive values 2% to 84%, negative predictive value 100%).⁽¹²⁾ A follow-up definitive test involving diagnostic audiological testing should be done as soon as possible after screening.

FIGURE 2: TWO MAIN TESTS USED IN UNIVERSAL NEWBORN HEARING SCREENING



WHO recommendation for universal screening for hearing impairment

The World Health Organization has recently published its recommendations on maternal and newborn care for a positive postnatal experience.⁽¹³⁾ This is a consolidated set of new and updated recommendations for routine postnatal care for women and newborns receiving facility or community-based postnatal care in any resource setting. One of the new



recommendations is on universal newborn screening for PBHL. PBHL is defined as bilateral permanent conductive or sensorineural hearing loss of 35 dB or greater in the better ear.

If UNHS indicates possible PBHL, a follow-up definitive test must be done as soon as possible after screening. Children cannot be considered to have hearing impairment until a definitive diagnostic test is done. This involves testing by an audiologist with a more detailed diagnostic auditory brainstem response in a highly-controlled environment.

WHO recommendation for Universal Newborn Hearing Screening

Universal newborn hearing screening (UNHS) with otoacoustic emissions (OAE) or automated auditory brainstem response (AABR) is recommended for early identification of permanent bilateral hearing loss (PBHL). UNHS should be accompanied by diagnostic and management services for children identified with hearing loss.

Basis for the WHO recommendation

The WHO recommendation is based on evidence derived from a systematic review on UNHS programmes to detect children with PBHL.⁽¹⁴⁾ The review included 30 non-randomized studies, of which five studies (of 1 023 610 newborns) had reported comparative effects of UNHS versus no UNHS.

Four of the five studies evaluated large population-based government programmes and prospectively followed all live-born infants from birth to screening at nine months of age. These studies also followed up all children with PBHL to ascertain developmental outcomes including receptive and expressive language and literacy at three to eight years.

This systematic review and meta-analysis found that UNHS increased the proportion of infants diagnosed with PBHL by nine months of age and improved the mean age of diagnosis by up to 13 months. There was also improvement in neurodevelopment (expressive and receptive language) in infants who received UNHS within eight years but very low certainty evidence showed no effect on literacy at 19.

However, there was no effect of UNHS on the proportion of children who were eventually identified with PBHL. Reviews of evidences gathered indicated that infants with PBHL identified through UNHS have significantly earlier referral, diagnosis and treatment along with improved communication outcomes, than those identified through various measures other than UNHS.⁽⁷⁾

Though the evidence is from high-income countries, the WHO Guideline Development Group (GDG) considered that there was enough evidence on resources, cost-effectiveness, values, equity, acceptability, and feasibility to implement UNHS in low- and middle-income countries. The GDG also recommended that parents and caregivers of all children should be informed about age-appropriate hearing and language development along with communication skills regardless of the screening results.

Guiding principles for UNHS

All infants should undergo hearing screening within the first month of life. All infants whose initial screening and subsequent re-screening warrant diagnostic testing, should have appropriate audiologic evaluation by no later than 3 months-of-age to confirm the infant's hearing status.

Once hearing loss has been diagnosed, the infant and family should have immediate access to early intervention service. This should begin as soon as possible after diagnosis, and no later than 6 months of age. **This is based on the 1–3–6 principle**.⁽¹⁵⁾ Some countries are moving to even earlier follow-ups based on the "1–2–3" principle.

FIGURE 3: 1–3–6 PRINCIPLE OF UNIVERSAL NEWBORN HEARING SCREENING



Regardless of the outcome of newborn hearing screening, all infants and children should be routinely monitored with respect to hearing, cognitive development, communication, attainment of educational milestones, and general health and well-being.

Target group

The universal newborn hearing screening (UNHS) programme aims to cover all infants. All infants irrespective of risk factors born in facilities should be screened before discharge. The programme should also aim to cover all births including home births.

If implementing UNHS is very challenging at the beginning due to high birth rate and resource limitation, the first step would be to cover those infants at-risk (Table 1)⁽¹⁶⁾ and then rapidly expand from targeted screening to universal screening. Testing only infants considered "at-risk" is likely to miss approximately 50% who have no apparent cause for hearing loss.

TABLE 1: RISK FACTORS FOR EARLY CHILDHOOD HEARING LOSS

S. No.	Risk Factors
1.	Admission to a NICU for more than 5 days
2.	Bilirubin levels at or above exchange levels
3.	Aminoglycoside administration for more than 5 days
4.	Asphyxia or hypoxic ischemic encephalopathy
5.	In utero infections such as cytomegalovirus, herpes, rubella, syphilis and toxoplasmosis
	(Continued)

(Continued)

S. No.	Risk Factors
6.	Craniofacial malformations or syndromes (Eg. Pendred syndrome)
7.	Meningitis
8.	Infections with blood culture positivity
9.	Caregiver concern, and
10.	Consanguinity or family history of hearing loss

Method of screening

Typically, the UNHS programmes are a two-stage approach.

FIGURE 4: THE TWO STAGE UNIVERSAL NEWBORN HEARING SCREENING



Age and timeframe for screening

First-stage screening: This should take place as early as after 24 hours of life and it should be completed preferably before discharge. By the age of one month of the infant at most, the screening should be completed First-stage screening can be performed as close to hospital discharge as possible, but there should be the possibility for a potential second-stage screening prior to discharge, if needed. In small infants, the screening should take place as soon as the baby weighs 1.5 kg. When the birth takes place outside of a hospital setting or where the screening programme is, for example, linked with immunization visits or well-baby clinic visits, it may not be possible to screen during the recommended one-month period. In this case, the first-stage screening should take place no later than six weeks of age.

Second-stage screening: Infants who fail the first-stage screening, should undergo a second-stage screening. This can occur either while still in hospital and following a gap of at least

several hours from the first screening to decrease the false-positive test result due to transient newborn conditions; or as soon as possible after being discharged. It needs to be noted that vernix, amniotic fluid can interfere with the screening. An otoscopy maybe indicated in such cases. The second screening should be preferably an auditory brain stem response (ABR).

Alternative arrangements must be made for completing the hearing screening of infants for whom it is not medically advisable or practical to do so in a timely manner, for example infants in an NICU, or on ventilators, or with severe life-threatening conditions. If screening is delayed, the procedure should be ensured once the infant is medically stable (15).

Screening tests

The techniques most often employed and successfully used in the universal neonatal hearing screens are: (i) AABR and (ii) OAEs. Both provide non-invasive recordings of physiologic activity underlying normal auditory function and are easily performed in neonates and infants. There is no clear advantage of one technology over the other. There are specialised portable machines available which provide both OAE and AABR for hearing screening. AABR is preferred over OAE in high-risk infants. It is also primarily used for secondary screening. In smaller infants, an instrument such as BERA phone which does not require a probe to be placed in the ear canal may be considered.

Prerequisites

- The screening room need not be sound proof but the background noise should be as minimal as possible.
- » The baby should be well fed to ensure that the baby is not hungry and crying.
- » The baby should be quiet and still. It is ideal if the baby is sleeping.
- > Having the baby swaddled during testing will help to keep the body movements minimal and not to knock off or remove the probe out of his or her ear during the test.

Oto-acoustic emissions

Principle

The principle of the test is that the sound vibrations emitted from the normal cochlear amplifier flow to the ear canal where the acoustic energy is recorded. During screening a small probe is placed in the ear canal, which delivers sound stimuli into the auditory system. In a healthy ear, the sound stimuli are transmitted through the middle ear to the inner ear where the outer hair cells of the cochlea produce an active response or emissions. These emissions are picked up by a microphone in the probe, analysed by the screening unit and an automated "pass" or "refer" result is displayed on the unit screen.

Procedure: The steps of the procedure are described in Box 1.

