Refining clinical algorithms for a neonatal digital platform for low-income countries: a modified Delphi technique

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ABSTRACT

Objectives To determine whether a panel of neonatal experts could address evidence gaps in local and international neonatal guidelines by reaching a consensus on four clinical decision algorithms for a neonatal digital platform (NeoTree).

Design Two-round, modified Delphi technique.

Setting and participants Participants were neonatal experts from high-income and low-income countries (LICs).

Methods This was a consensus-generating study. In round 1, experts rated items for four clinical algorithms (neonatal sepsis, hypoxic ischaemic encephalopathy, respiratory distress of the newborn, hypothermia) and justified their responses. Items meeting consensus for inclusion (>80% agreement) were incorporated into the algorithms. Items not meeting consensus were either excluded, included following revisions or included if they contained core elements of evidence-based guidelines. In round 2, experts rated items from round 1 that did not reach consensus.

Results Fourteen experts participated in round 1, 10 in round 2. Nine were from high-income countries, five from LICs. Experts included physicians and nurse practitioners with an average neonatal experience of 20 years, 12 in LICs. After two rounds, a consensus was reached on 43 of 84 items (52%). Per experts’ recommendations, items in line with local and WHO guidelines yet not meeting consensus were still included to encourage consistency for front-line healthcare workers. As a result, the final algorithms included 53 items (62%).

Conclusion Four algorithms in a neonatal digital platform were reviewed and refined by consensus expert opinion. Revisions to NeoTree will be made in response to these findings. Next steps include clinical validation of the algorithms.

INTRODUCTION

Globally, 2.5 million newborns die each year in the first 28 days of life. Most of these deaths (98.5%) occur in low-income countries (LICs), and 40% occur on the first day of life. The neonatal mortality rate has halved since 1990, but modelling of global newborn mortality data suggests that a further two-thirds of current deaths could be prevented if evidence-based solutions were implemented. One of the WHO Sustainable Development Goals is to end preventable deaths of newborns in all countries and to reduce the neonatal mortality rate from the current rate of 18 per 1000 live births to less than 12 per 1000 by 2030. Targeting newborn care in LICs is thus an urgent priority, especially the three most common causes of mortality—infant deaths (36%), premature (28%) and intrapartum complications (23%).

The WHO neonatal guidelines are internationally recognised as the leading and most respected source of guidance. However, one of their limitations is that they are primarily based on data from high-income countries, as there is often a lack of evidence in LICs due to limited diagnostic aids, data and research. WHO aims to address the challenge of developing setting-appropriate neonatal guidelines by improving stakeholder involvement.
(design guidelines for specific audiences), clarity of presentation (often guidelines are too long and technical) and attention to dissemination.7 Mobile health (m-health) technology and digital platforms are potential approaches to implementing these measures and improving the quality of newborn care.8

An international team of researchers, clinicians and software developers in the UK, USA, Malawi, Bangladesh and Zimbabwe codesigned and co-developed with Malawian and Zimbabwean healthcare workers (HCWs) a neonatal digital platform (NeoTree) for facility-based newborn care in LICs. It combines immediate digital data capture (which is shared with HCWs via local dashboards), evidence-based algorithmic clinical decision and management support, newborn education and data linkage to national data systems on one platform.9 The algorithms in the Malawian version of the NeoTree support decisions according to established international10 and Malawian neonatal guidelines.11 In situations where guidelines were not applicable, the NeoTree clinical team used clinical judgement to complete the algorithm development. In the absence of extensive trial or epidemiological data in LICs, alternative techniques to consolidate best available low-quality evidence can be used, such as expert opinion. This study aims to use the modified Delphi technique to determine whether a panel of experts in newborn care can reach a consensus opinion about key clinical decision algorithms used in a digital platform to assist HCWs caring for facility-based unwell newborns in LICs.

METHODS
Study design
This study used a two-step modified Delphi technique.12 The Delphi technique was chosen because it is an effective method of gathering expert knowledge from geographically diverse leaders in the field to address complex clinical problems that lack evidence.

Recruitment
Twenty-two neonatal experts were invited to participate in the study. This number represented an adequate sample size,13 and permitted a manageable amount of data collection. Participants were recruited if they were a physician or neonatal nurse practitioner with more than 10 years neonatal experience (at least three in LICs), neonatal postgraduate training, fluency in English, internet access and willingness to participate. Neonatal experts known to the researchers for their clinical expertise, research and contributions to guideline development in LICs were identified in equal numbers from both LICs and HICs. No financial incentive was offered, but reimbursement for costs of Skype calls was provided for some experts in LICs.

Algorithms and item generation
The four clinical decision algorithms selected for review were neonatal sepsis, hypoxic ischaemic encephalopathy (HIE), respiratory distress of the newborn and hypothermia. These conditions represent the leading preventable causes of neonatal mortality and are the most difficult to diagnose and manage appropriately in LICs with some of the weakest WHO grade recommendations and quality of evidence.15 For example, the European definition of neonatal sepsis is two or more clinical symptoms and two or more laboratory signs in the presence of, or as a result of, suspected or proven infection.16 This definition is not possible in LICs where laboratory investigations are not routinely available.17

Items were identified by comparing the algorithms side by side with the international (WHO) and local neonatal guidelines (Care of the Infant and Newborn in Malawi—COIN) from which they had been derived. This comparison generated a comprehensive list of items where discrepancies in diagnostic parameters and treatment recommendations required expert opinion. Once finalised, the clinical algorithms and list of items (henceforth referred to as questionnaire) were piloted with two paediatricians with neonatal experience in LICs. Ambiguous items were amended accordingly.

Delphi technique
The questionnaire was circulated by email to the experts with specific instructions at least 2 weeks before they were interviewed. Each algorithm was verbally and diagrammatically explained with their references specified (ie, WHO, COIN or NeoTree research team) to aid in decision-making during the interview (online supplemental file 1). Round 1 interviews were conducted in June and July 2018. Experts were sent up to two reminder emails to schedule their phone or Skype interview. Interviews were conducted privately from a home office. Standardised questions were used to review each item from the questionnaire. Experts were asked to rate their level of agreement for including an item in an algorithm using a five-point Likert scale. A five-point scale was chosen because evidence suggests that a five-point scale appears to be less confusing than a seven-point scale and to increase expert response rate.18 Each rating was followed by open-ended questions to obtain the experts’ rationale for their response and any amendment or additional items they would propose. All interview data were transcribed using both audio recordings and notes made during the interview by the facilitator. All responses were anonymised (with participant numbers) and reviewed together with the quantitative results.

The upper limit of agreement among experts has been recommended to be set at 80% (4 or higher on the Likert scale) for Delphi studies.13 Due to our sample size, this upper limit was used to apply greater rigour to item inclusion. Items that met consensus (≥80% agreement) were included or were modified with minor changes to wording based on expert advice. Items that did not meet consensus (<80%) were removed or modified according to the feedback from the expert panel and submitted for the second round. Items that did not meet consensus
were still included if they were part of WHO and COIN guidelines so that frontline HCWs continued to follow the current standard of care. A second questionnaire was designed with modified items and expert additions from the first round (eg, inclusion of the Thompson encephalopathy score19).

In round 2 (June and July 2019), this second questionnaire was distributed electronically to the 14 experts from round 1 (online supplemental file 1). A results summary from round 1 was sent to the experts, and the full set of anonymised results were made available at their request. Two email reminders were sent to non-responders. Experts again rated items on a Likert scale and explained their ratings. Responses were analysed as described in round 1, and items meeting ≥80% consensus were kept for the final NeoTree algorithms.

Patient and public involvement

While key stakeholders were involved in codeveloping the NeoTree digital platform, there was no patient or public involvement in this Delphi study.

Consent procedures

The goals and processes of the project were explained to the experts in their email invitation, and consent was obtained by email agreement. Experts were verbally informed at the beginning of the first round that their responses would be kept anonymous.

RESULTS

Twenty-two neonatal experts were invited to participate. Sixteen responded; one declined due to lack of financial incentive, and one declined due to conflict of interest. All respondents had work experience in Africa; one respondent had over 20 years of clinical experience in Malawi and contributed to the development of the COIN guidelines. Demographics of the expert panel are listed in table 1.

Round 1

Fourteen experts (63% response rate) completed round 1. Interviews averaged 73 min (40–110 min). Thirty-four items (45%) reached consensus (figure 1). These items were either: (1) included, unmodified (32%); (2) included, modified (11%) or (3) changed for clarification in the second round (2%). Items that did not reach consensus (55%) were either: (1) excluded from the revised algorithm (30%); (2) included because they were part of WHO/COIN guidelines or the Thompson score (11%) or (3) changed and submitted for a second round (14%) (table 2).

The expert panel consistently stated that algorithm items must comply with WHO danger signs and COIN guidelines for neonatal sepsis, irrespective of whether the panel agreed with them. For example, experts thought ‘bulging fontanelle’ was ‘subjective; there are non-infectious causes … many babies’ fontanelles bulge when they just cry.’ Another item that did not meet consensus was ‘poor feeding,’ which experts found vague for multiple reasons, including: ‘it is too subjective; it depends on how long for … many newborns do not feed well on the first day of life.’ However, experts agreed that poor feeding was a sign of possible sepsis if it was ‘a new onset of poor feeding when the infant had previously been feeding well.’ This item was changed to ‘new onset of poor feeding’ for the final algorithm.

Two items that were included because they are part of the COIN guidelines highlighted inconsistencies with WHO guidelines. For example, COIN uses a temperature of more than 37.5°C as a fever for a newborn, while WHO and most experts use more than 38°C. Therefore, 37.5°C was included for the Malawian digital platform, but 38°C will be used for other countries. Other items where a difference between the recommendations and the guidelines occurred were antibiotic choice and duration for neonatal sepsis.

Modifications usually involved adopting the language used by WHO or COIN, but there were items that experts felt needed clarifying. For example, experts felt that ‘twitching or abnormal movements’ needed to be added to the WHO term ‘convulsions’ because seizures in a neonate can be very subtle. Certain items that could not be revised easily were submitted for the second round according to feedback from the expert panel. For example, experts disagreed that ‘very/extremely premature (<32

<table>
<thead>
<tr>
<th>Table 1 Characteristics of the Delphi panel from round 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Characteristics</strong></td>
</tr>
<tr>
<td><strong>Location</strong></td>
</tr>
<tr>
<td>Experts from HICs</td>
</tr>
<tr>
<td>Experts from LICs</td>
</tr>
<tr>
<td><strong>Level of expertise</strong></td>
</tr>
<tr>
<td>Neonatologist</td>
</tr>
<tr>
<td>Paediatrician</td>
</tr>
<tr>
<td>ANNP</td>
</tr>
<tr>
<td><strong>Years of neonatal experience following graduate degree (mean±SD)</strong></td>
</tr>
<tr>
<td>Overall</td>
</tr>
<tr>
<td>In LICs</td>
</tr>
<tr>
<td><strong>Work experience in LICs</strong></td>
</tr>
<tr>
<td>Africa</td>
</tr>
<tr>
<td>Asia</td>
</tr>
<tr>
<td>Central America</td>
</tr>
<tr>
<td><strong>Country of medical degree</strong></td>
</tr>
<tr>
<td>UK</td>
</tr>
<tr>
<td>USA</td>
</tr>
<tr>
<td>South Africa</td>
</tr>
<tr>
<td>Rwanda</td>
</tr>
<tr>
<td>Sudan</td>
</tr>
<tr>
<td>Zimbabwe</td>
</tr>
</tbody>
</table>

ANNP, advanced neonatal nurse practitioner; HICs, high-income countries; LICs, low-income countries.


