

## Neonatal infection: antibiotics for prevention and treatment

**[D] Evidence reviews for maternal and neonatal risk factors for early-onset neonatal infection**

*NICE guideline <number>*

*Evidence reviews underpinning recommendations 1.3.1-1.3.9 and research recommendations in the NICE guideline*

*December 2020*

*Draft for Consultation*

*These evidence reviews were developed  
by NICE Guideline Updates Team*



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# 1 Risk factors for early-onset neonatal 2 infection

## 3 1.1 Review question

4 What is the accuracy of clinical prediction models for early-onset neonatal infection and what  
5 is their effectiveness in guiding management in the baby?

### 6 1.1.1 Introduction

7 Neonatal infection is a significant cause of mortality and morbidity in newborn babies. It can  
8 lead to life-threatening sepsis, which accounts for 10% of all neonatal deaths. Early-onset  
9 neonatal infection is typically defined as infection that occurs within 72 hours of birth.

10 Predicting which babies are most at risk of early-onset neonatal infection is important to help  
11 determine who should receive antibiotic treatment. A culture taken from blood or  
12 cerebrospinal fluid which tests positive for the organisms associated with infection is the  
13 gold-standard for identifying which babies should receive treatment. However, waiting for the  
14 results of these tests may delay treatment. A tool which can predict which babies are most at  
15 risk of early-onset neonatal infection is therefore important to help identify those who will  
16 benefit from early treatment whilst reducing the number of babies who receive unnecessary  
17 treatment. This will also reduce other associated risks, such as the development of  
18 antimicrobial resistance. The aim of this review is therefore to evaluate existing clinical  
19 prediction models for early-onset neonatal infection and determine their effectiveness in  
20 guiding management of the baby.

### 21 1.1.2 Summary of the protocol

22 The review was divided into 2 parts. Part A aimed to identify studies assessing the accuracy  
23 of clinical prediction models in identifying babies with early onset infection. Part B aimed to  
24 identify 'test and treat' randomised controlled trials that assessed the effectiveness of clinical  
25 prediction models in guiding management.

26 Part A

<b>Population</b>	<ul style="list-style-type: none"><li>• Unborn or newborn babies under 72 hours</li><li>• Pregnant women</li></ul>
<b>Interventions</b>	Any validated risk tool using multiple predictors to predict the risk of development or the presence of early-onset neonatal infection. For example: the neonatal early-onset sepsis calculator (Kaiser Permanente)
<b>Reference standard</b>	<ul style="list-style-type: none"><li>• culture-proven infection from a sample taken within 72 hours of birth where available or within the study-defined period for early onset neonatal infection</li><li>• antibiotics for suspected bloodstream infection (in neonate)</li></ul>
<b>Outcome Measures</b>	For each outcome, accuracy measures will be reported where available, for example: <ul style="list-style-type: none"><li>• Odds ratios/hazard ratios</li><li>• Model fit, including discrimination (C statistic, area under ROC curve) and calibration (r squared)</li><li>• Sensitivity, specificity, positive and negative predictive values</li></ul>

27

1

2 Part B

<b>Population</b>	<ul style="list-style-type: none"> <li>• Unborn or newborn babies under 72 hours</li> <li>• Pregnant women</li> </ul>
<b>Interventions</b>	Any validated risk tool using multiple predictors to predict the risk of development or the presence of early-onset neonatal infection. For example: the neonatal early-onset sepsis calculator (Kaiser Permanente)
<b>Comparators</b>	<ul style="list-style-type: none"> <li>• standard care: treatment according to risk stratification based on clinician experience or existing clinical protocols (for example, existing NICE guidance)</li> <li>• Comparisons between risk tools followed by treatment according to risk stratification by tool results will also be included.</li> </ul>
<b>Outcomes</b>	<p>Neonatal outcomes:</p> <ul style="list-style-type: none"> <li>• culture-proven infection from sample taken within 72 hours of birth where available or within the study-defined period for early-onset neonatal infection</li> <li>• antibiotics for suspected bloodstream infection (within 72 hours of birth or within the study-defined period for early-onset neonatal infection)</li> <li>• mortality (at different time points – peri-natal mortality (stillborn or within 7 days from birth) or greater than 7 days from birth)</li> <li>• respiratory distress within 72 hours of birth or within the study-defined period for early-onset neonatal infection</li> <li>• health-related quality of life, measured using a validated tool (during the neonatal period and at the latest time point reported in study)</li> <li>• hospital length of stay</li> <li>• number of babies prescribed antibiotic treatment</li> </ul> <p>Family outcomes:</p> <ul style="list-style-type: none"> <li>• psychological distress in baby’s family as measured using a validated scale (e.g. parental stressor scale NICU; modified Rutter Malaise Inventory) (during the neonatal period and at the latest time point reported in study)</li> </ul>

3 **1.1.3 Methods and process**

4 This evidence review was developed using the methods and process described in  
5 [Developing NICE guidelines: the manual](#). Methods specific to this review question are  
6 described in the review protocol in [Appendix A](#). For full details of the methods used in this  
7 review, see the [methods document](#).

8 Declarations of interest were recorded according to [NICE’s 2018 conflicts of interest policy](#).

9 Prospective and retrospective observational cohort or cross-sectional studies (part A) and  
10 test and treat randomised controlled trials (part B) were considered in addition to systematic  
11 reviews of these study types. The review protocols specified that, where possible, subgroup  
12 analyses would be conducted for gestational age of the baby (preterm vs term). However,  
13 this was not possible as most studies included both preterm and term babies, and the results  
14 were not separated by gestational age. Results were stratified by population where the  
15 models were evaluated on different cohorts, such as mothers with chorioamnionitis.

1 **1.1.4 Prognostic evidence**

2 **1.1.4.1 Included studies**

3 A joint search was carried out to identify studies specified for this evidence review, and a  
4 similar evidence review for studies assessing clinical prediction models for late-onset  
5 infection (for details, see evidence review E – Risk factors for late onset). This returned a  
6 total of 1,252 results, of which 68 were identified as potential included studies. Full text  
7 articles were ordered and reviewed against the inclusion criteria, of which 7 met the inclusion  
8 criteria for the review. Two additional studies were included from a systematic review making  
9 included references in total.

10 The search was re-run in July 2020 to identify any studies which had been published since  
11 the date of the original search. This combined search for early- and late-onset prediction  
12 models returned a total of 244 results of which 14 were identified as possible included  
13 studies. After full text review, 13 were excluded. The one included study examined the use of  
14 a clinical prediction model for early-onset infection. In total there were therefore 10 studies  
15 which met the inclusion criteria for this review (5 prospective cohort studies, 5 retrospective  
16 cohort studies).

17 The majority of the evidence (9 studies) investigated the use of the Kaiser Permanente  
18 neonatal sepsis calculator, including one study that compared the prognostic accuracy of the  
19 calculator against the recommendations from the 2012 version of this guideline. One study  
20 examined the use of a different model, based on various demographic and clinical factors.  
21 Studies reported the information needed to calculate prognostic outcomes for sensitivity,  
22 specificity and likelihood ratios. Only one study reported model fit statistics (c-statistic), and  
23 none reported hazard or odds ratios. No studies matched the protocol for Part B of the  
24 review (RCTs for different risk predictor tools).

25 **1.1.4.2 Excluded studies**

26 See [Appendix J](#) for excluded studies and reasons for exclusion.

27 **1.1.5 Summary of studies included in the prognostic evidence**

28 **Table 2 Summary of included clinical studies**

Study	Study type and follow-up time	Population	Prediction model
Carola 2018 (n=896)	<ul style="list-style-type: none"> <li>Retrospective cohort</li> <li>Follow-up time not reported but study investigated early-onset infection</li> </ul>	<ul style="list-style-type: none"> <li>Newborn babies with a gestational age <math>\geq 35</math> weeks</li> <li>Born to mothers with clinical chorioamnionitis <i>diagnosis of chorioamnionitis was made by an obstetrician based on intrapartum fever (temperature <math>\geq 38^{\circ}\text{C}</math>) alone or in conjunction with maternal leukocytosis, uterine tenderness, foul-smelling amniotic fluid, and maternal or fetal tachycardia</i></li> </ul>	<ul style="list-style-type: none"> <li>Kaiser Permanente neonatal sepsis calculator</li> <li><i>Background incidence of early-onset infection set at 0.5/1000 live births (CDC national incidence)</i></li> </ul>