BOX 1: STEPS OF OTOACOUSTIC EMISSION PROCEDURE

- » Ask the caregiver to hold the baby in a comfortable position.
- » Make sure that the cables are not wrapped around any part of the device and that the cables are separated and untangled while carrying out the test.
- » Visually examine the probe for any wax/dirt collection; In case of which use the cleaning floss/wire for the removal of the same.
- » Switch on the device by briefly pressing the power button and wait for the startup and splash screens.
- » Proceed further only if the baby is quiet; sleeping is ideal. Having the baby swaddled during testing will help to keep the body movements minimal and in order not to knock the probe out of his or her ear during the test.
- » Choose the appropriate probe size to best fit the baby's ear canal. Slide the foam tip all the way over the base of the probe until it can't go any further.
- While inserting the probe in the ear canal, aim the probe toward the infant's nose. Pinna can be pulled back and down to fully open the ear canal for a good probe fit. Once the probe tip is in place, stick the clip on the probe cord to the baby's clothes to keep the probe from pulling out of the baby's ear.
- » Avoid holding the probe while administering the test. By holding the probe in the baby's ear, it can get pushed against the wall of the ear canal, preventing the signal from getting through.
- » Prior to begin the test enter the demographic details of the baby. Then navigate to test selection screen, select the type of screening to be performed- DPOAE/ TEAOE (as available)
- » Choose the ear to be tested first: right ear or left ear
- » On choosing to start the procedure, calibration test is performed by the system itself. If "Probe error" appears, repositioning the probe is advised before trying again. The test starts automatically after calibration completes
- » When the test completes, the "Pass" or "Refer" result and test details are displayed on the screen.
- » Show the result to the caregiver when it appears on the screen. (You may not have access to the printer immediately)
- » Select the "Opposite ear". Insert the probe in the other ear, and touch Continue to repeat the process.
- » Clean the OAE probe and cable after each use.
- » Maintain a hearing screening register with all necessary details for running the programme.

Challenges with OAE screening: OAE is

highly sensitive (85–100%) and reasonably specific (91–95%). The problem with OAE testing is the high referral rate to audiologic centres. The main reason for false-positive outcomes with OAE are transient conditions in the external auditory canal (e.g. collapse of the ear canal and the presence of debris) and middle ear (e.g. presence of amniotic fluid and mucus), as well as high ambient noise level. An otoscopy maybe indicated in such cases. These problems usually resolve within the first few hours or days of life, and if the screening protocol

FIGURE 5: OTOACOUSTIC EMISSION MACHINE



involves more than one OAE tests, more babies will pass it and the referral rate will be lower.

As OAEs are generated within the cochlea, this cannot be used to detect neural (eighth nerve and auditory brainstem pathway) dysfunction that may result from exposure to ototoxic drugs or hyperbilirubinemia. To diagnose such pathologies, auditory brainstem responses (AABR) are used.

Automated auditory brainstem response

Principle

AABR is an auditory evoked potential that originates from the auditory nerve. It can detect impairment on the level of cochlea, auditory nerve, and auditory pathway in the brainstem. AABR measurements are obtained by placing disposable surface electrodes on the forehead and recording brain wave activity in response to sound. The normal AABR takes the form of five successive neural waves labelled I–V. An infant's waveform is compared with the template of standard AABR infant data and the result "pass" or "fail" is determined.

Procedure: The steps of the procedure are described in Box 2

FIGURE 6: AUTOMATED AUDITORY BRAINSTEM RESPONSE MACHINE



BOX 2: STEPS OF AUTOMATED AUDITORY BRAINSTEM RESPONSE PROCEDURE

- » For AABR, three electrode leads are attached on the forehead, cheek and nape. Place the electrode leads and attach the snap electrodes to the recommended sites. (Colour and site of placement may vary depending on the instrument). Eg:
 - White electrode on the Vertex/forehead, as high as possible, near the hairline.
 - **Red** electrode on the **Nape** (canter on back of the neck).
 - Black electrode/ Common on the cheek.
- » For reducing the electrical impedance and to allow better conductivity of the ABR electrical signals, prepare the skin for the electrodes by a skin preparing gel (e.g. NuPrep). The baby might show discomfort during the removal of electrode leads due to the sticking property of the material.
- » Switch on the device by briefly pressing the power button, and wait for the start-up and splash screens.
- » Proceed further only if the baby is quiet; sleeping is ideal. Having the baby swaddled during testing will help to keep the body movements minimal and in order not to knock the probe out of his or her ear during the test.
- » Choose the appropriate probe size to best fit the baby's ear canal. Make sure you slide the tip all the way over the base of the probe until it can't go any further.
- While inserting the probe in the ear canal, aim the probe toward the infant's nose. Pinna can be pulled back and down to fully open the ear canal for a good probe fit. Once the probe tip is in place, stick the Clip on the probe cord to the baby's clothes to keep the probe from pulling out of the baby's ear.
- » Avoid holding the probe while administering the test to prevent it from getting pushed against the wall of the ear canal, preventing a signal from getting through.
- » Prior to begin the test enter the demographic details of the baby. Then navigate to test selection screen, select the type of screening to be performed: ABR.
- » Choose the ear to be tested first: right ear or left ear.
- » Touch **Start screening**.
- » An impedance check is automatically performed. When impedance is acceptable, it is indicated by 'GOOD' against each electrode in the form of the message.
- » Touch Continue. If the impedance check does not pass, reposition the electrodes and try again.

(Continued)

(Continued) BOX 2: STEPS OF AUTOMATED AUDITORY BRAINSTEM RESPONSE PROCEDURE

- Calibration test is performed by the system itself after impedance check. If Probe Error appears, repositioning the probe is advised before trying again. The test starts automatically after calibration completes.
- » When the test completes, the "Pass" or "Refer" result and test details are displayed on the screen.
- » Select the "Opposite ear". Insert the probe in the other ear, and touch "Continue" to repeat the process.
- » Show the result to the care giver when it appears on the screen. (You may not have access to the printer immediately).
- » Clean the ABR probe and cable after each use.
- » Maintain a hearing screening register with all necessary details for running the programme.

Considerations in choosing the screening test

AABR enables the distinction between conductive and cochlear hearing loss. It is highly sensitive to detect pathological mechanisms inducing hearing problems through disruption of afferent impulses, which is known as auditory neuropathy spectrum disorders.

Presence of OAEs and concomitant major AABR abnormalities usually signify auditory neuropathy. On the contrary, absence of OAE and preservation of normal AABR recordings usually signifies problems in middle ear.

There is no clear advantage of one technology over the other. One or both screening tests may be used depending on local protocols. Where costs permit or for infants in the NICU, AABR screening is recommended. Box 3 provides important points to consider before selecting OAE or AABR as a screening test.

BOX 3: CONSIDERATION IN SELECTION OF SCREENING TEST

- » Screening with OAE alone will not detect infants with auditory neuropathy, which constitutes approximately 10% of congenital hearing loss.
- » The incidence of auditory neuropathy, detected by AABR, is significantly higher among infants admitted to NICU.
- » When using OAE, transient-evoked OAE (TEOAE) has greater sensitivity, as it can detect hearing levels as low as 30dBHL.

(Continued)

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(Continued) BOX 3: CONSIDERATION IN SELECTION OF SCREENING TEST

- » Both OAE and AABR screening demonstrates high sensitivity and specificity, although specificity may be marginally higher with AABR.
- » AABR may be more costly than OAE. However, it is to be noted that while the initial investment is higher for AABR, the follow-up costs may be greater for OAE due to higher "refer" diagnoses and false-positive rates.
- » AABR is likely to take slightly longer to record than OAE.
- » OAE is more sensitive to background noise levels than AABR.
- » A combined OAE and AABR screening protocol has been reported as providing the best positive predictive value. However, the cost of purchasing both types of screening equipment may be prohibitive for many countries.

The steps of OAE and AABR procedure can be seen in the video provided with the guidance. This video can be accessed by scanning the QR code available on the back page of this guidance.

Time considerations

Time required for each screening test is approximately 20 minutes, including settling the baby, performing the test, recording the results, and discussing the results with parents; screening may take longer if the baby is restless or has difficulty settling. The test itself takes approximately five minutes. Servicing and recalibration of screening equipment according to manufacturer specifications is needed. The first screening should usually be completed prior to discharge.

Supplies required

A quiet room in the facility is required for doing the hearing tests, preferably close to the postnatal wards. It can be done in the bedside in case of low noise setting. Information pamphlets (pictorial or written) for parents are useful. Ear tips for OAE screening or sensors / electrodes or disposable earphones for AABR are required. The hearing screening should be appropriately documented on a hearing screen card or in the baby record. Templates for referrals should be available. In addition to the OAE or AABR device, computer or other devices compatible with testing software are needed. Electricity for computer use, printing and charging the screening device battery are also needed.

Specifications for equipment

The box below provides information about the equipment specifications for OAE, TEOAE and AABR.