Figure 1. Outcome of algorithm items after round one and round two of Delphi technique.

**ROUND ONE**

- Consensus achieved (≥80%) N = 34
  - No changes N = 24
  - MCTW N = 8
  - Expert opinion contradicts WHO/COIN N = 7
- Consensus not achieved (<80%) N = 41
  - Wording changed N = 5
- Items excluded N = 22

Included in NeoTree algorithm N = 40

Further clarification N=2

Round 2 N = 22
N = 13 plus new items N = 9
N = 11

**ROUND TWO**

- Consensus achieved (≥80%) N = 9
  - No changes N = 8
  - MCTW N = 1
- Consensus not achieved (<80%) N = 13
  - Straightforward change N = 3
- Items excluded N = 9

Included in NeoTree algorithm N = 13

Abbreviations: COIN = Care of the Infant and Newborn in Malawi; MCTW = minor changes to wording; WHO = World Health Organisation

Figure 1 Outcome of algorithm items after round 1 and round 2 of the Delphi technique. COIN, Care of the Infant and Newborn; MCTW, minor changes to wording.

weeks gestation)’ was a major risk factor for sepsis if ‘the baby was delivered as a clean cold caesarean section for maternal reasons and the mother was not in labour.’ Eighty per cent of experts highlighted that the algorithm should include weight to guide gestation because ‘gestation is often unknown’ and ‘you are relying on [the] Ballard score which has plus or minus 2 weeks accuracy.’ Similar opinions regarding method of delivery and the importance of birth weight were expressed for ‘slightly premature (32–36 weeks gestation).’ Both gestational age brackets were submitted into the second round as risk factors for sepsis after modifying the items to include WHO weight parameters to guide gestation.

Other items that did not gain consensus and were submitted for the second round included items that experts felt needed further clarification. ‘Born before arrival’ as a minor risk factor for sepsis was clarified to the experts that this meant the baby was born en-route to the hospital (either in a vehicle or on the roadside, both being considered dirty environments in Malawi). A ‘neonate admitted with or history of a fever’ as a minor risk factor for sepsis was changed to ‘mother reports a non-measured fever’ in the second round. Lastly, because experts considered the term ‘birth injury’ unclear, we asked them in round 2 to define what they considered a ‘significant birth injury.’
<table>
<thead>
<tr>
<th>Subject</th>
<th>Items</th>
<th>Agree, %</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sepsis</strong></td>
<td>Maternal fever &gt;38°C in labour</td>
<td>91</td>
<td>Include</td>
</tr>
<tr>
<td><strong>Diagnosis</strong></td>
<td>PROM &gt;18 hours</td>
<td>74</td>
<td>Include (WHO RF)</td>
</tr>
<tr>
<td><strong>Major RF</strong></td>
<td>Offensive smelling liquor</td>
<td>74</td>
<td>Include (WHO RF); MCTW</td>
</tr>
<tr>
<td></td>
<td>Very/extremely premature (&lt;32/40 weeks)</td>
<td>74</td>
<td>Second round</td>
</tr>
<tr>
<td></td>
<td>Prolonged second stage (&gt;3 hours)</td>
<td>53</td>
<td>Exclude</td>
</tr>
<tr>
<td><strong>Minor RF</strong></td>
<td>Prematurity (32–37 weeks gestation)</td>
<td>81</td>
<td>Second round</td>
</tr>
<tr>
<td></td>
<td>Born before arrival</td>
<td>70</td>
<td>Second round</td>
</tr>
<tr>
<td><strong>Major signs symptoms</strong></td>
<td>Grunting or severe respiratory distress or moderate-severe work of breathing</td>
<td>97</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>Lethargy</td>
<td>93</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>Red skin all around umbilicus</td>
<td>81</td>
<td>Include, MCTW</td>
</tr>
<tr>
<td></td>
<td>Jaundice &lt;24 hours old</td>
<td>83</td>
<td>Include, MCTW</td>
</tr>
<tr>
<td></td>
<td>Tachypnoea &gt;60 bpm (&gt;2 hours old)</td>
<td>83</td>
<td>Include, MCTW</td>
</tr>
<tr>
<td></td>
<td>Convulsions</td>
<td>89</td>
<td>Include, MCTW</td>
</tr>
<tr>
<td></td>
<td>Pustules all over body</td>
<td>80</td>
<td>Include, MCTW</td>
</tr>
<tr>
<td></td>
<td>Bulging fontanelle</td>
<td>77</td>
<td>Include (WHO danger sign)</td>
</tr>
<tr>
<td></td>
<td>Temperature &gt;37.5°C</td>
<td>73</td>
<td>Include for Malawi version</td>
</tr>
<tr>
<td></td>
<td>Admitted with or history of fever</td>
<td>68</td>
<td>Second round</td>
</tr>
<tr>
<td></td>
<td>History of apnoea</td>
<td>67</td>
<td>Exclude</td>
</tr>
<tr>
<td></td>
<td>Bilious vomiting</td>
<td>61</td>
<td>Second round</td>
</tr>
<tr>
<td><strong>Minor signs symptoms</strong></td>
<td>Tachypnoea 60–80 bpm and &lt;2 hours old</td>
<td>85</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>Pallor</td>
<td>81</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>Weak or absent suck (and &gt;34/40 weeks)</td>
<td>73</td>
<td>Exclude</td>
</tr>
<tr>
<td></td>
<td>Poor feeding</td>
<td>73</td>
<td>Include (WHO danger sign), MCTW</td>
</tr>
<tr>
<td></td>
<td>Irritability</td>
<td>70</td>
<td>Second round</td>
</tr>
<tr>
<td></td>
<td>Distended abdomen</td>
<td>67</td>
<td>Second round</td>
</tr>
<tr>
<td></td>
<td>Heart rate &gt;160 bpm that cannot be explained by fever/crying</td>
<td>64</td>
<td>Exclude</td>
</tr>
<tr>
<td></td>
<td>Mild work of breathing</td>
<td>55</td>
<td>Exclude</td>
</tr>
<tr>
<td><strong>Additional RF?</strong></td>
<td>Cut-off at 72 hours for early vs late neonatal sepsis?</td>
<td>100</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>Definition of maternal fever &gt;38°C?</td>
<td>93</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>Should PROM be &gt;18 hours or &gt;24 hours in LICs?</td>
<td>93</td>
<td>Include&gt;18 hours</td>
</tr>
<tr>
<td></td>
<td>Hypothermia &lt;35.5°C</td>
<td>83</td>
<td>Second round</td>
</tr>
<tr>
<td></td>
<td>Fever in a newborn should be classified as &gt;37.5°C in this setting?</td>
<td>83</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>Please comment on our weighting system of major=100% / Minor=50%</td>
<td>77</td>
<td>Exclude</td>
</tr>
<tr>
<td></td>
<td>Cut-off at &gt;34/40 weeks for absent suck as a sign of sepsis?</td>
<td>60</td>
<td>Exclude</td>
</tr>
<tr>
<td></td>
<td>Reduced movement of limbs</td>
<td>43</td>
<td>Exclude</td>
</tr>
<tr>
<td></td>
<td>Joint swelling</td>
<td>42</td>
<td>Exclude</td>
</tr>
<tr>
<td></td>
<td>Criteria for ‘consider meningitis’</td>
<td>42</td>
<td>Second round</td>
</tr>
<tr>
<td><strong>Management</strong></td>
<td>Do you agree with the antibiotic doses?</td>
<td>93</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>Do you agree with the specified sepsis investigations if possible?</td>
<td>83</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>Antibiotic duration for symptomatic sepsis=7–10 days?</td>
<td>83</td>
<td>Include (change to stop at day seven if clinically well)</td>
</tr>
<tr>
<td></td>
<td>Do you agree with the antibiotic choices if no local recommendation?</td>
<td>80</td>
<td>Include (add WHO choices)</td>
</tr>
<tr>
<td></td>
<td>Antibiotic duration for asymptomatic sepsis=5 days?</td>
<td>66</td>
<td>Include for Malawi, exclude for international</td>
</tr>
<tr>
<td><strong>Birth</strong></td>
<td>Resuscitation: BVM &gt;5 mins / CPR&gt;10 mins</td>
<td>94</td>
<td>Include</td>
</tr>
<tr>
<td><strong>Asphyxia</strong></td>
<td>Foetal distress</td>
<td>86</td>
<td>Include, MCTW</td>
</tr>
</tbody>
</table>

Continued
The second significant algorithmic finding was on HIE. An academic expert in neonatal encephalopathy discouraged the use of the term ‘birth asphyxia,’ a term used by Malawian HCWs and therefore incorporated into the original algorithm.

You really must not call it birth asphyxia because birth asphyxia means failing to breathe at birth and what you are talking about is encephalopathy.

Additional feedback on the algorithm focused on the combination of risk factors or clinical signs and symptoms to consider or diagnose HIE. Experts cited a lack of evidence for using risk factors to diagnose birth asphyxia...
and that the digital platform should only be using clinical signs and symptoms.

Birth asphyxia is not about risk factors. If you have encephalopathy, it is a clinical diagnosis, and it is irrelevant what your risk factors are.

Experts recommended using a validated encephalopathy score, which was incorporated into the HIE algorithm. The risk factors that met consensus may be used as prompts to perform the Thompson score, which uses clinical signs and symptoms exclusively to diagnose HIE.

Third, for the respiratory algorithm, experts highlighted that ‘It is hard to make an accurate diagnosis of a respiratory condition without investigations.’ Therefore, the algorithm should focus instead on the management of respiratory distress. All respiratory conditions (respiratory distress syndrome, meconium aspiration, congenital pneumonia and transient tachypnoea of the newborn (TTN)) now fall under the umbrella diagnosis of respiratory distress of the newborn within the algorithm. For teaching purposes, the four respiratory conditions will be included as ‘diagnoses to consider’ in the management.

Finally, for the hypothermia algorithm, experts commented that first-line treatment for all newborns be skin-to-skin care including those who were severely hypothermic (<32°C) unless they showed any signs or symptoms of being unstable. Additionally, experts did not think it was realistic to review a newborn every 15–30 min when hypothermic. No major revisions were made to the hypothermia algorithm.

