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Filtered sunlight, solar powered phototherapy and other strategies for managing neonatal jaundice in low-resource settings

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ABSTRACT

Challenges in treating severe neonatal jaundice in low and middle-income country settings still exist at many levels. These include: a lack of awareness of causes and prevention by families, communities and even sometimes health care professionals; insufficient, ineffective, high quality affordable diagnostic and therapeutic options; limited availability of rehabilitation provision for kernicterus. Collectively these challenges lead to an unacceptably high global morbidity and mortality from severe neonatal jaundice. In the past decade, there has been an explosion of innovations addressing some of these issues and these are increasingly available for scale up. Scientists, healthcare providers, and communities are joining hands to explore educational tools, low cost screening and diagnostic options including at point-of-care and treatment modalities including filtered sunlight and solar powered phototherapy. For the first time, the possibility of eliminating the tragedy of preventable morbidity and mortality from severe NNJ is on the horizon, for all.

1. Introduction

In recent years, global burden of disease modelling has identified severe neonatal jaundice (NNJ) as an important cause of mortality with by far the greatest burden in low and middle-income countries (LMICs) [1,2]. The multi-morbidities experienced by survivors who had progressed to acute bilirubin encephalopathy (ABE) are significant enough to be quantified in terms of global Disability Adjusted Life Years [DALYs] [3]. The long-term disabilities from chronic bilirubin encephalopathy (kernicterus) include dyskinetic (choreo-athetoid) cerebral palsy, deafness, language processing disorders, and motor and speech delays [4].

In high income settings (HIC), the reality of high quality prevention, early diagnosis, treatment in neonatal intensive care and rehabilitation has transformed the outcome for babies at risk and affected by severe NNJ. Within one generation, the HIC setting has demonstrated that mortality and severe morbidity from NNJ is largely preventable. Most ABE in high income countries today occurs in very premature infants or

rare mishaps due to gaps in communication and follow-up. In addition, advances in technology have given the survivors of ABE in HIC the opportunity for education and employment using the assistance of electric-powered wheelchairs, personal computers, and other devices.

The management of severe NNJ in LMICs is a starkly contrasting story at all levels: prevention, management and rehabilitation, leading to dramatically different outcomes in both morbidity and mortality [5]. The sad reality is that many survivors of (ABE) in LMICs are intellectually normal but essentially “locked-in” a body that physically does not work yet without access to devices to help them reach their full potential [4].

For decades, researchers around the world have sought to better understand severe NNJ and improve outcomes. Despite their efforts, many gaps still exist across all areas and as always, these gaps are deeper and wider in LMIC settings.

The management of severe NNJ in the LMICs is, once again, a story of the three delays: delay in seeking care, delay in reaching an appropriate medical facility and delay in receiving adequate care at the

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facility [6]. In this current paper, we identify seven areas of challenge in severe NNJ management in LMIC settings that contribute to these delays. These include community awareness, prevention, screening, diagnosis, treatment, follow-up, policy and guidelines. For each, we describe the current typical LMIC situation for severe NNJ management, identify ongoing challenges and highlight the potential strategies needed as we move forward into the period of Every Newborn Action Plan (ENAP) and Sustainable Development Goals (SDGs).

2. Gaps and solutions

2.1. Education and awareness

Research across a spectrum of LMICs (noted below) has identified a lack of knowledge about causes and management of severe NNJ by both communities and health care providers, which is higher in groups of lower socio-economic and lower educational status [2]. In the LMIC setting, many babies are born at home, or discharged in < 24 h leaving the mother and family as the main caregivers. Despite efforts to include both early jaundice and high levels of jaundice (visible on palms and soles and in eyes) [7] in programs such as Integrated Management of Childhood Illness (IMCI), much misinformation including traditional practices and cultural beliefs about NNJ persist. This lack of ability to identify and awareness in the potential seriousness of severe NNJ contribute to the first delay – deciding to seek care – leading to many infants having signs of ABE at presentation in LMICs [2,6,8,9]. Examples of community practices from LMICs that may delay appropriate diagnosis and treatment of severe NNJ include: keeping babies indoors for extended periods of time, attributing causality to eating yellow food or palm oil or cold water during pregnancy [6,10,11], failure to recognize serious NNJ [2,10,12], treating with antibiotics, stopping breast feeding, unripe pawpaw, herbal treatments, putting babies under home neon lights or unfiltered sunlight usually briefly and often in the early morning [9–15].

Research has also shown, in some situations, a gap in healthcare provider understanding and expertise in the modalities of management, including urgency of referral, monitoring and follow-up which may lead to delay in effective treatment which can also contribute to morbidity and mortality [6,8,12].