Study	Study type and follow-up time	Population	Prediction model
Dhudasia 2018 (n=6090)	<ul style="list-style-type: none"> <li>Retrospective cohort</li> <li>72 hour follow-up</li> </ul>	<ul style="list-style-type: none"> <li>Neonates with gestational age <math>\geq 36</math> weeks gestation</li> </ul>	<ul style="list-style-type: none"> <li>Kaiser Permanente neonatal sepsis calculator <i>Background incidence of early-onset infection set at 0.5/1000 live births (CDC national incidence)</i></li> </ul>
Goel 2020 (n=3593)	<ul style="list-style-type: none"> <li>Prospective cohort</li> <li>72 hour follow-up</li> </ul>	<ul style="list-style-type: none"> <li>Newborn babies with a gestational age <math>\geq 34</math> weeks</li> </ul>	<ul style="list-style-type: none"> <li>Kaiser Permanente neonatal sepsis calculator <i>Background incidence for early-onset infection set at 0.5/1000 live births (closest estimated incidence from studies of term and near-term infants in high-income countries including the UK)</i></li> <li>Current 2012 NICE guidelines</li> </ul>
Hershkovich-Shporen 2019 (n=1341)	<ul style="list-style-type: none"> <li>Prospective cohort</li> <li>Duration of follow-up not reported</li> </ul>	<ul style="list-style-type: none"> <li>Gestational age of 35 weeks or more</li> <li>Risk factors for early-onset neonatal sepsis</li> <li>Receiving antibiotics in the first 72 hours of life</li> <li>Symptoms of suspected early-onset sepsis</li> <li>Proven sepsis</li> </ul>	<ul style="list-style-type: none"> <li>Kaiser Permanente neonatal sepsis calculator</li> <li><i>Background incidence for early-onset infection set at 0.6/1000 live births (based on incidence in the centre between January 2008 - January 2015)</i></li> </ul>
Joshi 2019 (n=319)	<ul style="list-style-type: none"> <li>Prospective cohort</li> <li>72 hour follow-up</li> </ul>	<ul style="list-style-type: none"> <li>Born to mothers with clinical chorioamnionitis <i>diagnosed by the obstetric team and is treated with intravenous broad-spectrum antibiotics</i></li> <li>Neonates with gestational age <math>\geq 34</math> weeks</li> <li>Well-appearing infants</li> </ul>	<ul style="list-style-type: none"> <li>Kaiser Permanente neonatal sepsis calculator <i>Background incidence for early-onset infection set at 0.6/1000 live births</i></li> </ul>
Money 2017 (n=362)	<ul style="list-style-type: none"> <li>Retrospective cohort</li> <li>Duration of follow-up not reported but study investigated early-onset infection</li> </ul>	<ul style="list-style-type: none"> <li>Well-appearing infants</li> <li>Born to mothers with clinical chorioamnionitis <i>According to maternal ICD-9 codes</i></li> </ul>	<ul style="list-style-type: none"> <li>Kaiser Permanente neonatal sepsis calculator <i>Baseline incidence of early-onset infection set at 0.5/1000 (based on CDC national incidence)</i></li> </ul>
Popowski 2011 (n=399)	<ul style="list-style-type: none"> <li>Prospective cohort</li> </ul>	<ul style="list-style-type: none"> <li>Women with prolonged rupture of membranes at <math>\geq 34</math> weeks gestation</li> </ul>	<ul style="list-style-type: none"> <li>Predictive model (unnamed)</li> </ul>

Study	Study type and follow-up time	Population	Prediction model
	<ul style="list-style-type: none"> <li>72 hour follow-up</li> </ul>	<ul style="list-style-type: none"> <li>Singleton pregnancies</li> </ul>	<ul style="list-style-type: none"> <li>Based on predictive factors: maternal white blood cell count, C-reactive protein concentration, pathogenic genital bacteria. Includes potential confounding factors: gestational age, antibiotic prescription at admission, type of management (expectant or active)</li> </ul>
Shakib 2015 (n=698)	<ul style="list-style-type: none"> <li>Retrospective cohort</li> <li>Duration of follow-up not reported but study investigated early-onset infection</li> </ul>	<ul style="list-style-type: none"> <li>Newborn babies with a gestational age <math>\geq 34</math> weeks</li> <li>Born to mothers with clinical chorioamnionitis based on a discharge ICD-9 diagnosis code of 762.7, 658.40, 658.41, or 658.43</li> </ul>	<ul style="list-style-type: none"> <li>Kaiser Permanente neonatal sepsis calculator</li> <li>No information on baseline incidence of infection</li> </ul>
Sloane 2019 (n=896)  <i>Follow-up study from Carola 2018</i>	<ul style="list-style-type: none"> <li>Retrospective cohort</li> <li>Follow-up time not reported but study investigated early-onset infection</li> </ul>	<ul style="list-style-type: none"> <li>Newborn babies with a gestational age <math>\geq 34</math> weeks</li> <li>Born to mothers with clinical chorioamnionitis diagnosis made by an obstetrician based on intrapartum fever (temperature of <math>38^{\circ}\text{C}</math>) alone or in conjunction with maternal leukocytosis, uterine tenderness, foul-smelling amniotic fluid, and maternal or fetal tachycardia</li> </ul>	<ul style="list-style-type: none"> <li>Kaiser Permanente neonatal sepsis calculator</li> <li>Baseline incidence of infection set at 4/1000 live births. Based on the EOS incidence of 4.3/1000 live births in the population of infants exposed to chorioamnionitis in the NICU in the study</li> </ul>
Strunk 2018 (n=1732)	<ul style="list-style-type: none"> <li>Prospective cohort</li> <li>Follow-up from birth to 1688 hours of life (separated into <math>&lt;24</math> hours and <math>&gt;24</math> hours after birth)</li> </ul>	<ul style="list-style-type: none"> <li>Newborn babies with a gestational age <math>\geq 35</math> weeks</li> </ul>	<ul style="list-style-type: none"> <li>Kaiser Permanente neonatal sepsis calculator</li> <li>Baseline incidence of infection set at 0.44/1000 live births (based on local 2005-2014 rate)</li> </ul>

1 See [appendix D](#) for full evidence tables.

## 2 1.1.6 Summary of the prognostic evidence

### 3 1.1.6.1 Model summaries

#### 4 Kaiser Permanente neonatal sepsis model

1 The Kaiser Permanente neonatal sepsis model was developed in the USA and is designed to  
2 predict the risk of early-onset neonatal infection for any baby born at or after 34 weeks'  
3 gestational age. The model was developed from data that can be obtained from a patient's  
4 electronic medical record and requires a clinician to enter information on the local incidence  
5 of early-onset infection, gestational age of the baby, highest maternal antepartum  
6 temperature, duration of rupture of membranes, maternal group B streptococcal (GBS) status  
7 and the type and duration of intrapartum antibiotics given to the mother. This information is  
8 used to calculate a baby's risk of infection at birth. The clinician then determines whether the  
9 baby is well appearing, equivocal or has clinical illness and this information is used to provide  
10 guidance on how the baby should be treated. The calculator produces three  
11 recommendations depending on the baby's risk of infection; if a baby is at low risk then 'no  
12 culture or antibiotics' are recommended, if they are at moderate risk of infection then 'blood  
13 culture' is recommended alongside vitals every 4 hours for 24 hours and if the baby is at high  
14 risk then the recommendation is for 'empiric antibiotics'.

### 15 **Popowski 2011 model**

16 The model reported by Popowski was developed in France and designed for babies born at  
17 or after 34 weeks' gestational age whose mothers had prelabour rupture of membranes. The  
18 model was developed from information from serum samples and vaginal swabs at admission  
19 and data that could be obtained from a patient's electronic medical record. The final model  
20 includes white blood cell count and C-reactive protein levels. The study reported information  
21 on the algorithms used for the model but there is no evidence of a web-based tool or  
22 software that can be used directly by a clinician.

### 23 **1.1.6.2 Summary of clinical findings included in the evidence review**

24 Sensitivity, specificity and likelihood ratios

Comparison	No. studies	Sample size	Sensitivity (95%CI)	Specificity (95%CI)	Effect size (95% CI)	Quality
<b>Current NICE 2012 guidelines</b>						
Overall analysis	1	3588	0.60 (0.23, 0.88)	0.84 (0.83, 0.85)	LR+ 3.80 (1.80, 7.70)	Moderate
					LR- 0.48 (0.16, 1.39)	Low
<b>Kaiser Permanente neonatal sepsis calculator: babies recommended antibiotic treatment</b>						
Overall analysis	9	16697	0.56 (0.37, 0.73)	0.90 (0.81, 0.95)	LR+ 6.07 (2.84, 11.70)	Very low
					LR- 0.50 (0.31, 0.70)	Very low
Lower baseline incidence of sepsis (0.44-0.6/1000 live births)	8	16583	0.47 (0.29, 0.65)	0.94 (0.90, 0.97)	LR+ 8.57 (4.36, 15.10)	Very low
					LR- 0.56 (0.37, 0.75)	Very low
Higher baseline incidence of sepsis (4.0/1000 live births)	1	896	1.00 (0.57, 1.00)	0.41 (0.38, 0.44)	LR+ 1.69 (1.60, 1.78)	Moderate
					LR- <i>not calculable</i>	N/A
Babies born to mothers with chorioamnionitis	4	5552	0.48 (0.21, 0.77)	0.95 (0.79, 0.99)	LR+ 6.82 (2.20, 21.08)	Very low
					LR- 0.75 (0.51, 1.11)	Very low

Comparison	No. studies	Sample size	Sensitivity (95%CI)	Specificity (95%CI)	Effect size (95% CI)	Quality
<b>Current NICE 2012 guidelines</b>						
Overall analysis	1	3588	0.60 (0.23, 0.88)	0.84 (0.83, 0.85)	LR+ 3.80 (1.80, 7.70)	Moderate
					LR- 0.48 (0.16, 1.39)	Low
<b>Kaiser Permanente neonatal sepsis calculator: babies recommended either antibiotic treatment and blood culture or blood culture and vital sign monitoring every 4 hours</b>						
Overall analysis	5	5354	0.73 (0.40, 0.92)	0.66 (0.27, 0.91)	LR+ 2.44 (1.05, 6.24)	Very low
					LR- 0.47 (0.16, 0.92)	Very low
Lower baseline incidence of sepsis (0.44-0.5/1000 live births)	4	4458	0.69 (0.34, 0.90)	0.81 (0.72, 0.87)	LR+ 3.38 (2.13, 5.39)	Low
					LR- 0.64 (0.33, 1.25)	Very low
Higher baseline incidence of sepsis (4.0/1000 live births)	1	896	1.00 (0.57, 1.00)	0.07 (0.06, 0.09)	LR+ 1.07 (1.06, 1.09)	Moderate
					LR- <i>not calculable</i>	N/A
Babies born to mothers with chorioamnionitis	3	1956	0.67 (0.30, 0.91)	0.81 (0.65, 0.91)	LR+ 3.32 (1.65, 6.70)	Very low
					LR- 0.68 (0.34, 1.37)	Very low
<b>Popowski 2011 model – mothers with premature rupture of membranes (based on C-reactive protein and white blood cell count)</b>						
Overall analysis	1	399	0.94 (0.73, 0.99)	0.43 (0.38, 0.48)	LR+ 1.6 (1.4, 1.9)	High
					LR- 0.1 (0.02, 0.92)	Moderate

1 C-statistics

Comparison	No. studies	Sample size	c-statistic (95%CI)	Quality
<b>Popowski 2011 model – mothers with premature rupture of membranes (based on C-reactive protein and white blood cell count)</b>				
Overall analysis	1	399	0.82 (0.72, 0.92)	Moderate

2 See [appendix F](#) for full GRADE tables.

3 **1.1.7 Economic evidence**

4 **1.1.7.1 Included studies**

5 A single search was performed to identify published economic evaluations of relevance to  
6 any of the questions in this guideline update (see Appendix B). This search retrieved 4,398  
7 studies. Based on title and abstract screening, all of the studies could confidently be  
8 excluded for this question, as none of them were found to be relevant.