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BOX 4: SPECIFICATIONS FOR EQUIPMENT

Automated auditory brain Otoacoustic emission (OAE) stem response (AABR) Ability to do multiple screening tests Stimuli TEOAE, DPOAE Test mode-monaural/binaural Compact, handheld, touchscreen easy to use Level range-25 dB nHL to 45 dB nHL Automated pass/refer, pre-set screening parameters Impedance test-Automatic pre-test Disposable silicone ear tips of various sizes, Test time - 20 seconds to 2 minutes specially for newborns, that are easily accessible Memory - minimum 300 tests Probe cord length-min 120 cms Clinically proven & tested algorithms Probe cord holder to baby clothing Compatible software & report generation Transient evoked Otoacoustic Artifact rejection system - min emission (TEOAE) 100 microvolt Stimulus type - non-linear Click Transferable data & storage Level range - 60 dB peSPL to 83 dB peSPL Well studied for accuracy Automated pass/refer, pre-set screening pa Easy calibration Screener with limit at 35dB rameters Powered by AC or rechargeable Analysis bands - 1.4, 2, 2.8 and 4 kHz battery. (center frequencies) Quick battery charge time Pass criteria-minimum 3 out of 4 bands, min 4 dB SNR, min -5 dB SPL OAE level

Follow-up of the tests

The OAE/AABR provide the results as "Refer" or Pass".

"Refer" result: All infants who have a "refer" result after first screening should be followed up to ensure that they have a second screening. Infants who fail both first and second screenings should be referred for diagnostic testing and subsequently followed up.

'Pass' result: Parents/caregivers should be provided with information about the usual hearing and language milestones anticipated during a child's development. In situations where these milestones are not met, or where hearing loss is suspected, the child should undergo a hearing screening test, irrespective of previous test outcomes. This is important because hearing loss can develop at any time after birth, or be progressive in nature, which becomes apparent as the child grows.

Management

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Counselling the family

Several qualitative research studies exploring parental experiences of UNHS programmes indicate that, parents may experience anxiety related to UNHS, often feel unprepared for the positive and/or inconclusive results of a newborn hearing test and may need additional

support and information from knowledgeable and sensitive health workers. Willingness to accept screening has been associated with socioeconomic status and maternal education. Counseling the family hence assumes importance.

Counselling before the test

Caregiver needs to be informed that the current test is to check the functioning of the ear, as hearing ability is important for the development of speech. It involves a small probe/earphone to be kept in baby's ear (in both OAE and AABR). The probe and tips are designed so that they would not hurt the baby's ears. In AABR test, three electrodes are placed on the forehead, cheek, and nape. Before starting the procedure, the child must be fed and not kept hungry.

Counselling after the test

Counsel the family member about the test results, give them a hearing screening card where the test results and follow-up plan are mentioned, the card can also have the developmental milestones of speech and hearing. If it shows "pass," inform them that it confirms that the sound is reaching the beginning of the inner part of the ear. Tell them the importance of periodical follow-up and stimulation.

- » If the results come "refer", counsel the family that the test needs to be repeated/further evaluation needs to be done to confirm the hearing status. This result does not confirm the problem so further evaluation is very important.
- » Inform parents and caregivers about age-appropriate hearing and language development and communication skills regardless of the screening results (Figure 7)

	Hearing and Understanding	Language
At Birth	Suddenly responds to loud sounds like a bus horn when child is awake	Crying
Months	Turns the head to a new sound Just when the child is going to sleep a "ssshh" sound wakes up the child	Produces differential cry for hunger and happiness Repeats the same sound (Cooing, gooing)
Months o 1 Year	Looks around when a new sound is made Turns and looks up when name is called Does simple commands like "Put that down"	Produces sounds like O, U, P, B, M Babbles like speech Makes different speech sounds Plays sign games like "Koo -Kee"
-2 Years	Understands "say bye bye" Points to body parts such as nose, mouth Points to pictures in a book when named	Say 3-7 or more words Puts two words together to ask questions like appa gone Says more every month and says 200-300 words at the end of 2 years
-3 Years	Understands difference in words like "Go-Stop" Follows two commands like Get the ball and put it on the table	Has a word for almost everything Says two or three word sentences

FIGURE 7: NORMAL MILESTONES OF HEARING AND LANGUAGE

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Documentation of hearing screen

The results of the hearing screen should be recorded. It is best done on the "well-baby" or immunization card along with other details and screens, A separate hearing screen card can also be used. Having a separate card has the benefit of emphasizing the importance of hearing screen and development of hearing. It can also provide information on age-appropriate milestones and red flags (Figure 6).

FIGURE 8: EXAMPLE OF A HEARING SCREEN CARD WITH AGE-APPROPRIATE RED FLAGS

ENT (AUDIOLOGY)	Bring your child to the hospital immediately if these milestones are not reached by the time specified.
Timings: 9.00 a.m. to 12.30 p.m. Ph::080-22065043	By 6 months Not turning to a side when called
Language and Hearing Follow up Card Name:	By 1 year No speech like sounds
DOB:	By 1 ½ years Not saying words like amma, appa
Hospital No.	By 2 years Speaking less than 10 single words
Hearing Screening: I Screen : Pass/Refer	By 2 ¹ / ₂ years Not saying 2 words combinations
II Screen : Pass/Refer ABR : Pass/Fail	By 3 years Not speaking sentence of 3 words
Follow up schedule:	By 4 years Not saying clear sentences
Date <u>Time Plan</u>	Doing the hearing testing of children by 3 months of age helps to detect hearing loss early and if treatment is started it is good for the child's development
	Hearing Screening (Room No. 8) ENT Dept. (Audiology) - 27 Timings: Mon-Sat 9.00 a.m. to 12.30.p.m. Ph.: 080-22065043
	St. John's Medical College Hospital

Red flags for referral

Infants identified with any concurrent illness should be referred for the necessary treatment, in accordance with the best available standard of care. The following conditions, if identified, should lead to immediate referral for diagnostic audiology:

- » CMV infections
- » meningitis
- » congenital abnormalities of head and neck (e.g. unilateral or bilateral malformations of the ear, face or head)
- » syndromes associated with hearing loss, and
- » neonatal jaundice requiring exchange transfusion.

If any delay if diagnostic audiology is anticipated, a screening should be done.

Summary of the resource requirements for UNHS is given in table 2

TABLE 2: SUMMARY OF RESOURCE REQUIREMENTS FOR UNIVERSAL NEWBORN HEARING SCREENING

Staff	» Doctors/midwives/nurses» Specialist staff are not required
Training	» Training to administer screening tests (OAE and/or AABR)
Supplies	 » Information (written and/or pictorial, e.g. leaflets) for parents » For OAE screening: – Ear tips » For AABR screening: – Disposable earphones and sensors/ electrodes » Referral letters where required (paper, printing)
Equipment & Infrastructure	 » OAE device and software including small outer-ear probe with earphone and microphone » AABR device and software including ear couplers » Computer or other device compatible with testing software to assess results
Infrastructure	 » A quiet, calm space to carry out the test » Access to electricity for computer use, printing and charging the screening device battery
Time	» Approximately 20 minutes

Diagnostic assessment

If OAE/AABR fails, consider repeat testing followed by diagnostic testing by expert audiologist within 3 months. Infants may need facilitated referral to another facility for diagnostic assessment. Thereafter, by the age of 6 months, intervention should be started in all infants with hearing impairment.

Follow-up and early intervention

All well infants who have passed the screening test should be followed up with speech and language assessment at 3 months and 6 months, respectively. Intervention should ideally be initiated by the time an infant with hearing loss reaches the age of 6 months Family-centred approach is preferable: detailed counselling of parents and explaining the need and type of intervention is important.

The specific interventions are hearing aids, cochlear implants, sign language, rehabilitative measures and early education programmes. Hearing aids for amplification should be made available as soon as the diagnosis is made.

Human resources

At the facility level, the nurses, midwives or doctors can be trained to perform hearing screen with AABR or OAE. Specialist staff are not required for screening due to the simplicity of operating the equipment and automation of results.

All screening personnel should undergo training irrespective of any prior qualifications. Training should focus on screening equipment to be used and the standard operating procedures of the programme including documentation of results, data collection and management. Regular supervision of personnel in training is important for quality control and troubleshooting. There should be a protocol for periodic quality checks.

In busy facilities with a high birth rate, having designated trained personnel for only hearing screening may be beneficial. If feasible, an option of telemedicine for the follow-up maybe explored.

There should be a referral system to an audiologist for furthur diagnostic testing and intervention in a timely manner



Suggested algorithm

Setting up a UNHS in a geographic area

UNHS should be provided for all newborn infants. Programmatically this means training the nurses and doctors in all facilities where births happen and provision of essential equipment for screening. While at least one screening equipment is needed to start the programme, it is best to keep a spare to prevent interruption of screening services. At the least, spare probes are recommended. Access to quick repair of equipment is also needed,

It also implies setting up diagnostic facilities in the area of establishing linkages with such facilities. The programme should also document and develop indicators to monitor the implementation of the programme and the yield of the programme. In addition, linkages should be established to provide rehabilitation such as hearing aids, cochlear implants and guidance on special education.