**Round 2**

Ten (71%) experts completed round 2, seven electronically and three by telephone interview. Four experts dropped out (three from HICs, one from LIC); three did not respond to email reminders and one expert was unable to meet the completion deadline. Nine items (41%) reached consensus (figure 1). These items were either (1) included, unmodified (36%) or (2) included, modified in the revised algorithm (5%). Items that did not reach consensus (59%) were either (1) excluded

![Table 3](image)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Items                                                                 **</th>
<th>Agree, %**</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sepsis diagnosis</td>
<td>&lt;32/40 weeks gestation and/or &lt;1500 g</td>
<td>82</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>32–36/40 weeks gestation and/or 1500–2500 g</td>
<td>62</td>
<td>Exclude</td>
</tr>
<tr>
<td>‘Other’ RF</td>
<td>Babies born en route to the hospital</td>
<td>54</td>
<td>Exclude</td>
</tr>
<tr>
<td></td>
<td>Mother reports a non-measured fever</td>
<td>52</td>
<td>Exclude</td>
</tr>
<tr>
<td>Major sign</td>
<td>Bilious vomiting with severe abdominal distension</td>
<td>88</td>
<td>Include</td>
</tr>
<tr>
<td>‘Other’ sign/symptoms</td>
<td>Do you think a one-off T&lt;35.5°C should be added as a sign of neonatal sepsis in an LIC?</td>
<td>44</td>
<td>Exclude</td>
</tr>
<tr>
<td>Additional RF?</td>
<td>Swollen red eyelids with pus</td>
<td>88</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>Unconscious</td>
<td>86</td>
<td>Include, MCTW</td>
</tr>
<tr>
<td></td>
<td>Central cyanosis</td>
<td>78</td>
<td>Include (WHO danger sign)</td>
</tr>
<tr>
<td></td>
<td>Poor capillary refill or perfusion</td>
<td>68</td>
<td>Exclude</td>
</tr>
<tr>
<td></td>
<td>Does the baby look ill?</td>
<td>60</td>
<td>Exclude</td>
</tr>
<tr>
<td>Consider</td>
<td>Drowsy, lethargic or unconscious with T&gt;37.5°C</td>
<td>96</td>
<td>Include</td>
</tr>
<tr>
<td>Meningitis</td>
<td>Bulging fontanelle with T&gt;37.5°C</td>
<td>94</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>Irritability with a high-pitched cry with T&gt;37.5°C</td>
<td>92</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>Abnormal movements/twitching or convulsions with T&gt;37.5°C</td>
<td>90</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>Abnormal tone with T&gt;37.5°C</td>
<td>80</td>
<td>Include</td>
</tr>
<tr>
<td>HIE diagnosis</td>
<td>Do you agree with absent suck and gestation &lt;32/40 weeks as a sign of HIE?</td>
<td>42</td>
<td>Exclude</td>
</tr>
<tr>
<td></td>
<td>How should we describe ‘significant’ birth injury as a risk factor for HIE?</td>
<td>20</td>
<td>Exclude</td>
</tr>
<tr>
<td>RDN diagnosis</td>
<td>Do you agree with gestation &lt;34/40 for part of the diagnostic criteria for respiratory distress syndrome?</td>
<td>74</td>
<td>Include, change to WHO definition</td>
</tr>
<tr>
<td></td>
<td>Do you agree with coarse crackles (instead of unilateral crackles) for part of the diagnostic criteria for congenital pneumonia?</td>
<td>74</td>
<td>Include, change to WHO wording</td>
</tr>
<tr>
<td></td>
<td>Do you agree with T&gt;37.5°C or &lt;36.5°C for part of the diagnostic criteria for congenital pneumonia?</td>
<td>70</td>
<td>Include, change to expert suggestion</td>
</tr>
</tbody>
</table>

HIE, hypoxic ischaemic encephalopathy; LICs, low-income countries; MCTW, minor changes to wording; RDN, respiratory distress of the newborn; RF, risk factor; T, temperature.
Open access

Figure 2 Modification of the algorithms as a result of the Delphi technique. AB, antibiotics; BA, birth asphyxia; CPR, cardiopulmonary resuscitation; HAI, hospital-acquired infection; HIE, hypoxic ischaemic encephalopathy; LICs, low-income countries; MAS, meconium aspiration; RDN, respiratory distress of newborn; RDS, respiratory distress syndrome; RR, respiratory rate; TTN, transient tachypnoea of newborn.

(41%) or (2) included, modified according to WHO guidelines or expert suggestion (18%) (table 3).

In round 1, experts indicated that hypothermia was a major sign of sepsis and should be included in the sepsis algorithm if persistent. In round 2, we clarified that the digital platform is to be used at the time of admission onto the neonatal unit, at which point the HCW will only have one temperature reading. Experts in round 2 disagreed that a single temperature reading of <35.5°C was a sign of sepsis and felt that it would more likely be due to environmental hypothermia, a common problem in LICs. Additionally, in round 2, it was established that experts were much more concerned with extremely premature and/or ≤1500 g neonates (88% consensus) compared with slightly premature and/or 1500–2500 g neonates (62% consensus) being at risk for neonatal sepsis. Central cyanosis was an addition to the second round as an expert suggestion to include all WHO danger signs; despite missing consensus (with 78% agreement), it was ultimately included in the final sepsis algorithm to comply with WHO guidelines for danger signs.

All of the respiratory items marginally missed consensus. All three items were still included in the education sections of the digital platform with revisions in line with WHO diagnostic criteria. Modifications to the algorithms can be found in figure 2 and online supplemental file 2.

DISCUSSION

We report the use of a modified Delphi technique to review digital clinical pathway algorithms for four neonatal conditions managed by HCWs in LICs. Approximately two-thirds (62%) of the original algorithm items were ultimately included for use in the NeoTree digital platform based on consensus expert opinion and national/international guidelines. The NeoTree team revised the algorithms based on this feedback. Expert discussion emphasised gaps in evidence in neonatal care in LICs, highlighting areas for future research.

Each algorithm had components that triggered debate among the experts. For neonatal sepsis, three points were discussed. First, experts called for further evidence before adopting a ‘major’ and ‘minor’ algorithmic weighting system to diagnose neonatal sepsis. In response, the NeoTree research team are conducting a study in Zimbabwe and Malawi looking at which clinical indicators are predictors of positive blood cultures. Second, there was disparity in opinion regarding whether to give prophylactic antibiotics and the duration of antibiotics for newborns with risk factors for sepsis who remain clinically well without any supporting investigations (NeoTree’s equivalence to asymptomatic sepsis). The WHO recommendation to administer prophylactic antibiotics for a neonate with maternal risk factors for sepsis is considered
weak with very low-quality evidence.\textsuperscript{22} Despite reaching a consensus on particular risk factors (prolonged rupture of membranes, maternal fever), experts also highlighted the evidence base as weak. In terms of duration of treatment for asymptomatic sepsis, while expert opinion varied, the Malawian guidelines recommend a 5-day course\textsuperscript{11} while WHO recommends 2 days.\textsuperscript{15} The NeoTree algorithms will therefore keep to local and international recommendations, but the NeoTree team will feed back to the Malawian COIN expert panel that consensus suggested 5 days is too long to treat newborns with sepsis risk factors only. Third, experts disputed the treatment choice and duration for symptomatic neonatal sepsis; incidentally, WHO recommendations lack strong evidence or efficacy.\textsuperscript{17}

For the HIE algorithm, the Thompson score was preferred because it is simpler to perform, less time consuming and better at predicting poor outcomes in moderate and severe HIE during the first hours of life compared with the Sarnat score at 24 hours.\textsuperscript{19} The NeoTree research team suspected that measures such as examining for posturing and Moro reflex would be relatively complicated for frontline HCWs with minimal training to assess. However, neonatal experts’ experience and previous studies in LICs\textsuperscript{23} assured the team that the score is relatively straightforward to teach.

Several points of discussion also centred on the respiratory algorithms. First, experts noted that even with investigations in HICs respiratory conditions may be difficult to diagnose.\textsuperscript{24} Second, despite experts’ concerns about antibiotic overprescribing in LICs and the need to differentiate TTN from other respiratory conditions, they did not think this was currently feasible in LICs due to limitations in HCW capacity, resources and knowledge. Thus, experts agreed that all neonates with signs of respiratory distress should have respiratory support and antibiotics. A recent study justified the use of antibiotics for tachypnoea alone in a neonate in a resource-limited setting.\textsuperscript{25} Third, experts recommended performing chest X-rays (if available) only if imaging would change management (eg, a longer course of antibiotics for congenital pneumonia) or if the neonate was deteriorating.

With the proliferation of clinical digital platforms in HICs and LICs, there is growing concern with the quality and safety standards of their clinical guidance. Countries and organisations (including WHO) are now taking measures to ensure application developers fulfil a strict set of criteria to protect patients.\textsuperscript{26} While the Delphi technique can establish expert consensus, it may also strengthen the safety and quality standards of clinical algorithms. This technique has been widely used in developing paper-based neonatal clinical guidelines in HICs and LICs.\textsuperscript{57-29} There are also studies that have used the Delphi technique to develop items used in m-health tools.\textsuperscript{30-32} Our study is unique in the application of this technique to develop algorithms on a digital platform specific to neonatal care in low-resource settings.

This study has several limitations. The choice of using a modified two-step Delphi process meant that a final face-to-face meeting was not possible, which may have prevented some exchange of important information to clarify differences in expert opinion. However, this method allowed for the contributions of geographically dispersed experts, maintained their anonymity and prevented them from conforming to other experts. The recruitment of more experts from HICs (64%) compared with LICs (36%), despite originally inviting equal numbers to participate, could have contributed to expert panel bias. We invited three Malawian clinicians as experts; the absence of their input could be another limitation, since the algorithms had initially been contextualised to the Malawian setting. However, the end goal of NeoTree development is to be applicable in a wide range of resource-limited settings; therefore, experts with a broad geographical range of clinical experience were recruited. Drop-outs from the first to the second round could have affected the consensus level and contributed to attrition bias.

Some factors may have contributed to selection bias. The Delphi process is time intensive, which could have meant that those clinicians who are busier with perhaps even more clinical expertise or those with limited internet access (mainly LICs) could not participate. Additionally, offering a financial incentive might have obtained a more equal representation of experts. Another drawback of the Delphi being a labour-intensive process was that a year elapsed between the two rounds. Experts may have forgotten the algorithms and items from the first round in the second round if they did not read the summary of results or refresh their knowledge of the algorithms. Experts reported that they found the layout of the second questionnaire confusing; a redesign contributed to delays.

This study used the Delphi technique to refine four clinical decision algorithms in a neonatal digital platform designed for HCWs in LICs to standardise and improve the quality of newborn care. The key to implementing the NeoTree algorithms in other LICs will be to demonstrate that clinical algorithms in a digital platform versus paper-based guidelines can aid HCWs in making faster, more accurate diagnoses and provide better, more cost-effective treatment that will ultimately improve the quality of newborn care and reduce mortality. This will require a large-scale clinical-trial evaluation. Ultimately, with consensus opinion shaping the algorithms of this digital platform, accurate data capture, immediate clinical assessment and optimal medical care may be achieved to improve neonatal outcomes.

**Acknowledgements** We thank all the participants of the Delphi surveys for their invaluable contributions to refine the clinical algorithms and highlight open questions, including Dr Helen Brotherton, Dr Simbarashe Chimhuya, Dr Cathy Harrison, Dr Tyler Hartmann, Dr Hammad Khan, Dr Camilla Kindgon, Dr Tom Lissauer, Dr Azza Mashumba, Kathy Mellor (MBE), Professor Elizabeth Molyneux, Dr Cally Tann, Dr Clifff O’Callahan, Susan Quinton, and Dr Raissa Teteli. We would also like to thank Dr Brian Corden and Dr Alice Myers for their reviews of the manuscript.

**Contributors** CC led the development of the original algorithms refined in this paper, supervised by MH.ME, CC and MH conceived the study, generated the
methodology and designed the questionnaires. ME conducted the interviews and analysed the data. MMN and MHC produced the first draft and contributed equally to this manuscript. CC, FF and MH provided edits and comments to the draft. All authors reviewed and approved the final version of the manuscript.

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**Competing interests**  CC and MH are cofounders of the NeoTree platform and continue to conduct research related to its development. FF and MH are trustees of the NeoTree Foundation. The NeoTree platform is a not-for-profit product; none of the coauthors benefit financially.