9 The search was re-run in July 2020 to identify any studies which had been published since  
10 the date of the original search. This returned a total of 577 results. Based on title and

1 abstract screening, all the studies could confidently be excluded for this question. Thus, the  
2 review for this question does not include any study from the existing literature.

3 **1.1.8 Economic model**

4 This question was not prioritised for original economic analysis

5

## 1 2.1 Review question

2 Which maternal and fetal risk factors for early-onset neonatal infection should be used to  
3 guide management in the baby?

### 4 2.1.1 Introduction

5 Neonatal infection is a significant cause of mortality and morbidity in newborn babies. It can  
6 lead to life-threatening sepsis, which accounts for 10% of all neonatal deaths. For the  
7 purpose of this guideline, early-onset neonatal infection is defined as infection which occurs  
8 in babies up to 72 hours of age (corrected for gestational age).

9 Predicting which babies are most at risk of early-onset neonatal infection is important to help  
10 determine who should receive antibiotic treatment. A culture taken from blood or  
11 cerebrospinal fluid which tests positive for the organisms associated with infection is the  
12 gold-standard for identifying which babies should receive treatment. However, waiting for the  
13 results of these tests may delay treatment. Identifying the factors which can put a baby at  
14 high risk of neonatal infection is therefore important to help determine whether a baby should  
15 be given antibiotics while waiting for the results of a blood culture to confirm infection. The  
16 aim of this review is therefore to evaluate potential risk factors in the mother and the fetus  
17 and determine how well they can guide management of the baby.

### 18 2.1.2 Summary of the protocol

<b>Population</b>	<ul style="list-style-type: none"><li>• Unborn or newborn babies under 72 hours</li><li>• Pregnant women</li></ul>
<b>Risk factors</b>	<ul style="list-style-type: none"><li>• Behavioural and hygienic factors (for example adherence to infection control measures by medical professionals and parents/carers)</li><li>• Gestational age</li><li>• Intrapartum antibiotic prophylaxis (including the time before birth that it is received)</li><li>• Intrapartum fever higher than 38°C, or confirmed or suspected chorioamnionitis</li><li>• Invasive group B streptococcal (GBS) infection in a previous baby</li><li>• Maternal carriage of Methicillin-resistant Staphylococcus aureus (MRSA)</li><li>• Maternal GBS colonisation, bacteriuria, detection (including vaginal or rectal swab) or infection in the current pregnancy</li><li>• Maternal GBS colonisation, bacteriuria, detection (including vaginal or rectal swab) or infection in a previous pregnancy (including where the baby was well)</li><li>• Maternal obesity</li><li>• Maternal perineal infections</li><li>• Maternal suspected bacterial infection in the puerperium period</li><li>• Parenteral antibiotic treatment given to the woman for confirmed or suspected invasive bacterial infection (such as septicaemia) at any time during labour, or in the 24-hour periods before and after the birth [This does not refer to intrapartum antibiotic prophylaxis]</li><li>• Preterm prelabour rupture of membranes</li><li>• Suspected or confirmed infection in another baby in the case of a multiple pregnancy</li></ul>

	<ul style="list-style-type: none"><li>• Suspected or confirmed rupture of membranes for more than 18 hours in a preterm birth</li></ul>
<b>Reference standard</b>	<ul style="list-style-type: none"><li>• culture-proven infection from a sample taken within 72 hours of birth where available or within the study-defined period for early onset neonatal infection</li><li>• antibiotics for suspected bloodstream infection (in neonate) given within 72 hours of birth where available or within the study-defined period for early onset neonatal infection</li></ul>
<b>Outcomes</b>	Outcomes for predictive accuracy studies: <ul style="list-style-type: none"><li>• Sensitivity</li><li>• Specificity</li><li>• Positive and negative predictive values</li><li>• Positive and negative likelihood ratios</li></ul> If association studies are included due to a lack of predictive accuracy data: <ul style="list-style-type: none"><li>• Adjusted Risk ratios, Odds ratios, hazard ratios</li></ul>

### 1 **2.1.3 Methods and process**

2 This evidence review was developed using the methods and process described in  
3 [Developing NICE guidelines: the manual](#). Methods specific to this review question are  
4 described in the review protocol in [Appendix A](#). For full details of the methods used in this  
5 review, see the [methods document](#).

6 Declarations of interest were recorded according to [NICE's 2018 conflicts of interest policy](#).

7 Predictive accuracy studies were considered in addition to systematic reviews. For outcomes  
8 where no predictive accuracy studies were available, multivariate cohort studies that reported  
9 adjusted measures of association were included. The review protocol specified that, where  
10 possible, subgroup analyses would be conducted for gestational age of the baby (preterm vs  
11 term) and multiple births. Some evidence was available for single and multiple births, and  
12 where studies have included babies of different gestational ages this has been highlighted in  
13 the results.

14 Some studies reported outcomes that matched the protocol but were only reported as part of  
15 univariate analysis and not included in multivariate analysis. These outcomes are stated in  
16 the clinical evidence tables ([Appendix D](#)) but not reported in the analysis as they did not  
17 meet the criteria for multivariate analyses.

### 18 **2.1.4 Prognostic evidence**

#### 19 **2.1.4.1 Included studies**

20 A joint search was carried out to identify studies specified for this review question, and a  
21 similar review question for studies assessing risk factors and signs and symptoms in the  
22 baby for early-onset infection (for details, see [section 3.1](#) of this evidence review). This  
23 returned a total of 1,825 results, of which 55 were identified as potential included studies. Full  
24 text articles were ordered and reviewed against the inclusion criteria, of which 11 met the  
25 inclusion criteria for this review.

26 The search was re-run in July 2020 to identify any studies which had been published since  
27 the date of the original search. This combined search for late-onset maternal and fetal risk  
28 factors and risk factors in the baby returned a total of 143 results, of which 3 were identified  
29 as possible included studies. After full text review, all 3 were excluded. In total there were  
30 therefore 11 studies which met the inclusion criteria for this review (3 prospective cohort

1 studies, 8 retrospective cohort studies). No studies reported predictive accuracy data and so  
2 prognostic association data was considered instead.

3 Most of the multivariate cohort studies identified reported on the association between early-  
4 onset neonatal infection and chorioamnionitis (6 studies) or singleton births (3 studies). One  
5 study reported on the association between maternal obesity and early-onset infection and  
6 another examined the effects of intrapartum fever.

#### 7 2.1.4.2 Excluded studies

8 See [Appendix J](#) for excluded studies and reasons for exclusion.

#### 9 2.1.5 Summary of studies included in the prognostic evidence

Study	Study type and follow-up time	Population	Predictive factors
Dempsey 2005 (n=392)	<ul style="list-style-type: none"> <li>Retrospective cohort</li> <li>72 hour follow-up</li> </ul>	<ul style="list-style-type: none"> <li>All singleton neonates delivered at &lt;30 weeks gestational age</li> </ul>	<ul style="list-style-type: none"> <li>Chorioamnionitis</li> </ul>
Dior 2016 (n=46,560)	<ul style="list-style-type: none"> <li>Retrospective cohort</li> <li>72 hour follow-up</li> </ul>	<ul style="list-style-type: none"> <li>Women in labour who had a singleton live birth</li> <li>&lt;50 years old</li> <li>Had a term pregnancy (<math>\geq 37</math> weeks' gestation)</li> <li>Baby with a birth weight &lt;5000 g</li> <li>Spent &gt;1 hour in the delivery room</li> </ul>	<ul style="list-style-type: none"> <li>Intrapartum fever</li> </ul>
Garcia-Munoz 2014a (n=451)	<ul style="list-style-type: none"> <li>Prospective cohort</li> <li>72 hour follow up</li> </ul>	<ul style="list-style-type: none"> <li>Born in maternity unit or admitted to Neonatal Intensive Care Unit in the first 28 days of life</li> <li>Birth weight &lt;1500 g</li> <li>or &lt;30 weeks' gestational age</li> </ul>	<ul style="list-style-type: none"> <li>Chorioamnionitis</li> </ul>
Garcia-Munoz 2014b (n=8330)	<ul style="list-style-type: none"> <li>Retrospective cohort</li> <li>Duration of follow-up not reported</li> </ul>	<ul style="list-style-type: none"> <li>Birth weight &lt;1500 g</li> <li>&lt;32 weeks' gestational age</li> <li>Admitted to a neonatal unit</li> </ul>	<ul style="list-style-type: none"> <li>Chorioamnionitis</li> </ul>
Hakansson 2008 (n=344,127)	<ul style="list-style-type: none"> <li>Retrospective cohort</li> <li>Follow-up for first 27 days of life</li> </ul>	<ul style="list-style-type: none"> <li>Gestational age &gt;22 weeks</li> <li>Vaginal birth or emergency caesarean section</li> </ul>	<ul style="list-style-type: none"> <li>Maternal BMI (weight grouped by BMI. Obesity classified as BMI <math>\geq 30.0</math>)</li> </ul>
Klinger 2009* (n=15,839)	<ul style="list-style-type: none"> <li>Retrospective cohort</li> <li>Duration of follow up unclear</li> </ul>	<ul style="list-style-type: none"> <li>Infants whose data was collected by the Israel Neonatal Network on very low birth weight newborn infants (BW &lt;1500 g)</li> </ul>	<ul style="list-style-type: none"> <li>Chorioamnionitis</li> <li>Maternal fever</li> <li>Single/multiple birth</li> </ul>
Mularoni 2014 (n=14,719)	<ul style="list-style-type: none"> <li>Prospective cohort</li> <li>72 hour follow-up</li> </ul>	<ul style="list-style-type: none"> <li>Babies weighing 401 - 1500 g</li> <li>Babies with a positive blood culture and clinical signs of</li> </ul>	<ul style="list-style-type: none"> <li>Twin/singleton births</li> </ul>