Barriers to follow-up and rehabilitation have to be explored and addressed to scale up UNHS. Wherever feasible, the UNHS programme should be integrated with, or linked to, existing health-care, educational or social systems, and the procedures and outcomes documented and reported.

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CHAPTER 03

Universal screening for abnormalities of the eye

Need and rationale for screening

n estimated 1.14 million children aged 0–15 years are blind or severely visually impaired from eye conditions.⁽¹⁾ Most blind children are either born blind from congenital conditions or become blind before the age of 5 years from acquired conditions.⁽²⁾ The major causes of blindness in children are congenital and developmental cataract, corneal scarring, congenital eye anomalies, retinal dystrophies, glaucoma and retinopathy of prematurity.⁽³⁾ Severe visual impairment/blindness in neonates has serious implications in their overall development. It can result in delayed motor, language, emotional, social and cognitive development, with lifelong consequences. Causes of blindness in children vary widely from region to region, being largely determined by socioeconomic development, and the availability of primary health care and eye-care services.⁽⁴⁾

BOX 1: THE MOST COMMON CAUSES OF BLINDNESS IN CHILDREN WHICH CAN BE DETECTED AT BIRTH ARE^(3,5)



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Approximately half of all cases of childhood blindness can be avoided or treated.⁽⁴⁾ Congenital cataract and corneal scarring are the major contributors for childhood blindness; to achieve the goal, these two problems must be controlled.

Conditions that are present at birth can be detected by screening during the neonatal period. With universal eye screening we can identify the treatable conditions of the ocular system, such as congenital cataract, congenital glaucoma and retinoblastoma and affected newborns can be referred for treatment.

Congenital cataract is one of the major causes of childhood blindness accounting for a third of eye anomalies presenting at birth in high-income countries.⁽²⁾ This can be detected by universal eye screening. There is evidence to show that universal newborn eye screening helps in early diagnosis of congenital cataract without causing serious adverse effects.⁽⁶⁾ Newborns affected by conditions not amenable to treatment can be referred for vision rehabilitation.⁽²⁾ Management or referral for prompt treatment can save a child's eye and improve the quality of vision and life.^(3,5)

Current status and perspectives

Newborn eye screening (NES) relies on examining the eyes and eliciting clinical signs.

External examination of the eye is the simplest and includes a torchlight examination of the external structures. Red reflex test requires a handheld device, commonly a direct ophthalmoscope, and can be performed by anyone trained to deliver the test. The red reflex testing has reasonable sensitivity (67%, 95% CI = 9%–99%) for clinically significant

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anterior segment conditions, which is acceptable for screening purposes in most settings.

In high-income countries, universal newborn eye screening (UNES) is the standard of care. In low- and middle-income countries, it is not often included in newborn policies or practices for all term healthy newborns. Eight national publications have recommended UNES. Four were published by professional associations (in Canada and three in the United States of America) and four by ministries of health or government bodies (in Canada, the United Kingdom of Great Britain and Northern Ireland, India and New Zealand). All documents recommended red reflex testing and external eye examination, with four also recommending taking a case history. Details of the recommendations of different countries are provided in the annexure.



WHO recommendation for universal screening for abnormalities of the eye

The World Health Organization has recently published the WHO recommendations on maternal and newborn care for a positive postnatal experience.⁽¹⁾ This is a consolidated set of new and updated recommendations for routine postnatal care for women and newborns receiving facility- or community-based postnatal care in any resource setting. One of the new recommendations is on universal newborn screening for abnormalities of the eye.

As per WHO recommendations on maternal and newborn care, universal newborn screening for abnormalities of the eye should be done prior to discharge after a health-facility birth or at the first postnatal care contact in an outpatient setting after a home birth. Ideally, the screening should be done within the first six weeks after birth. An external examination of the eye and red reflex test should be conducted by trained health workers.⁽¹⁾

WHO recommendation

Universal newborn screening for abnormalities of the eye is recommended and should be accompanied by diagnostic and management services for children identified with an abnormality

Basis for the WHO recommendation

Evidence was derived from a systematic review of universal newborn eye screening (1). Fourteen studies were identified but only three compared universal red reflex screening with no screening. Findings suggest that universal red reflex testing at birth may increase the number of newborns with congenital cataracts referred for eye care in the first year of life (risk ratio (RR) = 9.83; 95% confidence interval (CI) = 1.36–71.20; low-certainty evidence) and those referred by 6 weeks (394 438 infants; RR = 4.61, 95% CI = 1.12–19.01) (Refer Annexure table 2).

A comparative study based on data from the Swedish Paediatric Cataract Register (PECARE) found that, among all the congenital cataract cases operated in the first year after birth, 13 per 100 000 children (a total of 561 743 newborns) were referred within 42 days (that is, 6 weeks) of birth when screened by early red reflex testing compared with 1.3 per 100 000 (population 308 181 newborns) who were screened using torchlight examination.

The Guideline Development Group (GDG) acknowledged the evidence reviewed is related to screening for a single condition (congenital cataract). However, since the red reflex test can detect a wide range of conditions, the GDG expanded the recommendation to cover all abnormalities of the eye that may be detected on a screening examination.

The recommendation is based on evidence from studies in all newborns, irrespective of gestation or presence/absence of high-risk factors. However, evidence from studies conducted only in high-risk populations such as preterm newborns or those with congenital anomalies was not considered. This recommendation is applicable to only healthy term newborns.

In keeping with the principles of screening, the extension of the recommendation to include diagnostics and management was made. Systems for screening, referral, diagnosis and management should be established or strengthened to ensure adequate follow-up and management for those who screen positive.

Brief overview of eye anatomy and terminology

The eye sits in a protective bony socket called the orbit. There are six extraocular muscles in the orbit which help in the movement of the eyeball. Parts of the eye are depicted in Figure 1 and Figure 2

FIGURE 1: PARTS OF THE EYE



FIGURE 2: EXTERNAL AND INTERNAL PARTS OF THE EYE AND OCULAR ADNEXA



Parts of the eye

- » Eyelids: These form the shutters which protect the eyeballs anteriorly.
- **» Conjunctiva:** It is a thin, transparent mucous membrane which lines the under-surface of the upper and lower eyelids, except the cornea.



- » Sclera: It is the tough coat of the eyeball and is white in colour.
- » Cornea: It is present on the front surface of the eye and is a transparent, smoothly curved surface which focuses the light entering the eye, providing most of the focusing power of the eye. The surface is kept smooth and in good condition by tears which are spread over the surface by normal blinking. Normally it is 9–10.5 mm at birth.
- » Lacrimal apparatus: It comprises lacrimal glands (which produce tears to keep the cornea and conjunctiva moist for smooth functioning), and lacrimal passages (which drain the continuously formed tears).
- » Iris and pupil: The coloured part of the eye is the iris. The iris has a hole in the centre called the pupil through which light enters the eye. In bright sunlight the pupil becomes smaller; in darkness, the pupil becomes larger.
- » Lens: The lens of the eye is a transparent structure present behind the iris and pupil. It is responsible for focusing the light that enters the eye. In a healthy eye it is impossible to see the lens with a torch. Loss of transparency in the lens can be due to a wide variety of causes and is called cataract.
- » Retina and optic nerve: The function of retina is to convert light energy into nerve impulses which are sent to the brain via the optic nerve where the perception of vision takes place

Target group

All newborns, irrespective of home or health-care facility delivery should have universal eye screening. This recommendation is applicable to all newborns, but in cases of high-risk populations such as preterm newborns or those with congenital anomalies or with risk factors for vision impairment (Table 1), additional tests such as retinal examination by an ophthalmologist are required, which is not within the scope of this implementation guidance.

Method of screening

- » External examination of the eyes followed by
- » Red reflex test

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Steps of screening for abnormalities of the eye

Prior to screening, take a brief ocular history to identify any risk factors for vision impairment (Table 1). Ask the parents the following questions

- » Do either of the parents have an eye condition that was present since birth?
- » Do any brothers or sisters of the child have an eye or vision problem?
- » Did the mother have a rash during the term of pregnancy with this child?