**Patient consent for publication**  Not required.

**Ethics approval**  Ethics approval was not required for this study according to the University College of London Research Ethics Committee.

**Provenance and peer review**  Patient consent for publication is not required.

**Data availability statement**  Data are available on reasonable request. All data relevant to the study are included in the article or uploaded as online supplemental information.

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2. Lawn JE, Blencowe H, Oza S. Every newborn: progress, priorities, and potential beyond survival. Lancet 2014;384:189–205.
Round one questionnaire

NeoTree questions on algorithms for expert review

Prior to each of these algorithms the user of the NeoTree must complete the emergency triage section. This section ensures that the baby is resuscitated as per Helping Babies Breathe, guiding the user to check for danger signs. Any abnormal parameters entered trigger immediate prompting to give appropriate resuscitation before addressing these diagnoses. Included in this will be a blood sugar measurement.

Section 1. Neonatal Sepsis

Summary of sepsis algorithm

For this part of the algorithm please assume you have the following equipment/resources:

- the NeoTree application on a tablet device
- a pulse oximeter
- a thermometer
- a clock
- a stethoscope
- oxygen
- bubble CPAP

Please assume, however, that you are working in an environment where there is no availability for blood cultures, inflammatory markers, white cell count, or chest x-ray. Lumbar puncture is available for gram stain, protein and cell count only. In the future these investigations may become more widely available in newborn facilities, and there is the potential to add these extra parameters to the NeoTree algorithm. But currently, when we say 'sepsis' we mean presumed sepsis that cannot be confirmed with laboratory investigations.

Within the NeoTree algorithm, the diagnosis of sepsis is divided into 4 categories according to the presence or absence of signs/symptoms and/or risk factors and the age of the newborn (Flowchart 1). In order to account for different levels of risk we have weighted both signs/symptoms and risk factors as ‘MAJOR’ or ‘MINOR’ according to COIN / WHO / best judgement. A MAJOR sign/symptom is weighted twice as heavily as a MINOR one, so that, for example, in the diagnosis of symptomatic sepsis either 1 MAJOR sign/symptom or 2 MINOR signs/symptoms will trigger the diagnosis. For asymptomatic sepsis only, risk factors are required. We have used a similar weighting system for risk factors.
Any major SIGNS/SYMPTOMS of sepsis?

N

Any minor SIGNS/SYMPTOMS of sepsis?

0 or 1

Any major RISK FACTORS for sepsis?

N

Any minor RISK FACTORS for sepsis?

0 or 1

Sepsis unlikely

Asymptomatic sepsis
(5 days of IV antibiotics)

≤ 72 hrs old

EONS - Asymptomatic

> 72 hrs old

LONS - Asymptomatic

Symptomatic sepsis
(7-10 days of IV antibiotics)

≤ 72 hrs old

EONS - Symptomatic

> 72 hrs old

LONS - Symptomatic

Flowchart 1: Categories of sepsis are divided by presence (symptomatic) or absence (asymptomatic) of signs/symptoms and by age of newborn
<table>
<thead>
<tr>
<th><strong>MAJOR risk factors</strong></th>
<th><strong>MINOR</strong> risk factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Maternal fever &gt;38°C in labour *+</td>
<td>1. Born before arrival (BBA)~</td>
</tr>
<tr>
<td>2. Offensive liquor*+</td>
<td>2. Prematurity (32-36/40 weeks gestation) (N.B in the app you can only round to the closest week i.e 36 or 37 weeks)~</td>
</tr>
<tr>
<td>3. Prolonged rupture of membranes (PROM) &gt;18 hrs*+</td>
<td></td>
</tr>
<tr>
<td>4. Prolonged second stage (&gt;3 hrs of active pushing)*</td>
<td></td>
</tr>
<tr>
<td>5. Very / extremely premature (&lt;32/40 weeks gestation)~</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>MAJOR signs/symptoms</strong></th>
<th><strong>MINOR</strong> signs/symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Temperature &gt;37.5°C*</td>
<td>1. Mild work of breathing~</td>
</tr>
<tr>
<td>2. Pustules all over body*+</td>
<td>2. Tachycardia (HR&gt;160) that can’t be explained by fever or crying~</td>
</tr>
<tr>
<td>3. Boil/abscess*+</td>
<td>3. Tachypnoea 60-80 bpm*+ at &lt;2hrs old~</td>
</tr>
<tr>
<td>4. Red skin all around umbilicus*+</td>
<td>4. Pallor+</td>
</tr>
<tr>
<td>5. Grunting or severe respiratory distress/mod-severe work of breathing*+</td>
<td>5. Abdominal distension~</td>
</tr>
<tr>
<td>6. History of apnoea~</td>
<td>6. Poor feeding/vomiting+</td>
</tr>
<tr>
<td>7. Jaundice &lt;24 hrs old+</td>
<td>7. Weak or absent suck (AND gestation &gt;34 weeks)~</td>
</tr>
<tr>
<td>8. Tachypnoea &gt;60°+ (except 60-80 bpm at &lt;2hrs old)~</td>
<td>8. Irritability*+</td>
</tr>
<tr>
<td>9. Convulsions+</td>
<td></td>
</tr>
<tr>
<td>10. Lethargy+</td>
<td></td>
</tr>
<tr>
<td>11. Bilious vomiting~</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td></td>
</tr>
</tbody>
</table>

bpm = breaths per minute, HR = heart rate

Notes: Source/Evidence used: *COIN, +WHO, ~NeoTree team best judgement

### Consider Meningitis:

For the following scenarios the NeoTree will ask the health care worker (HCW) to consider meningitis:

- Temp >37.5°C* AND any of
  - Bulging Fontanelle*+
  - Hypertonia+
  - Persistent irritability*+
  - Lethargy*+

OR

- Convulsions*+ / History of convulsions*
- Hydrocephalus (obviously enlarged head or OFC >37cm)~

Notes: Source/Evidence used: *COIN, +WHO, ~NeoTree team best judgement

### Explanatory notes for Sepsis algorithm:

- Regarding work of breathing, for the sake of simplicity the NeoTree algorithm asks the user to observe the work of breathing and rate it as mild, moderate or severe with the aid of educational videos on the app. There is the potential to include a validated respiratory distress score in future iterations.

- Hypothermia has not been included as a sign of sepsis due to the high rates of environmental hypothermia on admission in these settings. Persistent hypothermia despite warming may be included in future iterations.
We have separated mild tachypnoea of 60-80 in ages <2 hours into the minor signs/symptoms so that if it exists without any other signs/symptoms or risk factors it can have the diagnosis of transient tachypnoea of the newborn rather than sepsis.

**Sepsis diagnosis questions:**

<table>
<thead>
<tr>
<th>Question</th>
<th>Disagree</th>
<th>Agree</th>
<th>Discuss responses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Do you agree with the following MAJOR risk factors?</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Maternal fever &gt;38 °C in labour</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Offensive liquor</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. PROM &gt;18 hours</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Prolonged second stage (&gt;3 hours of active pushing)</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Very / extremely premature (&lt;32/40 weeks gestation)</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2. Do you agree with the following MINOR risk factors?</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Born before arrival (BBA)</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Prematurity (32-36/40 weeks gestation)</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3. Do you agree with the following MAJOR signs/symptoms?</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Temperature &gt;37.5 °C</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Admitted with or history of fever</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Pustules all over body</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Boil/abscess</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Red skin all around umbilicus</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Boil/abscess</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Grunting or severe respiratory distress or mod-severe WOB</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. History of apnoea</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Jaundice &lt;24 hours old</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. Tachypnoea &gt;60 bpm (except 60-80 &amp; &lt;2 hours old)</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k. Lethargy</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l. Convulsions</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m. Bilious vomiting</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>4. Do you agree with the following MINOR signs/symptoms?</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Mild work of breathing</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Tachycardia that can’t be explained by fever/crying</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Pallor</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Distended abdomen</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Poor feeding/vomiting</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Weak or absent suck (AND gestation &gt;34 weeks)</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Irritability</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. Tachypnoea 60-80 bpm &amp; &lt;2 hrs old</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5. Are there any additional risk factors, signs or symptoms that you think should be included for a low-income setting? For example...</strong></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>a. Hypothermia &lt;35.5 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| b. Joint swelling (NB NeoTree is more immediate mx).
| c. Reduced movement of limbs |   |   |   |   |
| Y/N, if yes Maj/Minor |   |   |   |   |
| Y/N, if yes Maj/Minor |   |   |   |   |
| Y/N, if yes Maj/Minor |   |   |   |   |
| 6. If you have not already stated. Should any of the risk factors or signs and symptoms be MAJOR or MINOR? |   |   |   |   |
| 7. Do you agree with the cut off from 72 hours for early and late neonatal sepsis? | 1 | 2 | 3 | 4 | 5 |
| 8. Do you agree with the definition of maternal fever being >38 degrees °C? | 1 | 2 | 3 | 4 | 5 |
| 9. Should PROM be >18 hours or >24 hours in this setting? | 18 hours = 1 | 2 | 3 | 4 | 5 |
| 10. Do you agree that fever in a newborn should be classified as >37.5 °C in this setting? | 1 | 2 | 3 | 4 | 5 |
| 11. Do you agree with the cut-off at 34 weeks gestation for the ‘no suck’ in a non-prem sepsis sign? | 1 | 2 | 3 | 4 | 5 |
| 12. Please comment on our weighting system of Major = 100%, Minor = 50% |   |   |   |   |
| 13. Please comment on the criteria for ‘Consider meningitis’ |   |   |   |   |

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Management of Sepsis:

Box 1. Management page for Sepsis in NeoTree:

**IV access**
Get IV access
*If possible*, perform sepsis screen
Sepsis screen: FBC, CRP, Blood Culture, +/- Lumbar Puncture
(CRP is C-reactive protein a marker of infection available in some labs)

**Antibiotics**
Start antibiotics according to local guidelines. If no guidelines give:
- Penicillin 50,000 iu/kg 12 hourly IV/IM and
- Gentamycin 3 or 5 mg/kg/dose 24 hourly IV/IM (LBW or Term)
Length of antibiotics treatment:
  a) Asymptomatic sepsis, treat for 5 days
  b) Symptomatic sepsis, treat for 7-10 days
Frequency of penicillin is 6 hourly if >7 days age
Use Flucloxacillin and Gentamycin if skin infection or pustules

**Supportive care**
Thermoregulation: aim for temperature between 36.5 - 37.5 °C
If baby has fever remove from warmer and unwrap
Provide oxygen or CPAP as needed according to TRY CPAP algorithm
Check blood glucose and provide feeding support as needed
  - Consider 10ml/kg fluid bolus if shocked as per SHOCK algorithm
  - Consider 2.5mls/kg 10% dextrose if BS <2.5 mmol or 45 mg/dl – as per HYPOGLYCAEMIA algorithm

*Source/Evidence used: *COIN

- The NeoTree antibiotic management guidelines for sepsis follows the Malawi COIN guidelines. The NeoTree recommends 5 days of IV antibiotics for asymptomatic sepsis and 7-10 days for symptomatic sepsis.
Sepsis management questions:

Table 3. Sepsis management questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Disagree</th>
<th>Agree</th>
<th>Discuss responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Do you agree with the specified sepsis investigations if possible?</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2. Do you agree with the antibiotic choices and doses if no local recommendation?</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3. Do you agree with antibiotic duration?</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>a) Asymptomatic sepsis = 5 days</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>b) Symptomatic sepsis = 7-10 days</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
Section 2. Birth Asphyxia

Summary of Birth Asphyxia algorithm:

We have divided the diagnosis of birth asphyxia into 2 categories according to the presence or absence of risk factors or signs/symptoms in Table 4:

A. Consider birth asphyxia = 1 risk factor AND 1 sign/symptom of birth asphyxia
B. Birth asphyxia = either
   2 or more risk factors AND 1 sign/symptom OR
   No known risk factors AND 2 or more signs/symptoms

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>Signs/Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Foetal distress*</td>
<td>• Absent suck AND &gt;34/40 gestation~</td>
</tr>
<tr>
<td>• Prolonged second stage*</td>
<td>• Hypotonia AND &gt;34/40 gestation~</td>
</tr>
<tr>
<td>• Delivery = Vacuum / EmCS / Breech~</td>
<td>• Irritable*+</td>
</tr>
<tr>
<td>• Apgar at 5 mins &lt;7+</td>
<td>• Lethargy*+</td>
</tr>
<tr>
<td>• Resuscitation: BVM for &gt;5 mins* / CPR* / resuscitated for &gt;10 mins~</td>
<td>• Coma*+</td>
</tr>
<tr>
<td>• Birth injury~</td>
<td>• Convulsions*+</td>
</tr>
</tbody>
</table>

EmCS = Emergency caesarian section, BVM = Bag valve mask ventilation, CPR = Cardio pulmonary resuscitation, BW = birth weight.