Study	Study type and follow-up time	Population	Predictive factors
		sepsis during the first 72 hours of life	
Ofman 2016* (n=2192)	<ul style="list-style-type: none"> <li>Retrospective cohort</li> <li>72 hour follow-up</li> </ul>	<ul style="list-style-type: none"> <li>Moderately preterm infants</li> </ul>	<ul style="list-style-type: none"> <li>Chorioamnionitis</li> </ul>
Ronnestad 2005 (n=462)	<ul style="list-style-type: none"> <li>Prospective cohort</li> <li>Follow-up for first week of life</li> </ul>	<ul style="list-style-type: none"> <li>Birth weight &lt;1000 g</li> </ul>	<ul style="list-style-type: none"> <li>Chorioamnionitis</li> <li>Gestational age</li> </ul>
Soraisham 2009 (n=3094)	<ul style="list-style-type: none"> <li>Retrospective cohort</li> <li>Follow-up for first 48 hours after birth</li> </ul>	<ul style="list-style-type: none"> <li>All singleton infants with birth gestational age &lt;33 weeks</li> <li>No congenital anomalies</li> </ul>	<ul style="list-style-type: none"> <li>Chorioamnionitis</li> </ul>

1 \*Also included in review question on risk factors in the baby for neonatal infection

2 See [appendix D](#) for full evidence tables.

3 **2.1.6 Summary of the prognostic evidence for predicting the development of**  
4 **early-onset neonatal infection**

Risk factor	No. studies	Sample size	Effect size (95% CI)	Quality
<b>Chorioamnionitis</b>				
Histological chorioamnionitis (babies <30 weeks' gestational age)	1 (Dempsey 2005)	392	Adjusted OR 6.9 (2.2, 20.0)	Moderate
Clinical chorioamnionitis in very low birth weight babies	1 (Garcia-Munoz 2014a)	451	Adjusted RR 6.13 (1.67, 22.58)	Moderate
	1 (Garcia-Munoz 2014b)	8330	Adjusted OR 3.10 (2.31-4.17)	Moderate
Clinical chorioamnionitis in preterm babies	1 (Soraisham 2009)	3094	Adjusted OR 5.54 (2.87-10.69)	Moderate
Clinical chorioamnionitis in moderately preterm babies	1 (Ofman 2016)	2192	Adjusted OR 4.1 (2.83-5.30)	Low
Clinical chorioamnionitis in extremely preterm babies	1 (Ronnestad 2005)	451	Adjusted OR 10.5 (3.3-33.4)	Moderate
<b>Intrapartum fever</b>				
Low febrile fever (38.0-38.9°C)	1 (Dior 2016)	43,560	Adjusted OR 7.44 (3.29, 16.85)	Moderate

Risk factor	No. studies	Sample size	Effect size (95% CI)	Quality
High febrile fever (>39°C)	1 (Dior 2016)	43,560	Adjusted OR 16.08 (2.15, 120.3)	Moderate
<b>Maternal obesity</b>				
Overweight mothers (BMI 25-29.9)	1 (Hakansson 2008)	344,127	Adjusted OR 1.3 (0.9, 2.0)	Low
Obese mothers (BMI 30.0)	1 (Hakansson 2008)	344,127	Adjusted OR 1.8 (1.1, 3.0)	Moderate
<b>Single vs multiple births</b>				
Very low birth weight babies	1 (Mularoni 2014)	14,719	Adjusted OR 1.4 (1.1, 1.8)	Moderate
	1 (Klinger 2009)	15,839	Adjusted OR 1.4 (1.1, 1.8)	Moderate
Babies born ≥22 weeks' gestational age	1 (Hakansson 2006)	319	Adjusted OR 1.1 (0.6, 2.0)	Moderate

1 See [appendix F](#) for full GRADE tables.

## 2 2.1.7 Economic evidence

### 3 2.1.7.1 Included studies

4 A single search was performed to identify published economic evaluations of relevance to  
5 any of the questions in this guideline update (see [appendix B](#)). This search retrieved 4,398  
6 studies. Based on title and abstract screening, all of the studies could confidently be  
7 excluded for this question, as none of them were found to be relevant.

8 The search was re-run in July 2020 to identify any studies which had been published since  
9 the date of the original search. This returned a total of 577 results. Based on title and  
10 abstract screening, all the studies could confidently be excluded for this question. Thus, the  
11 review for this question does not include any study from the existing literature.

## 12 2.1.8 Economic model

13 No economic modelling was undertaken for this review because of a lack of economic  
14 evidence and because the committee agreed that other topics were higher priorities for  
15 economic evaluation.

## 1 3.1 Review question

2 Which risk factors in the baby (including symptoms and signs) should raise suspicion of  
3 early-onset neonatal infection?

### 4 3.1.1 Introduction

5 Neonatal infection is a significant cause of mortality and morbidity in newborn babies. It can  
6 lead to life-threatening sepsis, which accounts for 10% of all neonatal deaths. For the  
7 purpose of this guideline, early-onset neonatal infection is defined as infection which occurs  
8 within 72 hours of birth (corrected for gestational age).

9 Predicting which babies are most at risk of early-onset neonatal infection is important to help  
10 determine who should receive antibiotic treatment. A culture taken from blood or  
11 cerebrospinal fluid which tests positive for the organisms associated with infection is the  
12 gold-standard for identifying which babies should receive treatment. However, waiting for the  
13 results of these tests may delay treatment. Identifying the factors which can put a baby at  
14 high risk of neonatal infection is therefore important to help determine whether a baby should  
15 be given antibiotics while waiting for the results of a blood culture to confirm infection. These  
16 factors can either be diagnostic, such as the signs and symptoms that babies commonly  
17 display when they have an infection, or prognostic, such as factors that are commonly  
18 associated with babies subsequently developing an infection. The aim of this review is  
19 therefore to evaluate potential risk factors as well as signs and symptoms in the baby to  
20 determine how they can guide management of the baby.

### 21 3.1.2 Summary of the protocol

<b>Population</b>	<ul style="list-style-type: none"> <li>• Newborn babies under 72 hours, or study definition for 'early onset' infection</li> </ul>
<b>Risk factors</b>	<p><b>Signs and symptoms (diagnostic)</b></p> <ul style="list-style-type: none"> <li>• Abnormal heart rate (bradycardia or tachycardia)</li> <li>• Altered behaviour or responsiveness</li> <li>• Altered glucose homeostasis (hypoglycaemia or hyperglycaemia)</li> <li>• Altered muscle tone (for example, floppiness)</li> <li>• Apnoea</li> <li>• Feed intolerance, including vomiting, excessive gastric aspirates and abdominal distension</li> <li>• Feeding difficulties (for example, feed refusal)</li> <li>• Jaundice</li> <li>• Local signs of infection (for example, affecting the skin or eye)</li> <li>• Metabolic acidosis (base deficit of 10 mmol/litre or greater)</li> <li>• Need for cardio-pulmonary resuscitation</li> <li>• Need for mechanical ventilation</li> <li>• Oliguria</li> <li>• Reduced oxygen saturation level</li> <li>• Seizures</li> <li>• Signs of neonatal encephalopathy</li> <li>• Signs of respiratory distress</li> <li>• Signs of shock</li> <li>• Temperature abnormality (lower than 36°C or higher than 38°C) unexplained by environmental factors</li> </ul>

	<ul style="list-style-type: none"> <li>Unexplained excessive bleeding, thrombocytopenia, or abnormal coagulopathy (International Normalised Ratio greater than 2.0)</li> </ul> <p><b>Risk factors (prognostic)</b></p> <ul style="list-style-type: none"> <li>Gestational age</li> <li>Colonisation with Group B streptococcus (GBS) or Methicillin-resistant Staphylococcus aureus (MRSA) in the baby</li> <li>Persistent fetal circulation (persistent pulmonary hypertension)</li> </ul>
<b>Reference standard</b>	<ul style="list-style-type: none"> <li>culture-proven infection from a sample taken within 72 hours of birth where available or within the study-defined period for early onset neonatal infection</li> <li>antibiotics for suspected bloodstream infection (in neonate) given within 72 hours of birth where available or within the study-defined period for early onset neonatal infection</li> </ul>
<b>Outcomes</b>	<p>Outcomes for diagnostic/predictive accuracy studies:</p> <ul style="list-style-type: none"> <li>Sensitivity</li> <li>Specificity</li> <li>Positive and negative predictive values</li> <li>Positive and negative likelihood ratios</li> </ul> <p>If association studies are included due to a lack of predictive accuracy data:</p> <ul style="list-style-type: none"> <li>Adjusted Risk ratios, Odds ratios, hazard ratios</li> </ul>

### 1 **3.1.3 Methods and process**

2 This evidence review was developed using the methods and process described in  
 3 [Developing NICE guidelines: the manual](#). Methods specific to this review question are  
 4 described in the review protocol in [Appendix A](#). For full details of the methods used in this  
 5 review, see the [methods document](#).

