Early detection of hearing impairment through newborn hearing screening (NHS) is the initial step to any early hearing detection and intervention (EHDI) programme. Universal newborn hearing screening (UNHS) is considered the gold standard worldwide. However, this approach may not initially be feasible for some developing contexts where contextual challenges to implementation exist. Targeted newborn hearing screening (TNHS) is a possible interim approach that may be implemented in such contexts. This chapter first discusses the different approaches to early detection of hearing impairment in South Africa, followed by the recommended approach for this context. The chapter concludes by suggesting possible solutions and recommendations for early detection of hearing impairment in South Africa and other low and middle-income (LAMI) countries that may not yet have early detection programmes in place.

Early detection of hearing impairment is conducted through NHS, and is usually followed by a comprehensive diagnostic audiological evaluation should a refer result be obtained from the screening. NHS has been used for over a century. Investigation of early detection of hearing impairment began in the 1800s with the use of subjective evaluation in the form of behavioural responses. It has now progressed to the use of objective measures in the form of otoacoustic emissions (OAEs) and the auditory brainstem response (Mencher & DeVoe, 2001), which are employed in NHS programmes globally. Similarly, risk-based hearing screening, commonly referred to as TNHS, was the first approach to early detection in the 1950s and 1960s, with the introduction of the high-risk register (HRR) to identify newborns and infants presenting with risk criteria for permanent congenital and early onset hearing impairment who require NHS (Mencher & DeVoe, 2001). Identification of infants at risk for permanent congenital and early onset hearing impairment based on established risk factors on the HRR was recommended by the Joint Committee on Infant Hearing (JCIH) in 1973. The use of this approach for early detection of hearing impairment gradually progressed toward the introduction of UNHS in 2000, which entails the screening of all newborns (JCIH, 2000, 2007).
Section One: Early Detection of Hearing Impairment

Approaches to early detection

There are two main approaches to early detection of hearing impairment, namely UNHS and TNHS. UNHS is the recommended screening approach and has replaced TNHS, particularly in high-income countries (Olusanya et al., 2007). This choice is due to a considerable proportion of infants not having risk factors for hearing impairment in most developed contexts (Patel, Feldman, Canadian Paediatric Society, & Community Paediatrics Committee, 2011). NHS programmes from 46 countries were reviewed and evaluated against the JCIH (2007) recommendations (Tann, Wilson, Bradley, & Wanless, 2009). From the 26 high-income countries included in the review, 18 (69 percent) were recorded as having implemented UNHS. This is in comparison to the middle-income countries where UNHS was indicated for eight (44 percent) of the 18 countries, and low-income countries where no UNHS programmes were indicated at the time (Tann et al., 2009). In South Africa, the 2007 position statement and the 2018 EHDI guidelines by the Health Professions Council of South Africa (HPCSA) also recommend the use of UNHS as the preferred approach for the public health care sector (HPCSA, 2007, 2018).

Universal versus targeted newborn hearing screening

Despite the preferred approach to early detection, it is important to highlight the advantages and limitations of each approach in light of the context in which the NHS programme is to be implemented.

Implementation of UNHS has shown to decrease the age of diagnosis of hearing impairment (Durieux-Smith, Fitzpatrick, & Whittingham, 2008; Ghogomu, Umansky, & Lieu, 2014), which may in turn lead to earlier intervention and its associated positive outcomes in terms of early childhood development. UNHS further facilitates detection of hearing impairment in infants without risk factors who may otherwise be missed. Of the 709 children in the study by Durieux-Smith et al. (2008), 128 (of whom 124 presented with risk factors) had been identified through UNHS or TNHS programmes and the remaining 581 had been referred by a physician. Children who were screened through either of the NHS programmes were diagnosed significantly earlier (mean age of diagnosis at 6.3 months) than those with risk factors who were referred (mean age of diagnosis at 34.5 months). In comparison to the children without risk factors, those with risk factors were diagnosed earlier. Despite differences in ages at diagnosis, only 21 of the 128 children who underwent NHS had a confirmed diagnosis and received intervention by three and six months of age, respectively. Durieux-Smith and colleagues (2008) propose that this may be due to other medical conditions...
taking priority over the identification of hearing impairment in those admitted to the neonatal intensive care unit. Similar findings in terms of a significant decrease in the age of diagnosis of unilateral sensorineural hearing impairment were also reported in a retrospective record review conducted at a single site in Missouri in the United States (Ghogomu et al., 2014). Findings from this study indicated that the mean age of detection of hearing impairment decreased from 4.4 years to 2.6 years of age with an increase in the rate of detection from 3 percent to 26 percent by six months of age.