Evidence/Source used: *COIN, +WHO, ~NeoTree team best judgement
Birth asphyxia diagnosis questions:

<table>
<thead>
<tr>
<th>Questions</th>
<th>Disagree</th>
<th>Agree</th>
<th>Discuss responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Do you agree with the diagnostic criteria for:</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. ‘Consider birth asphyxia’</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. ‘Birth asphyxia’</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Do you agree with the following risk factors for birth asphyxia?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Foetal distress</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Prolonged second stage &gt;3 hours duration</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Delivery = Vacuum / EmCS / breech</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Apgar at 5 mins &lt;7</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Resuscitation: BVM &gt;5 mins / CPR lasted &gt;10 mins</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Birth injury</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Do you agree with the following signs/symptoms for birth asphyxia?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Absent suck and gestation &gt;34/40</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Hypotonia and gestation &gt;34/40</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Irritable</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Lethargy</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Coma</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Convulsions</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Should birth asphyxia be classified as mild, moderate or severe?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Do you think the following sign/symptoms and risk factors should be included?</td>
<td>Y/N</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
<tr>
<td>a. Poor feeding</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Respiratory distress</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. &gt;4kg</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Are there any other risk factors or signs/symptoms to be added/removed?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Due to the difficulties of training HCW in checking safely for the Moro reflex in these settings we have removed from the assessment. Do you agree?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Box 2: Management page for Birth Asphyxia in NeoTree:

1. **Keep warm**
   KMC/radiant warmer
   (Unless the patient is hyperthermic)

2. **Respiratory support**
   Put on appropriate respiratory support

3. **Feeding support, anticonvulsants and antibiotics**
   Mild/Moderate:
   - Give NG feeds- most will have a poor suck reflex
   - Mother can still offer breast to develop the suck reflex
   - Check blood sugar (BS) and give 10% dextrose bolus if BS <2.5mmol/L or <45mg/dL

   Severe: where NG feeds are not tolerated, consider IV fluids.
   If evidence of seizure activity give **PHENOBARBITONE** as per convulsions page.

   Reassess suck, tone, coma, seizures every 8 hours for 72 hours in hospital
   Treat for sepsis with antibiotics

**Convulsions page in NeoTree:**

- Load phenobarbitone 20 mg/kg
- If seizures ongoing can reload twice
- Start 5 mg/kg maintenance (24 hours after loading dose)
- Stop phenobarbitone at 72 hours if no further seizures and neurologically normal

*Source/Evidence used: *COIN*

**Management of Birth Asphyxia questions:**

<table>
<thead>
<tr>
<th>Table 7. Management of Birth Asphyxia questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questions</td>
</tr>
<tr>
<td>Do you agree not to do passive cooling for infants in low resource settings?</td>
</tr>
<tr>
<td>Should the newborn be given IV fluids if not tolerating oral or NG feeds?</td>
</tr>
</tbody>
</table>
Section 3. Respiratory distress of the newborn (RDN)

Summary of the RDN algorithm:

For this part of the algorithm please assume you have the following equipment/resources:

- the NeoTree application on a tablet device
- a pulse oximeter
- a thermometer
- a clock
- a stethoscope
- oxygen
- bubble CPAP

Please assume, however that you do not have chest x-ray available to you. We have divided this diagnosis into the following 4 categories:

1. Meconium aspiration
2. Respiratory Distress Syndrome (RDS)
3. Congenital pneumonia
4. Transient Tachypnoea of Newborn

Flowchart 2: RDN diagnostic algorithm

MAS = Meconium aspiration, PROM = prolonged rupture of membranes, RDN = Respiratory Distress of Newborn, RDS = Respiratory distress syndrome, RR = Respiratory rate, TTN = Transient Tachypnoea of Newborn, Y = Yes, N = No.
Table 8. Signs/ Symptoms for RDN

- Grunting or severe recessions or moderate-severe work of breathing*
- Blue~ / cyanotic*
- Apnoea~
- History of fast or laboured breathing+
- History of noisy breathing~
- Saturations in air or oxygen <90%~
- Bilateral wheeze or crackles on auscultation+
- History of cough (only included in algorithm for congenital pneumonia)~

Source/Evidence used: *COIN, +WHO, ~NeoTree team best judgement

RDN diagnosis questions:

Table 9: RDN diagnostic algorithm questions

<table>
<thead>
<tr>
<th>Questions</th>
<th>Disagree</th>
<th>Agree</th>
<th>Discuss responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Do you agree that on admission a 'history' of fast or laboured breathing or noisy breathing is relevant as a sign or symptom of RDN when not present on admission?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Do you agree that tachypnoea of 60 - 80bpm &lt;2 hours old without signs or symptoms of sepsis should be treated as TTN, and no antibiotics given?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Do you agree with tachypnoea of &gt;60 for the other categories of RDN</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Are there any other signs/symptoms to be removed or to be considered?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Do you agree with the diagnostic criteria for:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) MAS?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) RDS?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) TTN?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) Congenital pneumonia?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Are there any other risk factors to be considered? For example: Diabetic mother for MAS and RDS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RDN Management:

We have presented the management for all 4 types of Respiratory distress of the newborn in one management page; however, in reality they each get an individual page in the app. NB. RDN – unspecified would be treated as per the ‘GENERIC’ section.
Box 3: Management page for Respiratory Distress of the Newborn (RDN):

Includes generic advice common to all 4 sub-diagnoses. Relevant disease specific advice is also included and specified below

**GENERIC:**
- Airway and respiratory support
- Position airway & suction
- If saturations <90% in air put on oxygen+
- If >1kg consider CPAP according to TRY algorithm
- Feeding support
- If breathing 60-80 bpm use cup/NGT
- If needing CPAP use OGT
- If breathing >80bpm consider IV fluids
- IV Access for Antibiotics
- Give antibiotics (except if TTN)

**MECONIUM ASPIRATION**
- Think – is this really meconium aspiration?
- Just because there was meconium at delivery doesn't mean it was aspirated.
- Most aspiration occurs in utero before the baby is born, so more likely if there was foetal distress in the labour, if the baby is sick with respiratory distress or has signs of birth asphyxia. Floppy babies with severe HIE and meconium aspiration are unlikely to benefit from CPAP.

**TTN**
- These babies are not unwell
- RR is usually between 60-80 bpm and they don't usually need oxygen
- This should resolve in the first few hours of life.
- TTN is more likely following elective C-section due to wet lungs
- Does not need antibiotics unless tachypnoea persists.

**RDS**
- Consult local guidelines for how to give CPAP

**CONGENITAL PNEUMONIA**
- Before commencing antibiotics consider a full sepsis screen but don't let this delay giving antibiotics.

*Source/Evidence used: *COIN, +WHO, ~NeoTree team best judgement*
Management of RDN questions:

### Table 10: Management of RDN questions

<table>
<thead>
<tr>
<th>Questions</th>
<th>Disagree</th>
<th>Agree</th>
<th>Discuss responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Do you agree with a cut off of 90% oxygen saturations before giving oxygen?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Do you agree to give antibiotics in all cases except TTN?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Do you agree with the time cut-off of at 2 hours for TTN? Would you have a higher or lower threshold?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. If it is possible to perform a CXR when and how would you recommend?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Please give any other comments or opinions of the above.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section 4. Hypothermia

Box 4: Hypothermia management page in NeoTree:

Mild = 36 - 36.4°C+
Mod = 32 - 35.9°C+
Severe = <32°C+

1. Warm the baby
   Mild: Skin to skin (KMC position)+
   Moderate/severe: place on warmer/resuscitaire~

2. Limit heat loss
   Make sure the baby is dry+
   Put on a hat and wrap up the baby+
   If on the resuscitaire put the sides up~
   Ensure room is free from drafts- windows and doors closed+
   The 4 ways by which a baby can lose heat are:+

3. Monitor
   Measure temperature every 15-30 minutes~
   Watch out for overwarming+
   Complete NeoTree assessment to assess for signs of
   infection, apnoea and hypoglycaemia*

Evidence/Source: *COIN, +WHO, ~NeoTree team best judgement
Hypothermia questions:
We have not included an algorithm for hypothermia here, as it is simply the diagnostic criteria stated at the top of the thermoregulation management page.

**Table 11: Hypothermia questions**

<table>
<thead>
<tr>
<th>Questions</th>
<th>Disagree</th>
<th>Agree</th>
<th>Discuss responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Do you agree with the diagnostic criteria for hypothermia?</td>
<td>1</td>
<td>2</td>
<td>3 4 5</td>
</tr>
<tr>
<td>2. Should we add more detail on ongoing management?</td>
<td>1</td>
<td>2</td>
<td>3 4 5</td>
</tr>
<tr>
<td>3. Any other comments?</td>
<td>1</td>
<td>2</td>
<td>3 4 5</td>
</tr>
</tbody>
</table>

**References**


Round two questionnaire

For items that did not reach a consensus (<80% agreement) the questions have been:

1. Removed
2. Kept because part of WHO or Malawian neonatal (COIN) guidelines
3. Changed and submitted below for a second round

For items with a consensus (>80% agreement) we have kept or changed to WHO wording on expert advice.

Please score the new items using the Likert scale of 1 (strongly disagree) to 5 (strongly agree) and provide comments for those items that you disagree with. Please read expert responses from round 1 for each item to aid your response for the second round.

Section 1. Neonatal Sepsis

Sepsis diagnosis questions

We did not reach a consensus on our major and minor weighting system approach to diagnosing neonatal sepsis, and we cannot come to a decision until we have done our clinical validation study and collected data from Zimbabwe study using blood cultures to identify which risk factors are most strongly predictive of sepsis. However, we would still like to explore the usefulness for ‘other’ risk factors to be included alongside the WHO and COIN danger signs.

1. Do you agree with the following ‘other’ risk factors for neonatal sepsis?

   A. Born before arrival (BBA)

Expert responses

I would never consider this a risk factor in a high resource setting for sepsis but in a low resource setting where you have no clue where or how the baby was born, what equipment was used and what the circumstances where I can see this as a risk factor.