TABLE 1: RISK FACTORS FOR VISION IMPAIRMENT

S. No.	List of risk factors which can lead to vision impairment*
1.	Prenatal and birth history: Prematurity, birth asphyxia, intrauterine infection
2.	Congenital conditions: Chromosomal abnormalities such as Down syndrome, any structural birth defect especially involving the facial structures, albinism
3.	Family history: Conditions causing blindness or severe visual impairment (e.g. congenital cataracts, congenital glaucoma, congenital squint, congenital nystagmus, retinoblastoma, sensorineural hearing loss and certain metabolic and genetic diseases)
4	Others: Hydrocephalus, infectious disease (e.g. toxoplasmosis, cytomegalovirus, herpes simplex), periventricular leukomalacia (PVL), any stage of ROP even if it regresses

*If any of the risk factors are present, infant should be referred to an ophthalmologist for detailed retinal examination by indirect ophthalmoscopy, even if initial screening tests are normal

The ALT tool (Table 2) is a useful approach for the screening of abnormalities of the eye.



External examination of the eye

External examination of the eye is a general inspection that includes the orbits, globes, eyelids, lacrimal sac, conjunctiva, iris and pupil. Steps for conducting external examination of eye are shown in Table 3, while the findings of examination and interpretation are shown in Table 4.

Time required: approximately 1–2 minutes

TABLE 3: EXTERNAL EXAMINATION OF EYE

S. No.	External Examination of the Eye
1.	Perform hand hygiene
2.	Examination is done preferably after breastfeeding; when baby is awake and quiet
3.	Can be examined on the caregiver's lap or examination table
4.	Done in a bright room with help of torchlight/ flashlight / pen light / arc light
5.	Look at orbit, eyelids, eyeballs, lacrimal sac, sclera, cornea, iris, pupil and observe the eye movements



TABLE 4: INTERPRETATION OF EXTERNAL EXAMINATION TEST

Parts of eye Normal findings Abnormal findings





Red reflex test

The red reflex test is used to detect changes in the fundus of the eye and opacities on the visual axis, such as cataract. It is also called the fundal reflex test.

Principle: Light from direct ophthalmoscope passes through the infant's pupil and reaches the retina. Part of the light is absorbed and part reflected. This reflected light from retina passes through the pupil appears as reddish-orange glow characterizing the normal colour of the retina and choroid. Table 5 describes the steps of red reflex examination using a direct opthalmoscope, while the figure shows the parts of a direct opthalmoscope.

TABLE 5: STEPS OF RED REFLEX EXAMINATION

S. No.	Red Reflex examination			
1.	Examination done in dimly light or dark room			
2.	Perform hand hygiene			
3.	Switch on direct ophthalmoscope (see figure) and adjust the brightness of light by rotating the rheostat. Adjust the aperture dial to get a large circle of light. Adjust the diopter power to "0"			
4.	Examination is done preferably after breastfeeding, when the child is awake and quiet			
5.	Can be examined on the caregivers lap or on the examination table			
6	If neonate is asleep, open the eyelids with fingers or ask the mother/family member to hold the neonate with head slightly held up, so that eyes are open			
7	Screening personnel can stand/sit 18 inches (40–50cm) away from the neonate (see figure).			
8	Focus the direct ophthalmoscope light to neonate's face and then visualize the fundus through the viewing window			
9	This test is done without dilating the eyes. If not possible to see red reflex, try in a dark room. If still not possible, then dilate the eyes with 1% tropicamide. Administer one drop of 1% tropicamide to each eye approximately 15 minutes before this examination			
10.	Visualize both fundi either individually or simultaneou	ıslv		

FIGURE 3: PARTS OF DIRECT OPHTHALMOSCOPE



The findings from a red reflex test and its interpretation are given below in Table 6 and Table 7.

TABLE 6: STEPS FOR RED REFLEX EXAMINATION

Normal findings	Abnormal findings
» bright-reddish orange in colour	» white in one eye/both eyes (absence of red reflex)
» contains no silhouette, and	» dark spots or other silhouettes, and
» symmetrical in character	» markedly diminished reflex
	» Abnormal red reflex seen in cataract, retinoblastoma, corneal scarring, squint, refractive error, retinal detachment.

TABLE 7: INTERPRETATION OF RED REFLEX TEST



Figure 4.1: Normal red reflex



Figure 4.3: White reflex in both eyes



Figure 4.2: White reflex in one eye



Figure 4.4: Dark spots or other silhouettes





The steps for external eye examination and red reflex examination can be seen in the video provided with the guidance. This video can be accessed by scanning the QR code available on the back page of this guidance.

Timing of screening

Screening should be performed in all neonates **prior to discharge, after a health-facility birth or at the first postnatal care contact in an outpatient setting after a home birth**. Ideally, the screening should be done within the first six weeks after birth.



Personnel for screening

The screening can be done by any healthcare personnel caring for the newborn such as **primary care physicians, paediatricians, ophthalmologists, or nurses** depending on the human resources available at each location. In each facility, healthcare personnel who are designated to do the test should undergo appropriate training. The training is focused on the proper use of screening equipment, screening procedure, interpretation of results of screening test and further management.

Place of screening

Screening test can be done on inpatient or outpatient basis. A dark room is preferred. Bedside evaluation can also be done if the light is sufficiently dimmed.

Specifications for Equipment

The equipment and supplies needed are shown in Table 8.

TABLE 8: EQUIPMENT AND SUPPLIES

Equipment	» direct ophthalmoscope, and» torch/flashlight/pen light/arc light.
Supplies	 » alcohol solution for hand hygiene » information (written and/or pictorial, e.g. leaflets) for parents, and » batteries (replaceable or rechargeable dry cell alkaline batteries depending on the specific device)

Specifications for direct ophthalmoscope

The specifications for the direct ophthalmoscope are suggested in Table 9.

TABLE 9: SUGGESTED SPECIFICATIONS FOR DIRECT OPHTHALMOSCOPE

Available with LED/halogen light source	Range of lenses not smaller than -35D to +20D with steps not greater than 1D.
Magnification up to 15x from direct vision to maximum magnification	Dust free sealed optics and aspherical optical system, with sturdy carrying case.
Red-free, blue and polarization filters and anti-reflection lens.	Should have rubber brow crest
Should have small and large spot sizes, fixation targets, slit aperture, hemi-spot and cobalt blue filter.	Additional accessories should be supplied – 1 bulb, 1 bulb holder and 1 bulb cover.
Illuminated lens dial	Warranty
Should have rechargeable battery with Charger/battery/mains operated.	Good AMC and CMC services
At least 3 apertures and fixation star	

*Annual maintenance contract/comprehensive maintenance contract

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A summary of the generic information and resource requirement for screening for abnormalities of the eye is provided in Table 10.

TABLE 10: SCREENING FOR ABNORMALITIES OF EYE – GENERALINFORMATION AND RESOURCE REQUIREMENT

Who can do the screening

Any health-care personnel (nurses/midwives/doctors) who have been trained to do red reflex test can perform the screening.

When should it be done

Prior to discharge after a health facility birth At the first postnatal care contact after a home birth.

Where is the screening done

In a dark room in the postnatal wards or in the outpatient department

How is it done

By external eye examination and by red reflex test.

Time required

The test takes approximately 1–2 minutes for external examination and about 5 minutes for red reflex test

Equipment

Pictorial tools, information leaflets Direct ophthalmoscope Torchlight/arc light, pen torch

Supplies

Alcohol for sterilization

Cotton swabs

Batteries (replaceable or rechargeable dry cell alkaline batteries

Arc light can be charged.

For troubleshooting, an annexure is provided at the end of the document.

Training

Training can be provided by an experienced neonatologist, paediatrician or ophthalmologist. Training can be provided individually or in groups either in-person or through videoconferencing. IEC materials can be shared for reference.

Emphasis on infection control

Though both external examination of the eye or red reflex test are non-contact with the eye, there should be emphasis on hand hygiene. A small increase in conjunctivitis has been found in one study.

Management

Diagnostic assessment

Any abnormality found in the external eye examination and/or red reflex is an indication for **referral to an ophthalmologist who is experienced in the examination of neonates, as soon as possible**. Further diagnostic assessment is done as per ophthalmologist depending on the abnormalities noted during the screening test.

For example: Congenital cataract may not require any further test to confirm the diagnosis. Eye globe abnormalities and retinoblastoma can be confirmed by imaging modalities such as ultrasonography and CT/MRI scans.

Referral

Prompt referrals to an ophthalmologist for further evaluation, diagnosis and timely management are crucial. If the infant has any risk factors for visual impairment, he/she should be referred to an ophthalmologist even if screening results are normal.