Both maternal and health care provider education is urgently needed [6,8,9,11]. Mass mobilization campaigns amongst communities much like those for awareness raising about other preventable diseases such as polio could help teach early recognition, reduce harmful traditional practices and provide the awareness about which facilities can provide rapid diagnosis, effective treatment and appropriate follow-up of infants with severe NNJ and thus decrease the prevalence of kernicterus. Empowering the often community trusted traditional birth-attendants and community health extension workers as referral agents may help to make these efforts successful and sustainable [2,6].

2.2. Prevention

Prevention strategies rely on the accurate understanding of the epidemiology of the many causes of severe NNJ, typically lacking in LMICs [6]. A limited understanding of these causes often contributes to the third delay in treatment. Those causes currently understood to be significant in LMICs are considered below:

The metabolic disorder glucose-6-phosphate dehydrogenase (G6PD) deficiency often presents with severe NNJ. If G6PD deficiency can be diagnosed, acute haemolysis can be often prevented by early treatment of mild-moderate NNJ and by avoiding contact with hemolytic agents such as camphor, naphthalene mothballs, mentholatum, henna, commonly used in many LMIC settings [9,16]. Although many LMICs meet the screening criteria for countries with > 5% prevalence of G6PD deficiency to test all newborns [17], the definitive, quantitative test for G6PD deficiency, typically used in HIC, is rarely done in LMICs for

resource reasons: a lack of machine availability, supplies and overall cost. An alternative qualitative test, the Beutler fluorescent spot test recommended in 1979 by the International Committee for Standardization in Haematology [18] is low cost (5–10 US cents per test) and has been used successfully in Africa [19] however challenges remain in scale-up, as the test is labour intensive and requires laboratory staff with particular expertise. However, other tests, have also been developed to meet the urgent need for simpler low-cost tests on the ground. These include cards using a qualitative enzyme chromatographic test which, shown to be reliable in neonates [20], may yet be more appropriate to use at scale in LMICs as they can be implemented by more generic staff in rural primary/secondary health facilities.

Preventing Rhesus D haemolytic disease of the newborn (RhD HDN), has been a success story in the HIC setting through effective health programming using anti-D Rhesus immunoglobulin [21]. In LMICs, the prevalence of Rh negative blood groups is often much lower, varying by region and country and subsequently RhD HDN is seen more rarely; however it still remains an important cause of severe NNJ [21]. Many women of child-bearing age in LMICs are not identified as being at risk simply because they do not know their blood group. The intervention of anti-D is often costly, of limited availability and requires continuous cold-chain. Enabling the global health systems to mirror the success story in the HIC in avoiding the consequences of RhD isoimmunisation remains a huge unmet need in LMICs [21].

Early identification of NNJ in other infants at high risk can prevent progression to severe NNJ. These include infants with sepsis, prematurity, sepsis, birth trauma (e.g. cephalohaematoma) and with a history of other siblings who developed severe NNJ [22]. Prevention for these at risk groups is also essential to close the gap in LMICs. Community based treatment of sepsis combined with filtered sunlight and/or solar powered phototherapy holds promise for early treatment of vulnerable infants in rural or conflict areas until such time as a referral is possible.

Preventing the devastating neurological consequences of ABE requires ongoing research. The seeming lack of correlation between serum bilirubin levels and outcomes remains an unanswered question that persists in all settings as does the question of whether there is scope for neuroprotection for example by reducing free bilirubin levels. There remains a need for appropriate high-quality research in and for LMIC settings, to prevent the ravages of severe NNJ.

2.3. Screening

Routinely screening all newborns for jaundice at treatment levels is critical to initiating appropriate management and can both prevent and treat severe NNJ. The recommendations for newborn assessment for danger signs include jaundice in a baby < 24 h or palm and sole jaundice at any time during a 4 visit postnatal schedule (within 24 h, on day 3, between day 7 and 14 and at 6 weeks) [7]. Home visits by a trained health worker are recommended during the first week of life, which is the critical time for the assessment of NNJ. However there remain significant gaps in quality postnatal care provision by the health systems in LMICs, which despite progress remain significantly behind antenatal care provision. Even if the infant is assessed at the appropriate time, in the LMIC setting, usually the only method available is visual inspection for jaundice using Kramer dermal zones scale. This subjective method which is even more challenging in babies with pigmented skins, has often been replaced in HIC settings with transcutaneous meters. In the LMIC setting, transcutaneous meters are rarely available and their use complicated by the challenge of conflicting evidence with regards to sensitivity of these devices in pigmented babies [23]. Screening methods being developed include low-cost paper tests for use by mothers to identify whether to take their infant for screening [24] and studies looking at the correlation between transcutaneous and serum bilirubin levels in different ethnic groups [23]. Other studies have already looked at transcutaneous bilirubin levels as

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