I don’t know this as a risk factor. I hesitate because there is so much controversy with that statement and we had a lot of discussion about this in Rwanda.

I guess there is then uncertainty with all the maternal risk factors. So yes, I agree but I don’t think there is any evidence behind it but I can see the logic.

It depends where. Yes, is they were born at home and un-booked mothers who have not had antenatal care but not if born in another facility.

Depends on where they were born and who delivered/cut the cord

It depends where the baby has been born. Quite a lot of babies are born outside the hospital and that would be mean every baby would need antibiotics.

I disagree. Is this to the hospital? I will have to disagree here because depending on where you live most babies do not even come to the hospital.

Traditionally this is what people have done but I don’t get very excited about it and I advise to follow the WHO guidelines.
<table>
<thead>
<tr>
<th>Original question</th>
<th>% agreement</th>
<th>Action taken</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Born before arrival (BBA)</td>
<td>64%</td>
<td>Change for COIN, Remove for international use</td>
<td>▪ BBA means that the baby was born in a vehicle (car, ambulance etc) or the roadside in Malawi which are considered dirty environments. ▪ Not included in WHO or COIN guidelines</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New proposed question</th>
<th>Indicate level of agreement</th>
<th>Your thoughts/comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Babies born en route to the hospital</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

B. Prematurity (32-36/40 weeks gestation)

Expert responses

If the baby was delivered as a clean cold caesarean section for maternal reasons and the mother was not in labour then antibiotics should not be given. However, if the baby was born spontaneously premature then they should be given antibiotics.

There was a study done recently in Tanzania, Professor Lindberg. Initially they had everyone on antibiotics and then they excluded the mothers who had caesarean sections for maternal reasons. They spoke about antibiotics being given to the mother and the fetus for 48 hours. Gestation should also be given as weight.

Usually gestation is reported in months not weeks.

Gestation is often unknown. Every baby was treated as sepsis in Zambia. Every baby had a cannula on the neonatal unit which was a risk of infection alone. Too many babies were getting antibiotics. Every mother who had a GA their babies was admitted to the neonatal unit, a cannula sited and antibiotics were given. There was no thought process at all.

Gestation is not very useful, I only ever see 28 weeks, 32 weeks or term documented. Weight and gestation are more useful < 1.5 kg preterm, < 1kg very preterm. 1.5-2 kg could be growth restriction.

Gestation should be in combination with weight as they often don't know the gestation.

It is nice to have weight and gestation. Often prematurity is not recognised as it should be so weight is useful to highlight prematurity.

You are better off using weight for gestation.

The simpler you make things the more effective they are. You are replying on ballard score which has +/- 2 weeks accuracy. So, a 31 weeker could fit into either category. I think you should just have prematurity just as a major risk factor.

Again, weight rather than gestation and low birth weight baby as a risk factor instead of prematurity and make it a major risk factor.
Agree for spontaneous but not for maternal reasons. Need to have weight and gestation/Ballard.

You need to have weight as well but they may be growth restricted and not premature but it is probably not a bad idea to have both premature and IUGR babies on antibiotics.

Add weight because sometimes the gestation is not known

I guess this is ok for one minor risk factor but I would also include weight to guide gestation.

I think my general comment would be the danger signs for WHO and the danger signs for essential care for every baby and essential care for small babies are the same. Those are probably the ones I would use to treat with antibiotics and not to treat with antibiotics.

Again, use weight. The weight is more useful than gestation. Being SGA is probably more important than premature.

<table>
<thead>
<tr>
<th>Original question</th>
<th>% agreement</th>
<th>Action taken</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Prematurity</td>
<td>71%</td>
<td>Change to include weight for gestation</td>
<td>▪ The application developers are trying to distinguish whether you are concerned with all premature babies being at risk of infection or just extreme (&lt; 32/40) or slightly (32-26 weeks) preterm ▪ Not included in WHO or COIN guidelines</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New proposed question</th>
<th>Indicate level of agreement</th>
<th>Your thoughts/ comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;32/40 weeks gestation or &lt;1500g</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>32-36/40 weeks gestation or 1500-2500g</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

C. Admitted with or history of fever – this question was originally asked as a MAJOR (DANGER) sign/symptom

Expert responses

I disagree. It needs to be repeated

It should be a minor risk factor

I agree. I would take it seriously if a mother reported that the baby had a fever because that is very unusual.

You need to say two temperatures or persistent.

There are so many mothers who over wrap their infants
I would monitor the baby. It should be a minor risk factor.

I disagree. This depends on whether the baby is going to be admitted for observation or not. Actually, I would read the reading myself because the rate of poor thermometers readings in developed countries is really high let alone in undeveloped countries so they would give every baby antibiotic. I am biased because I disagree with some of the WHO’s stance on even the danger signs. I think they are too general, too many kids get antibiotics that do not need to. If you look at work done published in Rwanda, Kosovo and other countries, it’s just that the antibiotic resistance rate is so high and kids are getting treatment that is unnecessary. So, I am going to lean probably most towards non-treatment than treatment.

I agree if this is the WHO or local guideline

<table>
<thead>
<tr>
<th>Original question</th>
<th>% agreement</th>
<th>Action taken</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. Neonate admitted with or history of fever</td>
<td>57% agreement as a MAJOR risk factor</td>
<td>Change to ‘other’ risk factor and change wording</td>
<td></td>
</tr>
<tr>
<td>New proposed question</td>
<td>Indicate level of agreement</td>
<td></td>
<td>Your thoughts/comments</td>
</tr>
<tr>
<td>Mother reports a non-measured fever</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Do you agree that the following is a DANGER/MAJOR sign or symptoms for neonatal sepsis?

**Bilious vomiting**

It could be a surgical reason and not sepsis.

In low resource settings yes we would start antibiotics

Definitely

Not alone.

It is a problem but I would not jump to sepsis.

It is a minor risk factor and it needs to be persistent to be major.

You are going to be over treating here because it could just be a congenital abnormality. It would be a minor risk factor.

It should be a minor risk factor and not stand alone.

That’s not a danger sign but I agree that it’s worth antibiotics but very rarely infectious. This kid is going to have one or two things wrong with it. The most likely thing is going to be a general obstruction. These babies in Africa are going to die. In a premature baby it is going to be NEC and giving that baby antibiotics might be helpful. It’s controversial.
Not in isolation. It should be a minor risk factor with abdominal distension

**Distended abdomen**

This is major risk factor in low resource settings as it usually frank fulminant NEC even with bigger babies. Surprised how common it was.

We do have to take it seriously. It is relatively subjective especially with preterm babies whose bellies always look big and round. I feel this needs 3 minors.

You again need to look for other reasons first. NEC is not as common in LIC.

If persistent

Very vague.

I disagree, you can get it from crying

This should be in combination with bilious vomiting and then this would be a major.

<table>
<thead>
<tr>
<th>Original question</th>
<th>% agreement</th>
<th>Action taken</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilious vomiting</td>
<td>50%</td>
<td>Change to combine with severe abdominal distension.</td>
<td>▪ Severe abdominal distension is a WHO sign of serious bacterial infection</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New proposed question</th>
<th>Indicate level of agreement</th>
<th>Please highlight whether it should be an ‘other’ risk factor or major (danger) sign</th>
<th>Your thoughts/comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilious vomiting with severe abdominal distension</td>
<td>1 2 3 4 5</td>
<td>Other or Major</td>
<td></td>
</tr>
</tbody>
</table>

3. Do you agree with the following ‘other’ signs/symptoms of neonatal sepsis?

**Irritability** [We acknowledge the comments suggesting the inclusion of “high pitched cry” but this is scored in a separate, meningitis algorithm]

**Expert responses**

It is vague. More description is needed i.e. Inconsolable baby with an abnormal high-pitched cry.

It is not a sign of sepsis per say

This is subjective and needs to be defined further. A true irritable inconsolable baby I would agree. It needs videos.

I would probably do irritability and high-pitched cry
It could be something else.

This should be a major risk factor because the child could have meningitis.

I disagree. Almost every baby in the 8-12 weeks of age is the most irritable thing in the world so I don't think so.

I would add lethargy and make this a major risk factor. I would try and simplify and not have all this major and minor and just have major. In practise this all gets too complicated and if there is something worrying you put them on antibiotics.

<table>
<thead>
<tr>
<th>Original question</th>
<th>% agreement</th>
<th>Action taken</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irritability</td>
<td>64%</td>
<td>Change</td>
<td>Not included in WHO or COIN guidelines</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New proposed question</th>
<th>Indicate level of agreement</th>
<th>Action taken</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irritable/ inconsolable baby</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Do you think hypothermia < 35.5 °C should be added as a sign of neonatal sepsis in a low-income setting?

**Expert responses**

It is a major if persistent hypothermia despite warming.

It is well recognised as a sign of sepsis. Suggested wording 'Hypothermia on two or more occasions.'

Yes, major. We know sepsis that can present as hypothermia or hyperthermia. It is just as important as a temperature of > 37.5 °C

Yes, minor. Hypothermia not responding to warming measures. Temperature instability is more useful than a specific high or low.

Yes, major but persistent hypothermia because I find many babies especially who are out born to be hypothermic.

Yes, major. Hypothermia despite efforts to warm. Hypothermia is a major problem. We have shown if you do not get your temperature up then your mortality is much higher. I would say this is very significant.

Yes, major. If it is persistent hypothermia despite normal supportive care.

Yes, major. What we have done for our definition of sepsis in the clinical trial that we are running is hypothermia < 35.5 °C after 1 hour of skin to skin. A lot of these babies are environmental, but I think the danger sign for sepsis is when you have a low temperature and you have had the best method of correcting, which is skin to skin contact and it is still low. You need to treat those for possible sepsis.
Yes, major. If it is persistent after addressing the environment of the baby it is a major risk factor.

Yes, minor. Temperature instability is common with sepsis and might be a better term to use.

Yes, major. I am very familiar with helping babies to breathe and very familiar with the IMCI. I am not so familiar with COIN and some of this may be COIN specific. But with hypothermia it’s more like the transient tachypnoea where if you are hypothermic after birth then that’s something related to not drying or warming. However, if you are hypothermic days later that is less likely to be due to the environment. Most of the kids are not septic right away they take 24-40 hours to become septic especially for early onset sepsis. You tend to get that coming through mum’s birth canal unless the mum’s membrane has been ruptured for a long period of time. Then you may be totally asymptomatic so at first you may have a cold baby because they did not dry the baby that’s one thing but there could be another baby that was totally not cold and then sporting a temperature of 35 °C because they became septic. Those are the two scenarios and there are environmental things added to it like if you are living in a cold area. Hypothermia would be more concerning to me later on than right after birth on admission to the neonatal unit. So, having new hypothermia, temperature instability or persistent hypothermia would all be concerning to me.

I personally don’t think so but follow WHO.

