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Review Article

Newborn hearing screening protocols and their outcomes: A systematic review

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ABSTRACT

Objective: To conduct a review of the most current research in objective measures used within newborn hearing screening protocols with the aim of exploring the actual protocols in terms of the types of measures used and their frequency of use within a protocol, as well as their outcomes in terms of sensitivity, specificity, false positives, and false negatives in different countries worldwide.

Methods: A systematic literature review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis. Electronic databases such as PubMed, Google Scholar and Science Direct were used for the literature search. A total of 422 articles were identified, of which only 15 formed part of the current study. The 15 articles that met the study's criteria were reviewed. Pertinent data and findings from the review were tabulated and qualitatively analysed under the following headings: country; objective screening and/or diagnostic measures; details of screening protocol; results (including false positive and negative findings, sensitivity and/or specificity), conclusion and/or recommendations. These tabulated findings were then discussed with conclusions and recommendations offered.

Results: Findings reported in this paper are based on a qualitative rather than a quantitative analysis of the reviewed data. Generally, findings in this review revealed firstly, that there is a lack of uniformity in protocols adopted within newborn hearing screening. Secondly, many of the screening protocols reviewed consist of two or more tiers or stages, with transient evoked otoacoustic emissions (TEOAEs) and automated auditory brainstem response (AABR) being most commonly used. Thirdly, DPOAEs appear to be less commonly used when compared to TEOAEs. Lastly, a question around routine inclusion of AABR as part of the NHS protocol remains inconclusively answered.

Conclusions: There is sufficient evidence to suggest that the inclusion of AABR within a NHS programme is effective in achieving better hearing screening outcomes. The use of AABR in combination with OAEs within a test-battery approach or cross-check principle to screening is appropriate, but the inclusion of AABR to facilitate appropriate referral for diagnostic assessment needs to be systematically studied.

1. Introduction

Early detection of hearing loss is conducted through newborn hearing screening (NHS). Identification of hearing loss through NHS has been investigated for over a century [1]. Investigations that began with the use of subjective evaluation in the form of behavioural responses in the 1800s has progressed to the use of objective measurements in the form of otoacoustic emissions (OAEs) and auditory brainstem response (ABR) [1].

A variety of objective screening measures may be used to conduct hearing screening in the newborn. These include transient evoked otoacoustic emissions (TEOAEs), distortion product otoacoustic emissions (DPOAEs), the automated auditory brainstem response (AABR) or a combination of otoacoustic emissions (OAEs) and AABR [2]. OAEs are acoustic signals generated from the outer hair cells within the cochlea reflecting the mechanical processes that provide an indication of the integrity of the cochlea [3]. Emissions are categorised by the presence or absence of an evoking stimulus with evoked OAEs being of greater clinical significance [4]. The AABR consists of an electrical response to auditory stimuli and assesses the peripheral auditory pathway from the ear to the brainstem [5].

Screening protocols and measures used within NHS programmes worldwide differ, with some countries and/or regions within a country using TEOAEs and AABR and others using DPOAE screening as well. For example, screening protocols in India consist of three stages with TEOAE at the first and second stages of screening followed by AABR at

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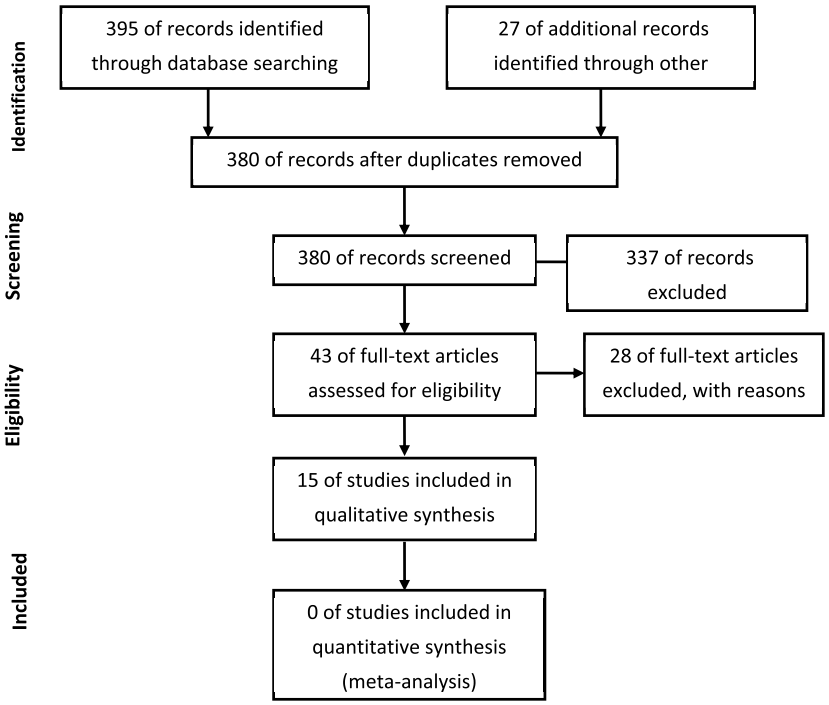