6 Declarations of interest were recorded according to [NICE's 2018 conflicts of interest policy](#).

7 Predictive accuracy studies were considered in addition to systematic reviews. For outcomes  
 8 where no predictive accuracy studies were available, multivariate cohort studies that reported  
 9 adjusted measures of association were included. The review protocol specified that, where  
 10 possible, subgroup analyses would be conducted for gestational age of the baby (preterm vs  
 11 term), multiple births and babies who have been admitted to hospital from home. Data was  
 12 available for gestational age, but no data was reported for babies admitted to hospital from  
 13 home. Some evidence was available for multiple births, and this was reported as part of the  
 14 maternal risk factors review (for details, see [section 2.1](#)). Evidence was separated by those  
 15 which reported prognostic (risk factors for infection) and diagnostic (signs and symptoms of  
 16 infection) factors.

### 17 **3.1.4 Prognostic and diagnostic evidence**

#### 18 **3.1.4.1 Included studies**

19 A joint search was carried out to identify studies specified for this review question, and a  
 20 similar review question for studies assessing maternal and fetal risk factors for early-onset  
 21 infection (for details, see [section 2.1](#)). This returned a total of 1,825 results, of which 55 were  
 22 identified as potential included studies. Full text articles were ordered and reviewed against  
 23 the inclusion criteria, of which 4 met the inclusion criteria for this review. No studies reported  
 24 diagnostic or predictive accuracy data.

1 The search was re-run in July 2020 to identify any studies which had been published since  
2 the date of the original search. This combined search for late-onset maternal and fetal risk  
3 factors, and risk factors in the baby returned a total of 143 results, of which 3 were identified  
4 as possible included studies. After full text review, all 3 were excluded. In total there were  
5 therefore 4 studies which met the inclusion criteria for this review (1 prospective cohort study,  
6 3 retrospective cohort studies). No studies reported predictive accuracy data and so  
7 prognostic and diagnostic association data was considered instead.

8 Of the 4 multivariate cohort studies identified, most were prognostic and reported on the  
9 association between early-onset neonatal infection and gestational age (3 studies). One  
10 diagnostic study reported on the association between respiratory distress syndrome and  
11 early-onset infection.

### 12 3.1.4.2 Excluded studies

13 See [Appendix J](#) for excluded studies and reasons for exclusion.

### 14 3.1.5 Summary of studies included in the prognostic and diagnostic evidence

Study	Study type and follow-up time	Population	Predictive factors
Hakansson 2006 (n=319)	<ul style="list-style-type: none"> <li>Retrospective cohort (prognostic)</li> <li>Follow-up for first 27 days of life</li> </ul>	<ul style="list-style-type: none"> <li>Gestational age &gt;21 weeks</li> </ul>	<ul style="list-style-type: none"> <li>Gestational age</li> <li>Twin/singleton births (subgroup analysis)</li> </ul>
Klinger 2009* (n=15,839)	<ul style="list-style-type: none"> <li>Retrospective cohort (prognostic)</li> <li>Duration of follow up unclear</li> </ul>	<ul style="list-style-type: none"> <li>Infants whose data was collected by the Israel Neonatal Network on very low birth weight newborn infants (BW &lt;1500 g)</li> </ul>	<ul style="list-style-type: none"> <li>Single/multiple birth</li> <li>Gestational age</li> </ul>
Ofman 2016* (n=2192)	<ul style="list-style-type: none"> <li>Retrospective cohort (diagnostic)</li> <li>72 hour follow-up</li> </ul>	<ul style="list-style-type: none"> <li>Moderately preterm infants</li> </ul>	<ul style="list-style-type: none"> <li>Respiratory distress syndrome</li> </ul>
Ronnestad 2005* (n=462)	<ul style="list-style-type: none"> <li>Prospective cohort (prognostic)</li> <li>Follow-up for first week of life</li> </ul>	<ul style="list-style-type: none"> <li>Birth weight &lt;1000 g</li> </ul>	<ul style="list-style-type: none"> <li>Gestational age</li> </ul>

15 \*Also included in review question on maternal and fetal risk factors for neonatal infection

16 See [appendix D](#) for full evidence tables.

### 17 3.1.6 Summary of the prognostic evidence for predicting the development of 18 early-onset neonatal infection

#### 19 3.1.6.1 Risk factors

Risk factor	No. studies	Sample size	Effect size (95% CI)	Quality
Gestational age				

Risk factor	No. studies	Sample size	Effect size (95% CI)	Quality
Very early onset infection in extremely premature babies	1 (Rønnestad 2005)	462	Adjusted OR <sup>1</sup> 1.1 (0.4, 3.6)	Low
Early onset infection in extremely premature babies	1 (Rønnestad 2005)	462	Adjusted OR <sup>1</sup> 3.0 (0.6, 14.9)	Low
Very low birthweight babies (1-week increase)	1 (Klinger 2009)	15,839	Adjusted OR <sup>1</sup> 0.98 (0.94, 1.03)	Low
Babies born ≥22 weeks' gestational age (<28 weeks vs 40 weeks)	1 (Hakansson 2006)	319	Adjusted OR <sup>1</sup> 22.1 (8.5, 57.4)	Moderate
Babies born ≥22 weeks' gestational age (28-31 weeks vs 40 weeks)	1 (Hakansson 2006)	319	Adjusted OR <sup>1</sup> 34.1 (18.6, 62.7)	Moderate
Babies born ≥22 weeks' gestational age (32-34 weeks vs 40 weeks)	1 (Hakansson 2006)	319	Adjusted OR <sup>1</sup> 11.2 (6.0, 21.0)	Moderate
Babies born ≥22 weeks' gestational age (35-36 weeks vs 40 weeks)	1 (Hakansson 2006)	319	Adjusted OR <sup>1</sup> 4.7 (2.5, 8.9)	Moderate
Babies born ≥22 weeks' gestational age (37 weeks vs 40 weeks)	1 (Hakansson 2006)	319	Adjusted OR <sup>1</sup> 3.5 (1.8, 6.5)	Moderate
Babies born ≥22 weeks' gestational age (≥42 weeks vs 40 weeks)	1 (Hakansson 2006)	319	Adjusted OR <sup>1</sup> 1.9 (0.9, 3.7)	Low

### 1 3.1.6.2 Signs and symptoms

Comparison	No. studies	Sample size	Effect size (95% CI)	Quality
Respiratory distress syndrome in moderately preterm babies	1 (Ofman 2016)	2192	Adjusted OR 2.05 (1.62-3.14)	Low

2 See [appendix F](#) for full GRADE tables.

### 3 3.1.7 Economic evidence

#### 4 3.1.7.1 Included studies

5 A single search was performed to identify published economic evaluations of relevance to  
6 any of the questions in this guideline update (see [appendix B](#)). This search retrieved 4,398  
7 studies. Based on title and abstract screening, all of the studies could confidently be  
8 excluded for this question, as none of them were found to be relevant.

1 The search was re-run in July 2020 to identify any studies which had been published since  
2 the date of the original search. This returned a total of 577 results. Based on title and  
3 abstract screening, all the studies could confidently be excluded for this question. Thus, the  
4 review for this question does not include any study from the existing literature.

5 **3.1.8 Economic model**

6 This question was not prioritised for original economic analysis.

## 1 **4.1 The committee’s discussion and interpretation of the** 2 **evidence**

### 3 **4.1.1. The outcomes that matter most**

4 The committee discussed the potential effects of true positive, true negative, false positive  
5 and false negative outcomes from tools designed to predict a baby’s risk of early-onset  
6 infection. A model that correctly identifies all those with infection (true positives) would result  
7 in antibiotics being prescribed to all those who need treatment, reducing the serious harms  
8 associated with neonatal infection. If a model correctly identifies all those without infection  
9 (true negatives) then it will avoid over-prescribing of antibiotics. This is a particular issue  
10 when evaluating neonatal infection as it can be difficult to diagnose and can therefore result  
11 in many babies being prescribed antibiotics to avoid any infections being missed and left  
12 untreated.

13 If a model does not accurately predict true positives and true negatives, then there are a  
14 number of potential harms. False positive results will result in babies being given antibiotics  
15 unnecessarily, and either admission to hospital or prolonged admission in hospital will lead to  
16 separation of the mother and baby, potentially causing anxiety and distress to the family. The  
17 mother may also have to remain in hospital for longer than she otherwise would. This has an  
18 impact on the family as well as the increasing costs of a longer hospital stay. False positives  
19 can also contribute to the development of antibiotic resistance. However, a false negative  
20 result is the biggest concern for parents and clinicians as there can be serious consequences  
21 if neonatal infection is left untreated. The most serious consequence is death of the baby, but  
22 delayed treatment can also have long-term health consequences, such as neuro-disability,  
23 which can have both emotional and financial impacts on the family as well as downstream  
24 treatment costs for the healthcare system. The committee therefore discussed how negative  
25 likelihood ratios should be prioritised over positive likelihood ratios as they believed that it  
26 was important that negative test results were accurate, and that neonatal infection was not  
27 incorrectly ruled out. As a result, the committee used a combination of likelihood ratios,  
28 sensitivity and specificity to examine the effectiveness of each clinical prediction model.  
29 Some studies also reported c-statistics. The committee agreed that this outcome was less  
30 useful as it weighs false negatives and false positives as equally important, which the  
31 committee agreed was not appropriate.

32 The committee highlighted that while babies tend to be discharged between 6-12 hours after  
33 birth if they appear healthy, there are often no follow-up observations in the community  
34 during the first 72 hours of life. It is therefore important for any prognostic model or risk factor  
35 tool to avoid false negative results, thereby ensuring that any babies at high risk of infection  
36 remain in the hospital for treatment and monitoring.