<table>
<thead>
<tr>
<th>Original question</th>
<th>% agreement</th>
<th>Action taken</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothermia &lt;35.5°C</td>
<td>78%</td>
<td>Change</td>
<td>▪ This is a WHO and COIN danger sign. Experts agreed if hypothermia was persistent despite warming it should be included. However, the app is currently designed for just point of admission so we will only have a one-off temperature reading. Starting antibiotics and considering infection is covered in the hypothermia algorithm if the infant stays hypothermic despite attempts at rewarming.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New proposed question</th>
<th>Indicate level of agreement</th>
<th>Your thoughts/comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single measurement of temperature of &lt;35.5°C</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

5. Are there any additional risk factors, signs or symptoms that you think should be included for a low-income setting?

Expert responses

Particularly for preterm babies some of these signs are less specific such as reduced movement of limbs or hypotonia you expect that in preterm babies anyway. There are not
actually any good validated nosocomial scores for preterm babies while they are in hospital so the Rosenberg criteria is probably the best one but it still only has a sensitivity of 77%. It has 5 criteria which are apnoea, pallor, jaundice, hepatomegaly and seizures. What is difficult here is that you need a certain level of clinical skill to pick up the hepatomegaly. I am not saying they should be used here but it may be interesting to look at. Rosenberg RE, Ahmed AS, Saha SK, et al. Nosocomial sepsis risk score for preterm infants in low-resource settings. J Trop Pediatr. 2009;56(2):82–89.

Did the mother get any intrapartum antibiotics is probably too difficult to to cooperate as you never know what time etc

Poor capillary refill or perfusion

Hypothermia

Did the mother get any intrapartum antibiotics? Or did the mother get a GA? These factors affect whether the baby will come out hypotonic, tachypnoeic/shallow breathing and these babies are going to get antibiotics.

Eye symptoms. Red eye with pus. It would be a minor.

I don’t think so. I would include all the danger signs from the WHO

Does the baby look ill?

<table>
<thead>
<tr>
<th>New proposed question</th>
<th>Rationale</th>
<th>Indicate level of agreement</th>
<th>Indicate whether it should be an ‘other’ risk factor or major (danger) sign</th>
<th>Your thoughts/comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Poor capillary refill or perfusion</td>
<td>Expert suggestion</td>
<td>1 2 3 4 5</td>
<td>Other or Major</td>
<td></td>
</tr>
<tr>
<td>B. Unconscious</td>
<td>WHO danger sign ‘not moving when stimulated’</td>
<td>1 2 3 4 5</td>
<td>Other or Major</td>
<td></td>
</tr>
<tr>
<td>C. Swollen red eyelids with pus</td>
<td>WHO localising sign of infection</td>
<td>1 2 3 4 5</td>
<td>Other or Major</td>
<td></td>
</tr>
<tr>
<td>D. Central cyanosis</td>
<td>WHO danger sign</td>
<td>1 2 3 4 5</td>
<td>Other or Major</td>
<td></td>
</tr>
<tr>
<td>E. Does the baby look ill?</td>
<td>Expert suggestion</td>
<td>1 2 3 4 5</td>
<td>Other or Major</td>
<td></td>
</tr>
</tbody>
</table>

6. Please comment on the criteria for ‘consider meningitis’

**Expert responses**

I prefer unstable temperature above 38 degrees or less than 36.5 degrees Celsius.
Bulging fontanelle yes, hypotonia yes but would also include hypertonia, floppiness, absent suck.

Remove 37 centimetres because it does not apply to a premature baby and just have obvious enlarging head.

It should be hypertonia or hypotonia. Irritability, lethargy is fine. Hydrocephalus is a very late sign of meningitis so not helpful acutely so should be removed. Convulsions need to be described as abnormal repetitive stereotypical movement.

Yes. That is fine

Hydrocephalus is rubbish. You would not get a head circumference.

I would disagree with the hydrocephalus bit as there could be an anatomical reason for their hydrocephalus.

You don’t usually get hydrocephalus very early on in meningitis. This one seems a bit odd to me. I would get rid of it. You can make the diagnosis with bulging fontanelle and everything else.

I have to say if you have hydrocephalus in the acute setting the symptoms or signs of hydrocephalus would be more important than the head circumference.

Add in high pitched cry/convulsive cry and abnormal movements (+/- convulsions). Often baby’s seizures are very subtle, it may be abnormal movements of the lips, or slightly abnormal movement of the legs which people don’t class as convulsions. Remove lethargy because it is non-specific. A febrile baby who is lethargic does not specifically point to meningitis.

Remove hypotonia it is too complex for nurses to assess for routine care and it should be kept simple.

Remove hydrocephalus it is a post meningitis event and they don’t present with it

Overall recommendation: Persistent temperature > 37.5, bulging fontanelle, persistent irritability with a convulsive cry, abnormal movements +/- convulsions

I would not have convulsions alone to diagnose meningitis as it could be birth asphyxia, I would want to see it with a temperature. I would remove hydrocephalus as it could be an anatomical cause.

I would add hypertonia/hypotonia

Agree with all of them

Happy with these.

I am guessing the only reason for diagnosing meningitis is for antibiotic duration.

I would say they need to have a temperature over 38 °C not 37.5 °C. You are going to have a lot of kids here with temperatures of 37.5 °C which seems low. Bulging fontanelle with a temperature of 38 °C seems reasonable. Hypertonia is a tough one to diagnose. A kid who had an in-utero stroke is going to be hypertonic. Do these kids get antibiotics every time they have a fever?

Acute seizures are straight forward. I like the way WHO does it and I do not normally say this because if the baby has convulsions acutely you treat. What if your kid has a seizure
disorder? You would have to give antibiotics constantly which is not going to treat anything because he has a seizure disorder. I would say it has to be acute seizures. Hydrocephalus, new onset? Baby? They pick standard deviations on the head circumference which is probably appropriate for a concern but then you are still treating 2 out of every 100 kids because of they just have a big head. I would say just go with the danger signs of fever, lethargy and convulsions which will give you a secure diagnosis and the rest are not.

I would not include hydrocephalus. Hydrocephalus is a separate issue and a whole different diagnosis.

<table>
<thead>
<tr>
<th>Original question</th>
<th>% agreement</th>
<th>Action taken</th>
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<tbody>
<tr>
<td>Temp &gt;37.5 °C AND any of • Bulging Fontanelle • Hypertonia • Persistent irritability • Lethargy OR • Convulsions/History of convulsions • Hydrocephalus</td>
<td>28% agreement</td>
<td>Change</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>New proposed question</th>
<th>Indicate level of agreement</th>
<th>Your thoughts/comments</th>
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</thead>
<tbody>
<tr>
<td>Bulging fontanelle</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Irritability with a high-pitched cry</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Drowsy, lethargic or unconscious</td>
<td>1 2 3 4 5</td>
<td></td>
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<tr>
<td>Abnormal movements/twitching or convulsions with temp &gt;37.5</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Abnormal tone with temp &gt;37.5</td>
<td>1 2 3 4 5</td>
<td></td>
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</tbody>
</table>
Section 2. Hypoxic Ischaemic Encephalopathy

1. Do you agree with the following risk factors for hypoxic ischaemic encephalopathy?

From expert feedback the term ‘birth asphyxia,’ has been changed to hypoxic ischaemic encephalopathy (HIE). In addition, NeoTree will no longer be using risk factors to aid making a diagnosis of HIE and it will be adjusted to use the already validated Thompson score. However, the risk factors that were agreed upon by experts in the first round will be a prompt on the app for the user to perform the Thompson score.

Birth injury

Expert responses

What do you mean by birth injury it needs to be defined.

As a screening tool it is a valid important thing to think about.

I disagree. Meaning what? This is really ambiguous and needs a description. It could be a facial laceration and that would not give you asphyxia.

I disagree. Need to define further. I would not consider a bruise or a cephalohematoma as an injury. It needs to be specific. However, I would still only consider as there are far more important risk factors which would be more predictive for the infant.

It depends on what the birth injury is. If they come out with a very moulded head, large cephalohematoma, fractured clavicle, erb’s palsy then I would assume they have had significant problems extracting. However, something like a laceration I would not consider as a significant birth injury. You need to specify the birth injuries.

I disagree. What are we talking about when we say birth injury here? More detail is needed. Broken bones or significant neurological deficit/nerve injury I would agree with.

You need to be more specific i.e. a fracture or nerve palsy.

Disagree. Too vague. I would not include this one.

This needs to be defined.

Disagree. These need to be defined because it is a very broad term. If there are palsies, cephalohematoma or subgaleal, fractures, extensive bruising then I would agree.

Disagree. For instance, bruising does not normally cause asphyxia.

<table>
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<tr>
<th>Original question</th>
<th>% agreement</th>
<th>Action taken</th>
<th>Comments</th>
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</thead>
</table>
| Birth injury as risk factor for HIE | 29% | Change | ▪ Not included in WHO or COIN guidelines  
▪ App developer is keen to see if we specify the birth injuries whether this can be included |

How should we describe “significant” birth injury?
2. Do you agree with the following signs/symptoms for hypoxic ischaemic encephalopathy?

Absence suck and gestation > 34/40

Expert responses

Disagree. This is not sensitive or specific. It could be because you are septic. I really worry that the approach to this is not scientific and it is not based on existing evidence base. WHO and COIN will have followed a formal process to what is included or excluded. I worry about any of the signs and symptoms that the app developers have suggested that are not evidence based to make a recommendation. Research needs to be done for any suggestions of the app developers and recommendations cannot be made until you have the evidence.

Disagree. I think it should be 35 weeks and this really depends on how old the neonate is. This assessment needs to be at least 1 hour of age as the infant needs some transition time.

Disagree. I would have the gestation at 32/33 weeks and then I would agree. For the rest I agree but my comment around these questions is that if you are measuring these signs and symptoms too early then you can overdiagnose. Often babies that have a lactic acidosis very early on but may not have a significant amount of hypoxia may be obtunded but then recover very quickly as oppose to a baby that has had a significant hypoxic hit and you need to wait at least an hour.

Disagree. I think the only reliable clinical signs are seizures, coma, flaccid and very poor tone. I would really use the Sarnat score or the Thompson criteria here. However, it is difficult to assess for HIE using the Sarnat score for preterm babies as it has mainly been designed for term babies. The Thompson score which I think was designed in East Africa has a much more pragmatic approach and I would use that to guide here.

Disagree. Just use the Sarnat stages.

<table>
<thead>
<tr>
<th>Original question</th>
<th>% agreement</th>
<th>Action taken</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absent suck and gestation &gt;34/40 weeks</td>
<td>57%</td>
<td>Change but include as part of the Thompson score</td>
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<tr>
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<td>Your thoughts/comments</td>
<td></td>
</tr>
<tr>
<td>Absent suck and gestation &gt;32/40 weeks</td>
<td>1 2 3 4 5</td>
<td></td>
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</table>
Section 3. Respiratory distress of the newborn (RDN)

1. Do you agree with the diagnostic criteria for Respiratory Distress of the Newborn (RDN):

From expert feedback the NeoTree application will no longer generate a respiratory diagnosis (respiratory distress syndrome, meconium aspiration, transient tachypnoea of the newborn) and it will just guide you to treating the symptoms. However, the above possible diagnoses will still be included as teaching points. NeoTree allows for multiple diagnoses i.e the preterm baby can have a diagnosis of RDS and pneumonia.

A. Respiratory distress syndrome

Expert responses

Lower gestation to 34-35 weeks. Older than that they are not at risk.

Agree. It’s reasonable. You have to both

Or diabetic mother

Yes agree. Include weight for suggested gestation.

I would say a lower gestation. The risk for a 36 weeker is relatively low. I would change gestation to weight and say < 2 kg.