Fig. 1. The PRISMA flow diagram describing the study selection process.

the third stage. In comparison, hospitals in the United States employ a two stage screening protocol with TEOAE and AABR screening at both stages [6]. These differences in protocols should not confuse but rather guide stakeholders to develop relevant protocols in ensuring that the implemented NHS programmes attain certain benchmarks that support early identification and intervention for hearing loss [7].

There are many reasons why countries may choose to adopt one recommended protocol over another and this speaks to context and the constraints imposed within certain health care environments. Nevertheless, the ultimate choice at any given point in time should therefore extend beyond resource constraints and should consider current evidence from published literature when deciding on the screening measures. The Institute of Health Economics (2012) aimed at determining the accuracy of automated screening measures, and their influence on specific benchmark indicators such as detection rate of hearing loss and age at diagnosis. They concluded that the use of two-staged protocols using a combination of technologies was safe for newborns and that both OAEs and AABR were equally accurate measures within NHS programmes [8].

One of the ethical standards for NHS is that an appropriate, reliable, valid and safe test should be available and suitable to the target population being screened, for example, well babies versus high-risk infants [6]. In the United Kingdom, for example, well babies are reported to receive TEOAE screening followed by AABR if indicated by poor TEOAE results, whereas newborns requiring NICU care routinely receive both TEOAE and AABR screening [9]. This screening practice differs from some birthing facilities in the United States of America, where AABR is the common screening measure of choice followed by DPOAE and TEOAE. Notwithstanding these criteria, particularly that relating to sensitivity and specificity of measures may result in missed cases of hearing loss or an increased number of false positive findings. Ultimately, the choice of screening measures and the approach to screening should be guided by evidence from well-conducted pilot studies in each country [6,10]. These findings should facilitate the standardization of protocols within similar contexts. A low false-positive rate is essential in the success of a NHS programme and the reduction of false-positive results is therefore a key goal in developing a more reliable NHS programme [11]. Despite various protocols described in literature, one needs to carefully and systematically evaluate evidence from relevant studies that would assist in informing our choice in selecting evidence-based best measures that are suited for individual contexts. The current systematic review paper aimed at providing a review of the most current research in objective measures used within newborn hearing screening protocols with the aim of exploring the actual protocols in terms of the types of measures used and their frequency of use within a protocol, as well as their outcomes in terms of sensitivity, specificity, false positives, and false negatives worldwide.

2. Methods

A systematic review of peer reviewed published literature related to hearing screening measures used within NHS programmes worldwide from 2007 to 2016 was conducted in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [12]. A number of electronic databases, namely, PubMed, Google Scholar and Science Direct were searched using the following key terms: newborn hearing screening, newborn hearing screening protocols, otoacoustic emissions, auditory brainstem response. Articles (with both qualitative and quantitative studies included) were chosen based on specific criteria. Firstly, the study had to have been published in English in peer reviewed scientific journals. Secondly, the article had to present original work related to NHS, of which one of the aims or aspects of the study needed to involve information related to the NHS protocol used and the outcome of this protocol in terms of false-positive rates, false-negative rates, sensitivity, specificity and/or referral rates. Thirdly, studies had to include at least one of these five test performance criteria. Lastly, articles were to report on studies conducted worldwide between 2007 and 2016, a time which was reflective of the time period post the Health Professions Council of South Africa (HPCSA) and Joint Committee on Infant Hearing (JCIH) early hearing detection and intervention (EHDI) position statements to the present time. Published articles related to the evaluation of specific screening equipment or software were excluded from the review. For reliability, two independent reviewers extracted specific information from the studies. Pertinent data and findings from the review were tabulated under the