While the overall benefits of UNHS are evident, there are limitations to this approach as well. First, less severe congenital hearing impairment (less than 30–40dB) is often not detected in UNHS programmes. The second limitation is related to UNHS programmes using a two-step screening protocol in which low-risk infants with auditory neuropathy may not be detected by the use of OAEs as the only screening measure (Patel et al., 2011).

Similarly, one of the most commonly reported TNHS limitations is that it may result in missed cases of hearing impairment. Between 25 and 50 percent of infants with hearing impairment may not be identified if only TNHS is utilised, and babies without risk factors for hearing impairment may be at risk of being identified late (Durieux-Smith & Whittingham, 2000; Hyde, 2005; Kountakis, Skoulas, Phillips, & Chang, 2002). ‘The percentage of babies missed may be due to the absence of hearing impairment in those with risk factors and the presence of hearing impairment in those without risk factors’ (Kanji, 2016, p. 51). However, despite these limitations, it is important to consider the context in which TNHS is conducted, as the proportion of neonates or infants with risk factors may be greater in some contexts than in others. TNHS may be a beneficial, interim screening method in LAMI countries where the recommendation of UNHS appears rather overwhelming or is not yet feasible. The development of an appropriate and contextually relevant HRR documenting the risk factors for hearing impairment may also assist in highlighting the cases that require monitoring and follow-up (Johnson, 2002).

Irrespective of the choice of approach, there is cost involved in implementation:

For NHS programmes, costs are incurred for all those screened, but the benefits are experienced by only a small percentage of neonates. The most important variables to include in such an analysis are the actual costs of the screening, the effectiveness of the screening, the prevalence of hearing impairment and the cost consequences associated with preventing, treating or managing hearing impairment. Assessment of benefits must then include both the health and economic benefits associated with preventing, treating or managing hearing impairment. (World Health Organization [WHO], 2010, p. 10)
The cost-effectiveness of UNHS and TNHS has been explored in eight different provinces in China (Huang et al., 2012) using the guidelines stipulated by the WHO (2010). UNHS was found to be more cost-effective when there was a good coverage rate in terms of the total number of newborns and infants screened, diagnosed and enrolled into an intervention programme. TNHS, on the other hand, was more feasible in provinces where all these rates were low. In order to improve TNHS in these provinces, Huang et al. (2012) recommended that pilot surveys be conducted to determine the context-specific risk factors for permanent congenital and early onset hearing loss. A systematic review by Colgan et al. (2012) suggested that the cost-effectiveness of UNHS can only be concluded if longer-term costs and outcomes associated with such programmes are accounted for.

A cost-effectiveness comparison of UNHS and selective screening (TNHS) of newborns with pre-specified risk factors was conducted by Burke, Shenton, and Taylor (2012) between a high-income and a LAMI country (United Kingdom and India). TNHS yielded a better positive predictive value (Burke et al., 2012). UNHS incurred more costs than TNHS as a result of a larger number of false positive findings. Costs may therefore be viewed as relative to the prevalence of hearing impairment in each region, with higher costs in regions with a lower prevalence as more infants need to be tested in order to detect those with hearing impairment (Burke et al., 2012). It may therefore be argued that the costs incurred in LAMI countries may be lower as that is where the prevalence of hearing impairment is reported to be higher in comparison to higher-income countries (Kanji, 2016).