1 disagree use weight < 2000g

I would say less than 34 weeks

Disagree in making a diagnosis. Just treat the symptoms

<table>
<thead>
<tr>
<th>Original question</th>
<th>% agreement</th>
<th>Action taken</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory Distress Syndrome</td>
<td>50%</td>
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<td></td>
</tr>
<tr>
<td>New proposed question</td>
<td>Indicate level of agreement</td>
<td>Your thoughts/comments</td>
<td></td>
</tr>
<tr>
<td>Gestation &lt;34/40 or &lt;2000g</td>
<td>1 2 3 4 5</td>
<td></td>
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</table>

B. Congenital pneumonia

Expert responses

I would change temperature to more than 38 °C or less than 36.5.

I would say hypothermia or hyperthermia and if you mention temperature you have to say both.

Not so sure I agree with foul smelling liquor

I would remove unilateral signs as pneumonia can be bilateral so just say coarse crackles.

I think the temperature should be more than 38 °C.
Disagree. Again, in my opinion, I would treat the symptoms and do not worry about diagnosing. For example, for congenital pneumonia, at CDC we had a whole panel of all the experts trying to agree on how to diagnose pneumonia. The decision of the panel was that it is impossible in a developed country to diagnose neonatal pneumonia. So, if you can't do it here how do you expect them to do it there. The temperature should also be more than 38 °C.

Again, I don't think you need risk factors. You are going to diagnose it even if there are no risk factors but it's fine.

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<tr>
<th>Original question</th>
<th>% agreement</th>
<th>Action taken</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Congenital Pneumonia</td>
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<td>Indicate level of agreement</td>
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<td>Your thoughts/comments</td>
</tr>
<tr>
<td>Temp &gt;37.5°C or &lt;36.5°C</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coarse crackles (instead of unilateral signs)</td>
<td>1 2 3 4 5</td>
<td></td>
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</table>
**ORIGINAL**

**Sepsis algorithm**

Any MAJOR signs/symptoms of sepsis

- No
  - Any MINOR signs/symptoms of sepsis
    - 0 or 1
      - Any MAJOR risk factor of sepsis
        - No
          - Any MINOR risk factors of sepsis
            - 0 or 1
              - Sepsis unlikely
            - >1
              - Asymptomatic sepsis
              - 5 days of IVAB
          - >1
            - Symptomatic sepsis
            - 7-10 days of IV antibiotics (IVAB)
    - >1
      - Yes
      - Symptomatic sepsis
      - 7-10 days of IV antibiotics (IVAB)
**REVISED Sepsis algorithm**

- Any MAJOR signs/symptoms of sepsis:
  - No
    - Any OTHER signs/symptoms of sepsis:
      - 0 or 1
        - Any MAJOR risk factor of sepsis:
          - No
            - Any OTHER risk factors of sepsis:
              - 0 or 1
                - Asymptomatic sepsis
              - >1
                - Yes
                  - Sepsis unlikely
            - >1
              - Yes
                - Symptomatic sepsis
                  - Other LICs
                  - Malawi
                    - 48 hours of IVAB
                    - 5 days of IVAB
                  - 7-10 days of IVAB
                    - Consider HAI if no improvement after 48 hours and change to second line AB
                    - Stop day 7 if clinically well
Revised neonatal sepsis risk factors, signs and symptoms

**Risk factors**

- **Major**
  - Maternal fever >38°C in labour
  - Prolonged rupture of membranes (PROM) >18 hours
  - Foul smelling amniotic fluid

- **Other risk factors**
  - <32/40 weeks gestation or <1500g (spontaneous labour only)

**Signs/symptoms**

- **Major**
  - Neonatal temperature >37.5 °C
  - Boil/abscess
  - Grunting/severe respiratory distress/ mod-severe WOB
  - Lethargy
  - Umbilical redness extending to the periumbilical skin or umbilicus draining pus
  - Deep jaundice: palms and soles of the baby deep yellow
  - Tachypnoea > 60 bpm
  - Convulsions/twitching or abnormal movements
  - Many or severe skin pustules
  - Bilious vomiting with severe abdominal distension
  - Bulging fontanelle
  - New onset of poor feeding
  - Not moving when stimulated
  - Swollen red eyelids with pus
  - Central cyanosis

- **Other signs/symptoms**
  - Pallor
Revised neonatal sepsis management

**Neonatal sepsis management**

**Investigations**
- *If possible* perform sepsis screen: FBC, CRP, blood culture
- LP only for those who have clinical signs of meningitis (but stable) or late-onset neonatal sepsis

**Antibiotic choices**
- 1st line: give local recommendations
- IM/IV gentamicin and benzylpenicillin or ampicillin
- 2nd line: If no improvement after 48 hours change to a third-generation cephalosporin
- IV cloxacillin and gentamicin if greater risk of staphylococcal (skin infection).

**Antibiotic duration (without investigations)**
- Asymptomatic sepsis: Treat for 48 hours and stop if well (Treat for 5 days in Malawi)
- Symptomatic sepsis: Stop at day 7 if clinically well otherwise continue for 10 days

**Antibiotic doses**
- **Gentamicin (IM/IV)**
  - <7 days: 3 mg/kg (LBW) and 5 mg/kg (normal BW) per dose once a day
  - >7 days: 7.5 mg/kg once a day
- **Ampicillin (IM/IV)**
  - <7 days: 50 mg/kg every 12 h
  - >7 days every 8 h
- **Benzylpenicillin (penicillin G) (IM)**
  - <7 days: 50 000 U/kg every 12 h
  - >7 days every 6 h

**Supportive care**
- Thermoregulation: aim for 36.5-37.5 °C
- Provide respiratory support oxygen or CPAP as needed according to CPAP algorithm
- Check blood glucose and provide feeding support as needed
- Consider 10ml/kg fluid bolus if shocked as per SHOCK algorithm
- Consider 2.5mls/kg 10% dextrose if BS<2.5 mmol or 45 mg/dl – as per HYPOGLYCAEMIA algorithm
**Any RISK FACTOR of Birth Asphyxia**

- 0
  - Any SIGN/SYMPTOM of BA
    - 1
      - Birth Asphyxia
    - 0
      - Unlikely BA
  - 1
    - Consider BA
  - >1
    - Birth Asphyxia

**Risk factors**
- Foetal distress
- Prolonged second stage
- Delivery = Vacuum/Emergency Caesarian section/Breech
- 5 minute Apgar <7
- Resuscitation: Bag valve mask >5 mins/CPR/resuscitation >10 mins
- Birth Injury

**Signs/symptoms**
- Coma
- Convulsions
- Lethargy
- Irritable
- Hypotonia AND >34/40 gestation
- Absent suck AND >34/40 gestation
REVISED Hypoxic Ischaemic Encephalopathy algorithm

No

Yes

$>37 \text{ weeks gestation}$

Unlikely HIE

Any RISK FACTOR of HIE

Any SIGN/SYMPTOM of HIE

Perform Thompson score to assess for HIE

Yes

No

Consider HIE but seek clinician review to confirm diagnosis

Risk factors

- Foetal distress
- Resuscitation: Assisted ventilation $>5$ minutes or CPR $>10$ minutes
- Apgar at 5 minutes $<7$

Signs/symptoms

- Coma
- Convulsions
- Lethargy
- Hypotonia
- Absent Moro reflex
- Absent suck
- Respiratory distress

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Revised Hypoxic Ischaemic Encephalopathy management

HIE management

Thermoregulation
Aim for normothermia
Avoid hyperthermia and hypothermia

Respiratory support
Give respiratory support as appropriate. Give oxygen if saturations <90% in air

Feeding support, anticonvulsants and antibiotics
Give feeding support as appropriate
1. Oral feeds (breast feed or bottle if breastfeeding is not possible)
2. Give NG feeds if BS < 2.5mmol/L or < 45mg/dL and not tolerating oral feeds
3. Give IV fluids if BS < 2.5mmol/L or < 45mg/dL and not tolerating NG feed

If evidence of seizure activity give Phenobarbitone as per convulsions algorithm.
Reassess suck, tone, coma, seizures every 8 hours for 72 hours in hospital
Treat for sepsis with antibiotics
Either RR >60 OR at least 1 SIGN/SYMPTOM of respiratory distress AND <48 hours old

Any SIGNS/SYMPTOMS of respiratory distress

Are ALL of the following true?
<2 hours old
>36 weeks gestation
RR 60-80
No major sepsis risk factors
No major or minor signs/symptoms of sepsis

If yes, go to TTN.

<37 weeks gestation?

Is there at least one of:
Meconium-stained liquor
Meconium-stained umbilicus
Meconium at delivery

If yes, go to RDS.

Is there at least one of:
Pyrexia >37.5 °C
Maternal pyrexia/PROM/Foul smelling liquor
Unilateral signs on auscultation

If yes, go to MAS.

RDS Unspecified
Congenital Pneumonia
REVISED
RDN management

Any SIGNS/SYMPTOMS of respiratory distress

- Oxygen saturations in air <90%
- Tachypnoea >60 breaths per minute
- Fever >37.5°C or <36°C and crepitations on auscultation
- Grunting
- Recessions
- Any increased work of breathing
- Cyanosis
- Apnoea

Unlikely RDN

Management
Revised Respiratory Distress of the Newborn management

Respiratory distress of the newborn management

InVESTIGATIONS
Perform a chest x-ray if it will change management or if the infant is not improving as expected or deteriorating.

Airway and respiratory support
Position airway
Give oxygen if oxygen saturations < 90% in air
If > 1kg consider CPAP according to CPAP algorithm

Feeding support
If breathing 60-80 bpm use cup/NGT
If needing CPAP use OGT
If breathing > 80bpm consider IV fluids

IV Access for Antibiotics
Give antibiotics including for suspected TTN (unless have chest x-ray and can safely exclude.)

Teaching points

Meconium aspiration
- Consider if meconium stained amniotic fluid
- Just because there was meconium at delivery doesn’t mean it was aspirated.
- Most aspiration occurs in utero before the baby is born, so more likely if there was foetal distress in labour or has signs of HIE
- Floppy babies with severe HIE and meconium aspiration are unlikely to benefit from CPAP.

Transient tachypnoea of the newborn (TTN)
- These babies are not unwell
- RR is usually between 60-80 bpm and they don’t usually need oxygen
- This should resolve in the first few hours of life.
- TTN is more likely following elective C-section or a rapid vaginal delivery.
- Give antibiotics if unable to exclude other causes i.e no chest xray

Respiratory distress syndrome
- Consider if < 37 weeks or diabetic mother
- Benefit from CPAP see Algorithm

Congenital Pneumonia
- Consider if temperature > 37.5 °C or < 36 °C and crepitations on auscultation
- Risk factors for sepsis i.e maternal fever/PROM/foul smelling amniotic fluid
Hypothermia Algorithm and management

Temperature <36.4 °C

No

Yes

Temperature >37.5 °C

No

Yes

Hypothermia
Mild = 36 - 36.4 °C
Mod = 32 - 35.9 °C
Severe = <32 °C

Normothermia

Address any environmental causes: unwrap or move baby from under resuscitaire

If fever persists follow NEONATAL SEPSIS algorithm

Hypothermia management

Warm the baby
• Skin to skin
• Place on warmer/resuscitaire if clinically unstable

Limit heat loss
• Make sure the baby is dry
• Put on a hat and wrap up the baby
• If on the resuscitaire put the sides up
• Ensure room is free from drafts - windows and doors closed

Monitor
• Recheck temperature every 30-60 minutes until normothermic
• Watch out for overwarming
• Complete NeoTree assessment to assess for signs of infection (consider if persistent hypothermia despite warming), apnoea and hypoglycaemia