A. Newborn eye emergencies: Send immediately on the same day

- » The central part of the eye (cornea) is exposed, and the eyelid is not covering it fully due to a defect in the eyelid/short eyelid/large eyeball protruding out.
- The central part of the eye (cornea) that was transparent and clear has now become white/ has developed some whitening lesion area with or without eye redness/eyelid swelling.
- » Child is in pain/crying/not feeding well and has red eye/swollen eyelids.
- » Swelling of eyelids or any swelling of acute onset in and around the eye.
- » Any eye injury (fall/forceps delivery eye injury/assault etc.).
- » Eye suddenly has become bigger or smaller as noted by family/friends.

» Eyelids are stuck together with redness and discharge and the inside of the eye is not able to see or does not look clear and/or is not looking normal.

B. Semi-emergency situations: Send as soon as possible, within a week

- » Failed red reflex test/not able to clearly see red reflex.
- » Any abnormality noted on torchlight examination other than of acute onset as above.
- » Newborn baby or a baby with a family history of blindness/poor vision/eye tumour such as retinoblastoma in parents/other children in the family.
- » Any persistent crossed eye, that is, abnormal eye position (squint) or abnormal eye movements such as shaking or wandering eyes.
- » Children having other birth defects or organ diseases (syndromic babies) that are known to have eye manifestations.
- » Mother/caregivers complain of having noted some eye problem in the baby but are not sure.

Premature infants need referral for retinopathy of prematurity screening by the age of one month. Figure 4 provides an approach for screening and referral.

FIGURE 4: FLOW CHART FOR UNIVERSAL SCREENING FOR ABNORMALITIES OF THE EYE



Treatment

Intervention is depending on the diagnosis as per advice of an ophthalmologist. For example, congenital cataract, congenital glaucoma, eyelid abnormalities require surgery, corneal opacity abnormally small or absent eye(s) requires rehabilitation, and retinoblastoma might require surgery or other treatment or both.

Timing of the intervention is also depending on the condition. Congenital cataracts are usually treated by surgery between 6 to 8 weeks of life.⁽⁷⁾ Results of the screening should be entered in the well-baby card (Figure 5)

FIGURE 5: EYE SCREENING CUM REFERRAL CARD

	Well-Baby Card			
Name of baby:		Sex:		
Date of birth:		Gestational age at birth		
Unique identification number:				
	Eye Screening			
Any risk factors for vision impairmer	nt: Yes/No			
Results of eye examination: Normal/Refer				
Results of red reflex test: Pass/Refe	r			

Setting up a universal screening programme for abnormalities of the eye

Universal screening for abnormalities of the eye should be provided for all newborn infants. Newborn eye screening should be integrated with the existing postnatal care services. For example, it should be included in the discharge preparedness checklist after facility birth, and as part of newborn examination in well-baby clinics in the first year after birth.

Programmatically this means training the nurses and doctors in all birth facilities and provision of essential equipment for screening. It also implies setting up diagnostic facilities for referral and management either in the area or establishing linkages with such facilities.

The number of visits from screening to management and loss to follow-up can be minimized. For example, by identifying and collaborating with a trained ophthalmologist in the district/ region where babies may be referred or having him/her attend the facilities or well-baby clinics on specified days and/or upon request. Such arrangements can be made for diagnosis and management of screen-positive babies as well as for training and re-training of facility staff. The programme should also ensure that appropriate equipment is available either in the facility, or referral services are provided. The programme should also document and develop indicators to monitor the implementation of the programme and the yield of the programme. Further, as some infants may have conditions not amenable to cure, rehabilitation services should be made available along with neurodevelopmental follow-up services.

Public education and awareness campaigns should be conducted to increase care-seeking by women and families related to newborn eye conditions, including information on places where care is available. Information on universal newborn screening for abnormalities of the eye, including management and outcomes, should be included in health management information systems to monitor its implementation.

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CHAPTER 04

Universal screening for neonatal hyperbilirubinaemia

Need and rationale for screening

Reonatal unconjugated (indirect) hyperbilirubinaemia is a common condition that affects approximately 60–80% of otherwise healthy newborns.^(1,2) It manifests in the initial days after birth as jaundice. Biochemically, it is defined by an increase in total serum bilirubin (TSB) as a result of an elevated indirect serum bilirubin. Although most newborns present with physiological jaundice, which is frequently normal and benign, a subset of newborns will develop severe disease warranting treatment and necessitating hospitalization in the first weeks after birth.^(1,2) Unconjugated bilirubin above a threshold level crosses the blood brain barrier and, if not diagnosed and treated in time, can lead to acute bilirubin encephalopathy, bilirubin-induced neurological dysfunction (BIND) or, in the most severe cases, kernicterus and/or jaundice-related death.

Clinically, jaundice is recognized by visual inspection. Visual inspection (with or without risk factor assessment) is a commonly used screening method, especially in resource-constrained settings. The visual assessment of jaundice may be difficult in neonates, especially in infants with darker skin tones. More importantly, the accuracy of visual assessment in predicting severe hyperbilirubinaemia has been found to be poor.⁽³⁾ Almost two-third of newborns with TSB in high-risk zones were misclassified based on visual assessment.⁽⁴⁾ Hence there is a need for alternate methods of assessing neonatal jaundice.

Current status and perspectives

Blood sample and laboratory estimation of total serum bilirubin is the most accurate method of estimating serum bilirubin. But it requires a heel prick and laboratory assessment. Serum bilirubin levels are also estimated non-invasively through the skin using a transcutaneous bilirubinometer (TcB). The TcB measures the yellowness of reflected light transmitted from the baby's skin. The TcB level is predicted based on a built-in algorithm. There is a good corelation between the TcB values and corresponding serum bilirubin (TSB) estimations.⁽⁵⁾ In one study, the sensitivity of the TcB to identify neonates requiring phototherapy was 76% [95% CI 64–86] and specificity was 90% [95% CI 86–94]. The positive predictive value (PPV) was 70% [95% CI 58–81] and negative predictive value (NPV) was 92% [95% CI 88–96].⁽⁶⁾ After the screening of jaundice using TcB, a serum bilirubin (TSB) may be needed

FIGURE 1: THREE METHODS OF SCREENING FOR NEONATAL JAUNDICE



in some neonates. A proportion of these neonates may require phototherapy. Several national guidelines recommend universal screening for neonatal hyperbilirubinaemia.⁽⁵⁾

WHO recommendation for universal screening for neonatal hyperbilirubinaemia

The World Health Organization has recently published its recommendations on maternal and newborn care for a positive postnatal experience.⁽⁷⁾ This is a consolidated set of new and updated recommendations for routine postnatal care for women and newborns receiving facility or community-based postnatal care in any resource setting. One of the recommendations is on universal screening for neonatal hyperbilirubinaemia at facility discharge.

WHO recommendation Universal Screening for Neonatal Hyperbilirubinaemia

Universal screening for neonatal hyperbilirubinaemia by transcutaneous bilirubinometer (TcB) is recommended at health facility discharge

Evidence was derived from a systematic review of universal screening for hyperbilirubinaemia in term healthy newborns at discharge.⁽⁸⁾ The systematic review included five studies (377 814 newborns), of which four studies were conducted in the USA and one in South Africa. This review suggests that universal screening by TcB for hyperbilirubinaemia may lead to a reduction in the proportion of newborns with severe hyperbilirubinaemia (defined as TSB> 20 mg/dl) and those requiring exchange transfusion when compared with clinical screening in healthy newborn infants>35 weeks.

There is also evidence that readmission for jaundice is reduced. Neonatal mortality, neurodevelopment and adverse effects were not reported in the systematic review. While there are some concerns that TcB screening may slightly overestimate TSB levels in newborns with dark skin colour/tone,⁽⁹⁾ it is well accepted that it is a reliable screening tool regardless of skin colour.⁽¹⁰⁾

The WHO guideline did not issue any recommendation for universal screening by TSB at health facility discharge. The systematic review on universal screening by TSB in term healthy newborns at discharge found uncertainty around the benefits of universal TSB screening compared with clinical screening for important clinical outcomes, such as the number of neonates with severe hyperbilirubinaemia or jaundice requiring an exchange transfusion or readmissions for jaundice.

The Guideline Development Group (GDG) decided not to formulate a recommendation on universal screening for neonatal hyperbilirubinaemia using TSB due to the lack of evidence comparing universal TSB with universal TcB measurement. Additionally, the GDG considered that the costs were large, and feasibility and acceptability varied markedly (7).

While TcB is the recommended method of universal screening for neonatal hyperbilirubinaemia, the GDG emphasized that the existing WHO recommendations on routine assessment of the newborn for danger signs, including jaundice- and yellow palms and soles, still apply.