37 The committee were also interested in the diagnostic accuracy of risk factors and signs and  
38 symptoms for early-onset infection. No studies reported sensitivity, specificity, predictive  
39 values or likelihood ratios for these outcomes. Instead, studies reported adjusted odds ratios,  
40 and risk ratios. These do not provide an indication of how well each risk factor or symptom  
41 can correctly identify a baby with or without early-onset neonatal infection. However, the  
42 committee were interested in these outcomes as they indicate which factors have the  
43 strongest association with infection. This helped them to decide which were the most  
44 important risk factors and signs to include in the risk factor and clinical indicators boxes in the  
45 recommendations. As the committee only wanted to consider the factors which were most  
46 relevant to early-onset infection, studies were only included if they had used a multivariate  
47 analysis which had adjusted for other potential risk factors for infection.

1 **4.1.2 The quality of the evidence**

2 **4.1.2.1 Clinical prediction models**

3 The outcomes from the evidence for prognostic models ranged from high to very low quality,  
4 with most outcomes either low or very-low quality. The quality of outcomes were commonly  
5 downgraded for imprecision in the results and for including studies at moderate risk of bias.  
6 All of the studies were directly applicable to the research question. Most of the evidence  
7 examined the use of the Kaiser Permanente neonatal sepsis calculator, with only one study  
8 reporting the details of a different prognostic model. One other study also compared the use  
9 of the calculator to the NICE recommendations. The committee therefore decided that only  
10 the neonatal sepsis calculator had sufficient evidence to be considered as an alternative to  
11 the NICE risk factors and clinical indicators.

12 Four studies examined the use of the Kaiser Permanente neonatal sepsis calculator in all  
13 babies over 34-, 35- or 36-weeks' gestational age. Five studies examined the use of the  
14 calculator specifically for babies who were born to mothers with chorioamnionitis. The  
15 committee discussed whether the results from the chorioamnionitis studies could be applied  
16 to all babies but, as the results did not differ greatly from the three studies that included all  
17 babies, the committee thought that the results could be generalised. Six of the studies in the  
18 review were based in the USA where the calculator was developed. Only one study (Goel  
19 2020) examined the use of the calculator in the UK. The committee discussed whether  
20 differences in the demographics of the population, in addition to differences in group B  
21 streptococcal (GBS) screening policies, could mean that the outcomes of the calculator may  
22 differ between the UK and the USA. GBS status is one of the factors in the neonatal sepsis  
23 calculator and the committee were unsure whether the unknown status in the UK would  
24 make assumptions about the mother that might change the outcome of the neonatal sepsis  
25 calculator. However, GBS status only contributes approximately 2% to the predictive weight  
26 of the model. This, in addition to the similarities in results between the UK study and the USA  
27 validation studies, meant that the committee did not feel it should recommend against the  
28 use of the neonatal sepsis calculator based on GBS status.

29 An important aspect of the neonatal sepsis calculator is the need for clinicians to enter a  
30 background rate for the incidence of early-onset neonatal infection. Further research is  
31 needed in the UK to identify what rate should be applied to reflect the local prevalence of  
32 neonatal infection, and whether this should be a single rate that is used across the UK or if it  
33 should vary by hospital. The committee did not feel that this should be a reason to  
34 recommend against the use of the neonatal sepsis calculator but potential differences in the  
35 incidence rate of infection between the UK and the USA, and the differences in GBS  
36 screening policies, meant that the studies that reported on the use of the calculator in the  
37 USA were downgraded as being partially applicable to the research question. The  
38 committee decided that the rate of infection should be considered as part of future research  
39 into the use of the neonatal sepsis calculator in the UK. This will help to ensure the accuracy  
40 of the outcomes of the calculator when used in NHS practice. For clinicians who are currently  
41 using the calculator, the committee decided to recommend that they should use either the  
42 national or local rate of infection, whichever is higher. This will help to increase the sensitivity  
43 of the calculator, thereby reducing the risk of a baby who has infection not being  
44 recommended for antibiotic treatment.

45 The imprecision of some of the results from the neonatal sepsis calculator studies was  
46 discussed, particularly when comparing the overall results of the calculator to the NICE  
47 guidelines. The neonatal sepsis calculator identified a slightly lower number of true positives  
48 to the NICE guidelines, and the likelihood ratios indicated that a positive outcome with the  
49 neonatal sepsis calculator would indicate a slightly higher chance of a baby having infection  
50 than a positive test from the NICE guidelines. However, the wide confidence intervals  
51 suggested variation in the results. This was particularly evident for the negative likelihood  
52 ratio for the NICE guidelines, which suggested that a negative outcome would indicate

1 anything between a large decrease in the probability of a baby having infection to a slight  
2 increase in their chance of having infection. This made it difficult for the committee to decide  
3 on recommendations based on likelihood ratios alone. This imprecision in the results may be  
4 due to the very low incidence of culture-confirmed early-onset neonatal infection in the  
5 studies, with many studies reporting only one baby with a confirmed infection. Given that  
6 both the NICE recommendations and the neonatal sepsis calculator were associated with a  
7 wide degree of imprecision, the committee did not think this should be a reason against  
8 recommending the neonatal sepsis calculator. Instead, they decided to recommend that the  
9 risk factors specified in boxes 1 and 2 is used to identify babies at risk of early-onset  
10 infection, but also stated that if the calculator is being used in clinical practice it should be  
11 used as part of a clinical audit. This will help give a clearer understanding of its effectiveness.  
12 Examples of the outcomes that should be collected in an audit (number of babies assessed  
13 using the calculator and number of true positive, false positive and false negative results  
14 when using the calculator) were included in the recommendation to ensure that the most  
15 relevant information on effectiveness is available. These outcomes were chosen as the ones  
16 needed to form a 2 x 2 table to examine the effectiveness of a prognostic tool. This  
17 information will be useful in future updates of this guideline to decide whether a stronger  
18 recommendation can be made in favour of the use of the Kaiser Permanente neonatal sepsis  
19 calculator.

20 Given the issues discussed above, the committee agreed that more evidence is needed  
21 before it could recommend the Kaiser Permanente neonatal sepsis calculator as the sole  
22 option for predicting risk of early-onset neonatal infection in the UK. More research is  
23 particularly important for babies born before 34 weeks' gestational age, as the neonatal  
24 sepsis calculator is only designed for babies born at a gestational age of 34 weeks or above.  
25 As such, the committee could not recommend the use of the calculator for this group of  
26 babies and this was stated as part of the calculator recommendations. Instead, a research  
27 recommendation relating to prognostic models was made which did not specify gestational  
28 age ([Appendix K](#)). This should help to ensure that the most effective prognostic tool can be  
29 determined for all babies, and not just those covered by the calculator.

#### 30 **4.1.2.2 Maternal and neonatal risk factors and clinical indicators**

31 The evidence for risk factors and signs and symptoms ranged from high to low quality and  
32 most studies were directly applicable to the research question. Each of the studies reported  
33 the use of a multivariate model but there was a wide range in the factors that the models  
34 were adjusted for, and most studies did not explain why those particular factors were chosen.  
35 The committee agreed that this could affect the validity of the data and so the quality of the  
36 outcomes from these studies were downgraded for risk of bias. However, the factors that  
37 were highlighted as potential risks for infection were consistent with their clinical experience.  
38 As such, they decided that they could still be identified as risk factors in the  
39 recommendations.

40 There was also variation in the populations that were included in each study, with some  
41 basing the inclusion criteria on gestational age or birthweight while other studies included all  
42 babies born in a particular setting. Consequently, the results were presented by individual  
43 study outcomes rather than pooled effect estimates. An additional issue was that many  
44 studies only reported the significant results from the models. This means that while one study  
45 may have reported an association between a particular factor and neonatal infection, it is  
46 unclear how many other studies also investigated that risk factor but found non-significant  
47 results. Where studies only reported significant results, they were therefore downgraded for  
48 risk of bias. The committee decided that risk factors would only be included as part of the  
49 recommendations if the evidence corresponded with their clinical experience.

50 Only one study examined the effects of maternal obesity on the risk of early-onset neonatal  
51 infection. The committee questioned the applicability of this research as mothers who were  
52 included in the analysis were grouped by the World Health Organisation definition of obesity

1 (BMI of 30.0 and above). It was highlighted that in clinical practice maternal obesity is now  
2 often defined as women with a BMI of 35 and above. Due to these differences in  
3 classification, this study was graded as partially applicable to the research question and the  
4 quality of the outcomes were downgraded. With such limited and partially applicable  
5 evidence, the committee decided that more relevant research was needed before  
6 recommendations could be made on maternal obesity and neonatal infection. A research  
7 recommendation was therefore made to reflect this ([Appendix K](#)).

8 The committee discussed the criteria for chorioamnionitis that was used in the research.  
9 Many studies used the Gibbs criteria or similar, and this is known to have relatively low  
10 sensitivity. It was raised that these criteria do not reflect the complexities of diagnosing  
11 chorioamnionitis in clinical practice where clinicians tend to look for more subtle signs to  
12 enable earlier diagnosis and treatment. These differences in definition may change the  
13 association between chorioamnionitis and neonatal infection. However, the committee was  
14 confident that its clinical experience supported the findings that chorioamnionitis is a risk  
15 factor for neonatal infection. They therefore agreed that these studies should remain  
16 applicable to the research question and that chorioamnionitis should remain part of the  
17 maternal risk factors table.

18 The studies which examined individual risk factors examined a wider range of populations,  
19 including babies born before 34 weeks' gestational age. As a result, the risk factor tables and  
20 their accompanying recommendations can be used for babies of any gestational age,  
21 including the population that are not covered by the neonatal sepsis calculator.