Weighing up the options for South Africa

UNHS is a commonly practised approach to early detection in developed countries, with well-established, standardised programmes, and dedicated screeners outside of the profession of speech pathology and audiology. While these developed countries have established NHS programmes and are concerned with the diagnostic follow-up and intervention aspects, South Africa appears to be in the early stages of implementation of NHS services and programmes (Kanji, 2016). Research and conceptual papers related to EHDI in South Africa have acknowledged the impracticalities of attempting to implement developed world models of NHS in developing countries (Moodley & Störbeck, 2015; Swanepoel, Delport, & Swart, 2004; Swanepoel, Hugo, & Louw, 2005).

Both approaches to NHS have been explored in the South African context. Studies involving UNHS have looked at different health care contexts – private and primary health care, secondary level hospitals and midwife obstetric units (MOUs) – in the public sector in two provinces (Bezuidenhout, Khoza-Shangase, De Maayer, & Strehlau, 2018; De Kock, Swanepoel, & Hall, 2016;
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Khoza-Shangase & Harbinson, 2015; Swanepoel, Ebrahim, Joseph, & Friedland, 2007).

A UNHS study conducted over a four-year period at a private hospital revealed a 75 percent coverage rate within the first 22 months when hearing screening was included in the hospital birthing package. However, the efficiency of the programme decreased to a 20 percent coverage rate during the following 26 months, when parents were responsible for payment of the NHS service (Swanepoel et al., 2007). Of the two studies conducted in the public health care sector, the study at a secondary level hospital included screening of 121 neonates out of a possible 2,704 births during the study period. Challenges to the implementation of UNHS included noise interference; vernix in the external auditory canal of neonates; human resource challenges due to a high patient-to-audiologist ratio, resulting in limited coverage; technical and equipment challenges; as well as early discharge of well babies (Bezuidenhout et al., 2018).

MOUs have been reported to serve as a useful platform for UNHS and follow-up with postnatal visits (De Kock et al., 2016). A study conducted over a 16-month period at three MOUs in the Western Cape revealed initial follow-up return rates to be high, with a decline for additional screening or diagnostic appointments (De Kock et al., 2016). The employment of dedicated non-professional screeners was reported to have positively influenced screening services, with quality training and regular supervision being vital to programme efficiency. While the HPCSA guidelines are geared toward UNHS and serve as the gold standard that audiologists in South Africa should aim to achieve, they are not necessarily applicable as the starting point in all health care sectors in the country.

Studies related to TNHS have been less frequently conducted in the South African context. However, findings from one study suggest the need to establish more context-specific risk factors in order to ensure effective implementation of TNHS programmes (Kanji, 2016). Results from this study indicate that the case history factors in the sample of high-risk neonates were not all present on the HRRs by the JCIH (2007) and HPCSA (2018). These differences in findings, along with those in Australian studies by Beswick, Driscoll, and Kei (2012), as well as Beswick, Driscoll, Kei, Khan, and Glennon (2013), highlight the need to specifically tailor risk factors to context. Kanji and Khoza-Shangase (2019) further highlight the importance of context itself as a risk indicator. These authors propose the concept of a quadruple influence on risk, which takes cognisance of the influence of the burden of disease, medical advancements, technological advancements and human advancements. The use of appropriate risk factors is further explored in chapter 6 of this book. It has also been suggested that TNHS be considered in contexts where UNHS is not yet feasible, particularly in hospital settings in the public health care sector, where high-risk neonates would be more likely to undergo follow-up and monitoring by paediatricians.
Section One: Early Detection of Hearing Impairment

The South African health care sector consists of a large public sector on which over 80 percent of the population is dependent (Naidoo, 2012). The Department of Health (DoH) focuses on other health priorities and specific health-related goals, such as the eradication of extreme hunger and poverty, the promotion of gender equality, reduction of child mortality, improvement in maternal health, and combating of HIV/AIDS, malaria and other major diseases (DoH, 2012).