During health facility stay, clinicians should ensure that all newborns are routinely monitored for the development of jaundice and that serum bilirubin should be measured in those at risk. Additionally, special emphasis should be placed on all infants to monitor if jaundice is detected on the first day, and also if palms and soles are yellow at any age in infants (11).

The postnatal age for universal TcB screening at discharge should be guided by the timing of health-facility discharge. The GDG stated that all healthy newborns should receive facility care for at least 24 hours after birth. The GDG also observed that transcutaneous bilirubin screening at discharge should be followed up with serum bilirubin measurement, appropriate treatment, and follow-up as indicated by age-appropriate nomograms. The purpose of universal predischarge bilirubin screening is to identify infants with bilirubin levels >95th percentile for their age (hours of life) which require treatment in the form of phototherapy or an exchange transfusion.

This implementation guidance document focuses on universal newborn screening with TcB and initiation of therapy. It is not intended to provide a comprehensive guidance on management of neonatal hyperbilirubinaemia , phototherapy and exchange transfusion.

Target group

These guidelines apply to healthy neonates more than 35 weeks of gestation (>35 weeks). Preterm neonates may require specialized care.

TcB screening is recommended for all neonates in a health facility, prior to discharge. Some neonates are at a higher risk to develop jaundice. These are tabulated below (see Table 1). Screening for neonates brought to the health facility after birth must be considered, especially if there are risk factors.

TABLE 1: RISK FACTORS FOR DEVELOPING SIGNIFICANT HYPERBILIRUBINAEMIA

Antenatal risk factors	Postnatal risk factors
Gestational age <40 weeks	Visible jaundice before 24 hours of life
Sibling or family history of phototherapy or exchange transfusion	Laboratory evidence of haemolysis
Family history of haemolytic blood disorders, e.g. G6PD deficiency	Suboptimal breastfeeding*
Rh or ABO incompatibility	Macrosomic infant
	Down syndrome
	Significant bruising – cephalhaematoma

*more common in neonates born to primigravida mothers or by caesarean section

Method of screening: Transcutaneous bilirubinometry

TcB is a method using reflectance photometry or transcutaneous colorimetry as a noninvasive estimate of TSB levels. This technique offers an objective measurement of the skin colour, from which a reading; reflecting the TcB, is derived.

Several devices are commercially available. They differ in their ease of use and their propensity to be affected by variations in skin colour. Clinicians should be aware that there may be variation in the results between different devices.^(12, 13)

A number of studies have shown that these instruments provide fairly accurate estimates of TSB in term and near-term newborn infants of varying races and ethnicities, generally providing values within 2–3 mg/dL of the TSB, if the TSB is less than 15 mg/dL.⁽¹⁴⁾ The technology tends to underestimate the actual TSB level and should be regarded as a screening mechanism rather than an accurate reflection of the TB. Hour-specific nomograms based on TcB measurements have been established both for term and late preterm infants.^(15,16)

Correlation between TcB and TSB at levels of 15 mg/dL and higher, as well as during and after phototherapy and in premature births or with infants with low birth-weight, needs further evaluation. The device has also been used successfully in community TcB screening.⁽¹⁷⁾

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FIGURE 1: TCB MEASUREMENT – GENERAL INFORMATION AND RESOURCE REQUIREMENT

Who can do the screening

Any health care personnel (nurses/midwives) who have been trained in the use of TCB can perform the screening.

When should it be done

TCB should be done for all neonates before discharge from the health facility. It is most reliable after 24 hours of age, hence the ideal time for screening is between 24 and 48 hours of life.

Where is the screening done

Bedside or in the outpatient department

How is it done

The step wise procedure is given in Table 3.

Time required

The test takes approximately two minutes to perform. Calibration time depends on the manufacturer.

Equipment and infrastructure

TcB machine Access to electricity

Supplies

- 1. Alcohol for sterilization.
- 2. Cotton swabs
- 3. TCB machine with the docking station and power source
- 4. Nomograms for age-based treatment thresholds.

For troubleshooting, an annexure is provided at the end of the document.

Specifications for Equipment

It is suggested that the transcutaneous bilirubinometer equipment procured for screening for neonatal hyperbilirubinaemia meets the specifications given in Table 2.

TABLE 2: SUGGESTED SPECIFICATIONS FOR TCB

Good correlation with serum bilirubin in studies	High memory capacity
Consistent readings	Accuracy- ±1.5 mg/dl
Wide gestational age and ethnicity profile 24–42 weeks	Quick calibration
Handheld portable, easy to use & disinfect	Transferable data & storage
Rechargeable battery	Warranty
Approved by USFDA	Availability of good maintenance services
No disposable parts	Battery powered with AC adapter
Touchscreen	Good service back up (AMC/CMC) *

*annual maintenance contract/comprehensive maintenance contract. The cost of a TcB machine ranges from US\$ 2500–6500.

Timing of TcB screening

The WHO guidelines recommend screening with TcB at facility discharge. This is based on the premise that all healthy newborns should receive care in the facility for at least 24 hours. TcB is the most reliable after 24 hours of age. If discharge is delayed beyond 48–72 hours, it is suggested that the TcB screening is done earlier than 72 hours. The ideal time for screening is between 24 and 48 hours of life. Screening may be done any time after 24 hours up to 72 hours of life, for neonates in hospital. Visual assessment of jaundice as part of clinical examination should be done twice a day and repeat TcB should be done as required. Newborns, who are brought into the facility, may be screened at the first visit, anytime between 24 hours and 7 days postnatally.

Place of screening

The TcB screening can be done by the bedside in the postnatal wards. There is no need of any special room or special requirements for TcB screening. It can also be done in the outpatient settings or even in the community settings.

Personnel for screening

Healthcare personnel- nurses- or midwives or doctors caring for the newborn, can be trained to use the TcB for screening. The procedure is simple and all health personnel including nursing aides can be easily trained. Services of special personnel can be avoided for regular screenings. The training takes about half hour, and it is often provided by the equipment manufacturing company at the time of installation. This simple procedure is also amenable to self-learning (using the accompanying video).

Steps of TcB measurement

The procedure of TcB is described in Table 3 using the example of Drager JM-105 jaundice meter. The procedure of TcB measurement can be seen in the video provided with the guidance. This videos can be accessed by scanning the QR code available on the back page of this guidance.

TABLE 3: STEPS FOR USING TCB



The screening test is fast and easy and the time to perform the test is estimated to be two minutes. The results are instantaneous. There is additional time required for the calibration prior to each measurement depending on the device. While JM-105 has a reusable probe tip and needs no consumables, some machines may require disposable probe tips.

A daily operational check is also needed depending on the device. Annual calibration on the TcB machine is recommended to preserve device efficacy and assist in accurate patient readings and treatment guidance. Common problems faced while using a TcB machine and their solutions are given in Annexure 5.

FIGURE 2: TRANS CUTANEOUS BILIRUBIN MACHINE IN DOCKING STATION



Visual assessment of jaundice

Historically, visual inspection has been the most commonly used method of screening newborns for hyperbilirubinaemia jaundice that progresses cephalocaudally (Figure 3). Digital pressure that blanches the skin diminishes the effects of pigmentation and local cutaneous perfusion which allows the detection of jaundice. Proper lighting is important in detecting subtle levels of jaundice. However, visual assessment is subjective, dependent on the observer experience and is notoriously inaccurate. (Figure 3)

FIGURE 3: CEPHALOCAUDAL PROGRESSION OF JAUNDICE AND KRAMER'S DERMAL ZONE (18)



All serum bilirubin values are in mg/dl.

Visual assessment is not recommended for universal screening for neonatal hyperbilirubinaemia . But it is important for the health worker to assess the infant twice daily for jaundice from the time of birth i.e. <24 hours. Any jaundice on the first day of life is pathological and it is detected by visual assessment. It is also important to educate the family to assess jaundice and recognise yellow palms and soles as a danger sign.

Diagnosis and management

Though the TcB correlates well with TSB, phototherapy should not be initiated based on only TcB. All decisions pertaining to treatment should be made after obtaining TSB. The TcB reading obtained, needs to be interpreted based on a bilirubin nomogram. The bilirubin nomograms may either be TcB nomograms or TSB nomograms. Country specific guidelines specify which bilirubin nomograms are to be used. Charts or bilirubin nomograms recommended by the American Academy of Pediatrics (AAP) and the United Kingdom's National Institute for Health and Clinical Excellence (NICE) are frequently used; they are provided in Annexure 3 and Annexure 4 for reference. On plotting the TCB value on a TSB nomogram, if it reads any value 3mg/dl below the threshold or at threshold for phototherapy or at >15mg/dl at any time, serum bilirubin estimation should be done. When the TSB level is above the threshold, phototherapy needs to be initiated. Once phototherapy is initiated, TcB can no longer be used for subsequent bilirubin estimations, this will require a TSB.