## 22 **4.1.3 Benefits and harms**

### 23 **4.1.3.1 Clinical prediction models**

24 The main concern of the committee in relation to any prognostic model or management tool  
25 for neonatal infection was the trade-off between the potential issues associated with over-  
26 treatment versus the risks from lack of treatment where a baby does have infection. Although  
27 there are harms associated with unnecessary antibiotic treatment, such as the potential for  
28 nephrotoxicity when a baby is given gentamicin, and increased length of stay in hospital, the  
29 committee decided that these were smaller than the risk of a baby not receiving treatment  
30 when they do have infection. It is therefore important that any clinical prediction model or  
31 framework can maximise the number of babies that are correctly identified as needing  
32 treatment, while minimising the number who are given antibiotics unnecessarily.

33

34 Most of the data on clinical prediction models was for the Kaiser Permanente neonatal sepsis  
35 calculator. The committee agreed that overall pooled results from 9 studies showed that the  
36 tool had good specificity, but that there was substantial uncertainty about the sensitivity, with  
37 wide confidence intervals in the results. The positive likelihood ratio was above the clinical  
38 decision threshold, suggesting that a positive test result from the neonatal sepsis calculator  
39 indicated a large to very large increase in the probability of a baby having infection. However,  
40 the negative likelihood ratio was on the clinical decision threshold, and so the committee  
41 thought that more research was needed before the calculator could be considered as the  
42 sole option for predicting a baby's risk of infection. One UK study compared the predictive  
43 accuracy of the Kaiser Permanente neonatal sepsis calculator with the recommendations in  
44 the 2012 guideline on neonatal infection, and the committee placed particular weight on this  
45 study when making recommendations. This study showed that both tools had similar  
46 sensitivity, but that the specificity of the neonatal sepsis calculator was higher, suggesting  
47 that using the neonatal sepsis calculator may result in fewer babies being treated with  
48 antibiotics who do not have infection. However, data on sensitivity were very uncertain  
49 because of the low number of cases of culture confirmed early-onset neonatal infection. This  
50 was particularly the case for the framework outlined in the 2012 NICE guideline which had  
51 data from only a single study with just 6 cases of confirmed neonatal infection. Given the

1 uncertainties in the evidence, the committee decided that a recommendation for a framework  
2 based on individual factors was appropriate, with an option for obstetric or paediatric centres  
3 to consider the Kaiser Permanente neonatal sepsis calculator as part of an audit which  
4 assesses and manages the risk of neonatal infection. The committee thought that using a  
5 framework based on individual risk factors (described in more detail in the section below)  
6 was likely to be a conservative approach which would result in more antibiotics being  
7 prescribed than the neonatal sepsis calculator, but might also identify more true cases of  
8 infection. However, as the evidence did not show one option to be clearly better than the  
9 other, and as the neonatal sepsis calculator is already used in some centres in the UK, the  
10 committee decided that the recommendation to use the calculator in the context of an audit  
11 was appropriate, as long as this was for babies with a gestational age of 34 weeks and  
12 above. In situations where the Kaiser Permanente neonatal sepsis calculator is used, the  
13 committee decided that clinicians should use the recommendations within the tool to decide  
14 whether to treat with antibiotics or monitor further, as the evidence included as part of this  
15 review is based on these categorisations.

16 Given the limited evidence on clinical prediction models in the UK (including the Kaiser  
17 Permanente neonatal sepsis calculator as well as the framework set out by NICE), the  
18 committee decided that a research recommendation was needed for the use of prognostic  
19 tools for early-onset neonatal infection specifically in the UK. This recommendation was for  
20 any prognostic model, meaning that other models can be designed and evaluated, which  
21 may be particularly important for specific populations, such as babies born before 34 weeks  
22 gestational age ([Appendix K](#)).

#### 23 **4.1.3.2 Individual risk factors and clinical indicators**

24 The committee decided that current evidence was not sufficient to make recommendations  
25 based only on clinical prediction models, so they also reviewed the evidence on individual  
26 risk factors and signs and symptoms of early-onset neonatal infection. The committee agreed  
27 that the structure of the recommendations outlined in the 2012 version of this guideline was  
28 still appropriate, with tables of risk factors and clinical indicators, some of which were  
29 designated as 'red flag' indicators. They decided that the recommendations in the 2012  
30 version of this guideline on when to start antibiotic treatment or carry out further monitoring  
31 based on the number of indicators and red flag indicators met were still appropriate, and so  
32 made recommendations that were very similar to those made previously.

33 The committee thought it was important to retain the separate tables for risk factors and for  
34 clinical indicators that were used in the 2012 version of the guideline. The risk factors list  
35 (Box 1) gives an indication of the factors that a clinician should be aware of before the birth  
36 and the clinical indicators list (Box 2) highlights the signs and symptoms to look for in the  
37 baby after birth. Separating risk factors and clinical indicators should make it clearer for  
38 clinicians when they are trying to make important decisions about whether a baby should be  
39 treated for neonatal infection. Although the committee decided to keep the format of the  
40 recommendations the same as the previous version of the guideline, they made some  
41 changes to the risk factors and clinical indicators based on the updated evidence and their  
42 knowledge and experience. These changes are outlined in the sections below.

#### 43 **4.1.3.3 Maternal risk factors**

44 When presented with the evidence for maternal risk factors, the committee decided to use a  
45 modified version of the risk factors table used in the 2012 version of the guideline (Box 1), as  
46 the main factors identified as risks for neonatal infection in the evidence review (intrapartum  
47 fever and chorioamnionitis) were already included in the table. Intrapartum fever and  
48 chorioamnionitis were a single risk factor in the 2012 guideline but, based on their clinical  
49 experience, the committee decided to separate these into two risk factors, as fever can also  
50 indicate other bacterial infections that are not chorioamnionitis. However, it specified that  
51 fever should only be considered a risk factor when there is suspected bacterial infection. This  
52 will avoid women who have a high temperature for other reasons, such as the side-effects of

1 an epidural, receiving antibiotics unnecessarily. The committee also discussed how a woman  
2 can have chorioamnionitis without having fever, and this should be considered a risk factor  
3 for infection. There was discussion about whether this separation of fever and  
4 chorioamnionitis into separate risk factors would result in an increase in the number of  
5 women prescribed antibiotics. However, as women with both chorioamnionitis and fever  
6 would generally be given antibiotics in practice, the committee did not think this would result  
7 have a big impact on antibiotic prescription or resistance.

8 The committee decided to remove parenteral antibiotic treatment from the list of risk factors.  
9 This decision was made based on changes in obstetric practice since the previous guideline  
10 update, meaning that the threshold for diagnosing a mother with septicaemia is now lower.  
11 This means that many babies are now receiving antibiotics based on this red flag risk factor  
12 alone. This is considered to be an issue for the overprescribing of antibiotics.

13 The committee combined the risk factors 'Invasive group B streptococcal infection in a  
14 previous baby' and 'maternal group B streptococcal colonisation, bacteriuria or infection in  
15 the current pregnancy' into a single item in the list because they considered that these items  
16 relate to the same risk factor. Having a previous baby with invasive group B streptococcal  
17 infection does not increase the risk of neonatal infection further if a mother is known to have  
18 group B streptococcal colonisation, bacteriuria or infection in her current pregnancy, and so  
19 this should not be considered an additional risk factor.

20 The committee revised the table to make the sections on rupture of membranes at term and  
21 preterm clearer, and to reflect current NICE guidance in this area. Confirmed pre-labour  
22 rupture of membranes at term for more than 24 hours was included to correspond with the  
23 recommendations in the intrapartum care guideline (NICE clinical guideline 190,  
24 recommendation 1.11.6). However, the committee decided that the time period for confirmed  
25 rupture of membranes for more than 18 hours in a preterm birth should be retained (as in the  
26 2012 version of the guideline) because there was no new evidence available in relation to  
27 this risk factor. Confirmed prelabour rupture of membranes was removed from the table  
28 because the committee felt that it is now covered by other risk factors in the table (preterm  
29 birth and confirmed rupture of membranes in a preterm or term birth). Consequently, they  
30 agreed that babies born to these mothers would still receive treatment when using the  
31 updated version of the NICE guidelines.

32 One other factor (single compared to multiple births) was identified in the evidence review.  
33 However, the committee did not think that it would be useful to highlight single births as a risk  
34 factor for infection, as this could result in most babies being identified as at higher risk of  
35 infection. It decided that there were other factors in the review that were more important to  
36 identify as potential risks for infection.

#### 37 **4.1.3.4 Neonatal risk factors and clinical indicators**

38 The committee also reviewed the risk factors and clinical indicators in the baby for early-  
39 onset infection. They decided to recommend a modified version of the risk factors (Box 1)  
40 and clinical indicators (Box 2) tables used in the 2012 version of the guideline as a starting  
41 point to modify based on new evidence as appropriate.

42 One of the most common risk factors identified in the evidence review was low gestational  
43 age. The committee discussed whether this should be an additional risk factor but agreed  
44 that this is already covered by the preterm birth risk factor. It was highlighted that while there  
45 are a number of risk factors in the baby, many of these are as a result of low gestational age.  
46 The evidence suggested that babies born at less than 32 weeks' gestational age are at  
47 greater risk of developing infection than those born at 32 weeks or greater. The committee  
48 discussed whether this should be added as additional information to the preterm birth factor,  
49 but it was deemed unnecessary as it would still count as one risk factor in the table. It was  
50 highlighted that babies who are slightly preterm and on a postnatal ward might be more at  
51 risk of an infection being missed because they might not be considered a high-risk group.

1 The inclusion of babies born before 37 weeks' gestation as a risk factor should therefore  
2 highlight to clinicians that these babies should be monitored for other signs of infection.