Considering South Africa’s health care context, and the importance of early detection of hearing impairment in newborns and infants, there is a need to seriously consider how early detection services may be adapted to better meet these realities (Kanji, 2018). A number of factors need to be considered when deciding on the most suitable approach to NHS, whether interim or long term (see Table 3.1). Khoza-Shangase explores the challenges and realities confronting the implementation of early detection services in South Africa in chapter 5.

### Table 3.1 Factors to consider when weighing up the approach to NHS

<table>
<thead>
<tr>
<th>Factor</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td>Human resources</td>
<td>Availability of audiologists and whether non-professional personnel are available to conduct screening</td>
</tr>
<tr>
<td>Equipment</td>
<td>Availability of equipment for screening and/or diagnostic assessment</td>
</tr>
<tr>
<td></td>
<td>Costs associated with maintenance of equipment</td>
</tr>
<tr>
<td>Data management</td>
<td>Availability of an effective and efficient data management and tracking system</td>
</tr>
<tr>
<td>Costs</td>
<td>Clinical assessment and management costs for newborns and infants with hearing impairment</td>
</tr>
</tbody>
</table>

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### Solutions and recommendations

Audiologists need to evaluate the contexts in which they work, and decide on the most suitable approach to early detection of hearing impairment. The evaluation needs to consider the costs involved with NHS, as well as the availability of equipment and human resources. This evaluation can be conducted using the needs assessment and planning guide in the HPCSA’s EHDI guidelines. Audiologists could trial the use of non-audiologists as screening personnel following training as detailed in the curriculum suggested in the EHDI guidelines. The guidelines include a practical training and competency checklist which can be used to evaluate non-professional screeners (HPCSA, 2018).

Once the chosen approach is well established, there needs to be consideration of how to better develop the programme that is in place. This can only
be done if it is evaluated regularly against key benchmarks specified in the
guidelines, including: ages by which screening and confirmation of hearing
impairment should take place in various levels of service delivery; evidence
of an otologic evaluation in children diagnosed with hearing impairment;
audiological and medical evaluations that are perceived as positive and sup-
portive by families; and support to families in terms of appropriate provision
of information and referrals for intervention (HPCSA, 2018).

Audiologists should also share key challenges and successes of the pro-
grames at appropriate forums in order to develop such programmes at pro-
vincial and national levels. Differences between levels of service delivery also
need to be explored and tiered approaches may need to be implemented
to ensure the highest possible coverage rate. In chapter 4, Petrocchi-Bartal,
Khoza-Shangase and Kanji explore implementation of early detection services
at various levels of service delivery in the South African context. Audiologists
need to record data accurately in order to monitor the efficiency of pro-
grames, document prevalence and incidence rates for hearing impairment
and use these data to motivate for funding for equipment.

As noted, careful consideration needs to be given to the possibility of
training non-audiologists as screeners in order to overcome human resource
shortages in developing contexts. In situations where TNHS is the chosen
approach, audiologists need to screen newborns and infants in neonatal
intensive care units and high care wards instead of using predetermined risk
factors. All case history factors should be recorded in detail at the time of
screening in order to facilitate retrospective, evidence-based research of risk
factors associated with hearing impairment.

Conclusion

UNHS is the gold standard approach to early detection of hearing impairment.
While this is the goal that LAMI countries such as South Africa need to strive
towards, attention needs to be paid to specific and local needs of the context.
This will ensure that the approach to early detection is contextually relevant,
realistic, responsive and appropriate at any given time. It will further provide
a beneficial start to service provision in terms of EHDI. ‘As health care profes-
sionals we need to acknowledge the limitations but not allow it to preclude us
from providing quality services within our means’ (Kanji, 2018, p. 3).

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