There are several hour specific TSB nomograms. The clinical management following screening should be based on nomograms as per country-specific guidelines. For example, AAP hour specific nomograms provide two charts to decide on the need for phototherapy based on presence or absence of neurotoxicity risk factors (see Annexure 3 for risk factors).⁽⁵⁾

When TSB values are above phototherapy level on the appropriate chart, the value should be plotted on the appropriate exchange transfusion charts, to determine if an exchange transfusion is needed. A simple algorithm is provided in Figure 4.

Gestational age assessment is an important prerequisite to management decisions in neonatal hyperbilirubinaemia. First trimester ultrasound is most accurate followed by a reliable last menstrual period (LMP).



FIGURE 4: ALGORITHM FOR SCREENING AND TREATMENT

*Threshold on the appropriate charts.

Referral

If facilities for phototherapy (or exchange transfusion if needed) are not available, the neonate will need referral to a higher centre. As bilirubin may be neurotoxic, referral should be as fast as possible. If an exchange transfusion is anticipated, blood samples from the mother should be sent if the mother is unable to accompany the baby.

Setting up a universal screening programme for neonatal hyperbilirubinaemia

Universal screening for neonatal hyperbilirubinaemia should be provided for all newborn infants. Programmatically this means training the nurses and doctors in all birth facilities and provision of essential equipment for screening. It also implies setting up diagnostic facilities for measuring TSB in the area of establishing linkages with such facilities.

The programme should also ensure that appropriate management in the form of phototherapy and exchange transfusion is available either in the facility or referral services are provided. The programme should also document and develop indicators to monitor the implementation of the programme and the yield of the programme. Further, as some infants may develop BIND despite the universal screening programme, linkages should be established to provide neurodevelopmental follow-up services.

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Annexures

Annexure 1: Recommendations of screening of the eye in different counties

Organization	Year/ Income	Age at Screening	Screening Test	Person Conducting Screeniing/Location of Screening
American Academy of Ophthalmology	2013/ High	Newborn	» RRT» "General eye health"	 » Ophthalmologist, paediatrician, family doctor, trained health professional » 'Newborn nursery'
American Academy of Ophthalmology	2017/ High	Newborn–6 months	 » RRT with ophthalmoscope » External eye examination » Pupil examination 	 » Trained physicians, nurses, others » Primary care/ community health professional
American Academy of Paediatricians	2016/ High	Newborn–6 months	» RRT» External eye examination» History	» Paediatricians
Public Health England	2019/ High	Newborn (within 72 h) and 6–8 weeks	 » RRT with ophthalmoscope » External eye examination » History 	 » Paediatric doctor, family doctor » Maternity unit, well-child visit
Joint Clinical Practice Guideline Expert Committee of the Canadian Association of Optometrists and the Canadian Ophthalmological Society	2019/ High	Newborn–3 months	 » RRT with ophthalmoscope » External eye examination 	 » Primary care provider/ non ophthalmological personnel » Well-baby visit
Government of Canada, First Nations and Inuit Health Branch	2010/ High	Newborn–3 months	 » RRT with ophthalmoscope » External eye examination » Corneal reflex for strabismus 	 » Primary care provider/ non ophthalmological personnel » Well baby visit
Ministry of Health, New Zealand	2014/ High	Repeat the measurement	» Repeat the measurement	» Repeat the measurement



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(Continued)

Organization	Year/ Income	Age at Screening	Screening Test	Person Conducting Screeniing/Location of Screening
Ministry of Health and Family Welfare, Government of India, Rashtriya Bal Swasthya Karyakram,	2017/ Lower middle	Newborn–48 –72 hour	 » RRT with ophthalmoscope » External eye examination » White reflex with torch » History 	 » Medical officers, pediatricians, nurses » Place of delivery/ neonatal units
World Health Organization, Regional Office for Europe	2015/ Most high	Newborn, day 3, 7–14, week 6	 » RRT with ophthalmoscope » External eye examination 	» Doctors, nurses, midwives

RRT – red reflex test

Annexure 2: Checklist for examination of the eye

Part of the eye	Normal findings	Checked
Eyeballs	» normal in shape	
	» Doth eyeballs are in socket	
Eye lids	» no swelling	
Conjunctiva	» no redness or discharge	
Sclera	» white in colour	
Cornea	 transparent and normal in size (9–12mm) 	
Iris	» Normal circular in shape	
	» Brown to black in colour	
Pupil	» normal circular in shape	
	» brown to black in colour	

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Annexure 3: Charts or bilirubin nomograms recommended by the American Academy of Pediatrics (AAP)

CHART 1: AAP PHOTOTHERAPY THRESHOLDS FOR NEONATES WITH NO RECOGNIZED NEUROTOXICITY RISK FACTORS



CHART 2: AAP PHOTOTHERAPY THRESHOLDS FOR NEWBORNS WITH NEUROTOXICITY RISK FACTORS



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NEUROTOXICITY RISK FACTORS ARE



CHART 3: AAP EXCHANGE TRANSFUSION THRESHOLDS FOR NEONATES WITH NO RECOGNIZED NEUROTOXICITY RISK FACTORS









Annexure 4: Charts or bilirubin nomograms recommended by United Kingdom's National Institute for Health and Clinical Excellence (NICE)

Charts recommended by American Academy of Pediatrics and the United Kingdom's National Institute for Health and Clinical Excellence (NICE) are frequently used and are provided below.

CHART 1: NICE GUIDELINES FOR TREATMENT THRESHOLDS FOR NEONATES OF 35 WEEKS OF GESTATION





CHART 2: NICE GUIDELINES FOR TREATMENT THRESHOLDS FOR NEONATES OF 36 WEEKS OF GESTATION

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CHART 3: NICE GUIDELINES FOR TREATMENT THRESHOLDS FOR NEONATES OF 37 WEEKS OF GESTATION

CHART 4: NICE GUIDELINES FOR MANAGEMENT OF JAUNDICE IN NEONATES >38 WEEKS OF GESTATION



Annexure 5: Troubleshooting for common problems in transcutaneous bilirubinometer

Table below provides an example of troubleshooting for common problems in the Dragger JM-105 jaundice meter.

Problem	Probable cause	Solution
ERROR01	Measured value is abnormal. For averages, the difference between measurements is excessively large.	Repeat the measurement
ERROR03	RAM error. Abnormalities or corrupted data in RAM.	Switch off the device and remove it from service.
ERROR03, ERROR04, ERROR06	Averaging failure, hardware failure	Switch OFF power. Wait 10 s. Switch ON power. If the failure continues, switch off the device and remove it from service.
ERROR05	Insufficient charge	Charge the device
Machine not switching on		
READY lamp blinks red during	Battery is over discharged when placed on the docking station.	Wait for a few minutes. The battery charge increases to 1.2 V or higher. The red READY lamp illuminates continuously.
charging	Battery temperature too high.	Allow battery to cool. Charging starts automatically when battery has cooled. If the failure continues, switch off the device and remove it from service.
	No battery connected to the JM105.	Connect battery
Charger lamp does not illuminate even when device is placed on the docking station	Docking station not connected to AC adapter or not connected correctly. AC adapter not connected to AC power or not correctly connected to AC power. Device is not seated correctly	Correctly connect docking station to AC adapter. Correctly connect AC adapter to AC power. Reseat the device in the docking station.
	in the docking station.	
Not possible to take measurement	Battery power is depleted.	Charge battery
	Touch screen is locked. Touch screen is frozen or has failed.	To unlock the touch screen, press the display lock button.
		Press the On/Off switch and the display lock button simultaneously and HOLD for 5 seconds. Power switches OFF. Then, switch ON power.
		Switch OFF power.
		Wait 10 s. Switch ON power.
		If the failure continues, switch off the device and remove it from service.
TCB reading comes as Zero (0).		This indicates that the bilirubin is very high, and phototherapy needs to be started immediately.
		A blood sample for a serum bilirubin (TSB) will also be needed.
		An exchange transfusion may also be needed.

For any other problems, please refer to the manufacturer's manual.



AN ST

 $\mathcal{X}^{(i)} = \left\{ \begin{array}{c} \frac{1}{2} \\ \frac{1$

4.1



Scan the QR code to view the screening test videos