3 There was very little evidence on clinical indicators for early-onset infection and so the  
4 committee decided to base their recommendations on the table of clinical indicators in the  
5 2012 version of the NICE guideline on neonatal infection. They made changes to this table  
6 based on their knowledge and experience and to make the table applicable to current  
7 practice (Box 2).

8 The committee decided to remove respiratory distress starting 4 hours after birth from the  
9 table of risk factors because they agreed that they would not want clinicians to wait 4 hours  
10 for treatment on the basis of this recommendation. Instead, they chose to retain 'signs of  
11 respiratory distress' as a factor in the table as this would include the group of babies who  
12 have symptoms beyond 4 hours after birth and should ensure that any babies who have  
13 infection will still receive the necessary treatment. The 2012 recommendations also had two  
14 recommendations for need for mechanical ventilation; one for preterm babies which was not  
15 a red flag risk factor and one for term babies which was a red flag. The committee agreed  
16 that mechanical ventilation is a risk factor for infection regardless of prematurity and so they  
17 decided to merge these into one recommendation which did not refer to whether a baby was  
18 born pre-term or at term for simplicity. They decided that this should be a red flag indicator.

19 For signs and symptoms in the baby, the committee decided to remove oliguria and local  
20 signs of infection from the recommendations table. Oliguria persisting beyond 24 hours after  
21 birth was removed because there is no clear definition of this risk factor, and the 24-hour  
22 time point is beyond the time when babies typically present with early-onset infection. The  
23 committee also considered oliguria to be a poor indicator of early-onset sepsis. The  
24 committee felt that local signs of infection should be removed because such infections are  
25 very common in newborn babies and including 'local infection' in the table may result in  
26 overprescribing antibiotics. Many local infections also require different management  
27 pathways to sepsis, such as oral or topical antibiotics.

#### 28 **4.1.3.5 Management of babies at increased risk of infection**

29 The committee made recommendations based on their knowledge and experience that were  
30 consistent with the recommendations from the 2012 version of this guideline and current best  
31 practice. These recommendations were designed to direct clinicians to other, evidence-  
32 based, sections of the guideline where they could receive guidance when deciding whether a  
33 baby should be given antibiotic treatment, what antibiotics should be given, or what to do  
34 when discharging the baby if there are no further concerns.

35 The committee discussed how the recommendations for the use of the NICE risk factors and  
36 clinical indicators, or the neonatal sepsis calculator may result in some babies beginning to  
37 receive treatment when they do not have an infection. However, this risk is mitigated by clear  
38 recommendations in other sections of the guideline (recommendations 1.9.1-1.9.4) on when  
39 clinicians should stop giving antibiotics. This will minimise the time that a baby receives  
40 treatment if a negative blood culture result is returned. Recommendations on duration of  
41 antibiotics for early-onset infection were from the previous version of the guideline, and were  
42 thought to be appropriate in ensuring that babies receive necessary and timely treatment as  
43 well as making sure that treatment is stopped as soon as it is safe to do so. As such, the  
44 committee did not think that these needed to be changed.

#### 45 **4.1.4 Cost effectiveness and resource use**

46 The committee were mindful that, as well as having potentially catastrophic consequences  
47 for the neonate, any infection that is missed can generate very substantial costs for the  
48 health and care system. They noted the clinical evidence, including one UK-based study  
49 suggesting that the neonatal sepsis calculator results in a similar number of false negatives  
50 as the NICE guidelines. However, the same study suggests that the calculator would lead to

1 a substantial reduction in false-positive diagnoses. This could be important in reducing the  
2 number of babies who receive unnecessary treatment for infection, which in turn results in  
3 decreasing hospital stays. Thus, the committee made a 'consider' recommendation to use  
4 either one of the tools to predict newborn babies' risk of sepsis, which is unlikely to be  
5 associated with increased NHS resource use.

#### 6 **4.1.5 Other factors the committee took into account**

7 The committee discussed the recommendations from the previous guideline and agreed that  
8 the guidance to perform an immediate clinical assessment, review the maternal and neonatal  
9 history and carry out a physical examination was important. This will ensure that a clinician  
10 has all the information they need to assess the baby's risk of infection and decide whether  
11 blood tests and treatment are needed. The committee did not think that this advice had  
12 changed since the previous update of the guideline and so this was included as part of the  
13 recommendations.

14 The committee highlighted the changes in obstetric practice since the previous update of the  
15 neonatal infection guideline in 2012. The awareness of maternal sepsis has changed, and  
16 fear of missing a diagnosis of sepsis has led to more women now being given antibiotics  
17 during labour. Currently, use of parenteral antibiotics during, before or after labour for  
18 confirmed or suspected bacterial infection (such as septicaemia) is one of the red flag  
19 indicators for babies being at high risk of early-onset neonatal infection. The change in  
20 perception of maternal sepsis (based on SEPSIS 6) has therefore led to a rise in the number  
21 of babies being given potentially unnecessary antibiotic treatment.

22 The committee also discussed the results of two additional studies that compared the  
23 suggested management of the NICE risk factors tables and the Kaiser Permanente neonatal  
24 sepsis calculator but did not meet the inclusion criteria for the review ([Appendix D3](#)). One  
25 (Pettinger 2019) was a systematic review and meta-analysis paper which retrospectively  
26 compared the management of the two tools, and the other (Morris 2020), was a cohort study  
27 which retrospectively compared the suggested management of the two tools at sites in  
28 England and Wales. The study designs did not meet the inclusion criteria for the review,  
29 because the sensitivity and specificity of the neonatal sepsis calculator were not assessed,  
30 and the Morris study only included babies with culture-confirmed infection. However, it was  
31 decided that it was important to consider the results given the direct comparison between the  
32 two tools included in the recommendations for this review. The committee felt confident that  
33 the Pettinger results reflected issues that had already been considered within the review and  
34 did not think that the findings should change any of the recommendations. The Morris paper  
35 highlighted instances for a number of babies with culture-confirmed infection where, at 4  
36 hours, antibiotic treatment was recommended by the NICE recommendations but not by the  
37 Kaiser neonatal sepsis calculator. The lower sensitivity of the Kaiser neonatal sepsis  
38 calculator supported the results of the review, and as this was based specifically in the UK,  
39 the committee decided that the findings were therefore relevant to take into consideration  
40 when deciding on recommendations. This further supported its decision that the Kaiser  
41 Permanente neonatal sepsis calculator could be used, but only where a clinical audit was  
42 taking place to help better determine its effectiveness.

43 The committee also considered equality issues. It noted that risk factors for neonatal  
44 infection vary according to ethnicity and the age of the mother. It was also particularly aware  
45 of evidence that group B streptococcus (GBS) colonisation was higher in women of Black  
46 African family origin, as was the likelihood of having a baby who is preterm (Puthussery et al.  
47 2019). They noted that the likelihood of having a baby who is preterm also increased with  
48 maternal age (Fuchs et al 2018). Having a preterm birth and GBS colonisation are included  
49 as risk factors in box 1 and so will be used to assess the risk of early-onset infection and  
50 determine antibiotic treatment.

1 **4.2 Recommendations supported by this evidence review**

2 This evidence review supports recommendations 1.3.1-1.3.9 and the research  
3 recommendations on clinical prediction models for early-onset infection and the risk of early-  
4 onset infection with maternal obesity.

5 **4.3 References – included studies**

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#### **4.3.2 Other citations**

Fuchs, F., Monet, B., Ducruet, T., Chaillet, N. and Audibert, F., 2018. Effect of maternal age on the risk of preterm birth: A large cohort study. *PLoS one*, 13(1), p.e0191002.

Puthussery, S., Li, L., Tseng, P.C., Kilby, L., Kapadia, J., Puthusserry, T. and Thind, A., 2019. Ethnic variations in risk of preterm birth in an ethnically dense socially disadvantaged area in the UK: a retrospective cross-sectional study. *BMJ open*, 9(3), p.e023570.

# 1 Appendices

## 2 Appendix A – Review protocols

3 Review protocols for review protocols on the accuracy and effectiveness of clinical prediction models (A.1, Part A – Prognostic accuracy studies  
4 and A.2, Part B – Test and treat RCTs), individual maternal risk factors (A.3) and individual neonatal risk factors (A.4) are all included in the  
5 appendices below.

### A61 Review protocol for clinical prediction models - part A (prognostic accuracy studies)

ID	Field	Content
0.	PROSPERO registration number	CRD4201915161
1.	Review title	Risk factors for early-onset neonatal infection
2.	Review question	<ul style="list-style-type: none"><li>• What is the accuracy of clinical prediction models for early-onset neonatal infection and what is their effectiveness in guiding management in the baby?</li></ul>
3.	Objective	<p>To identify risk prediction models for early-onset neonatal infection that should be used to guide management in the UK:</p> <ul style="list-style-type: none"><li>• covers maternal risk factors associated with pre-pregnancy, antenatal, intrapartum and postnatal periods (including previous pregnancy history, antenatal events, gestational age and GBS carriage when known (GBS</li></ul>

		<p>screening is not currently recommended by the UK national screening committee)) and fetal risk factors</p> <ul style="list-style-type: none"><li>• includes symptoms and signs in the mother</li><li>• covers events relating to the baby after birth (postnatal events) and signs of sibling infection up to 72 hours after birth</li><li>• includes consideration of how soon after birth symptoms, signs or other indicators should raise suspicion of early-onset neonatal infection (for example, 0, 12, 24, 36, 48, or 72 hours; although 0-24 hours probably most likely)</li></ul> <p>This review has been divided into 2 parts. Part A (outlined in this review protocol) will assess the predictive accuracy of risk prediction tools. Part B (outlined in a separate protocol) will assess the effectiveness of these tools in guiding management.</p> <ul style="list-style-type: none"><li>• Currently there is one main tool identified by the committee and stakeholders, the neonatal sepsis calculator (Kaiser Permanente). This calculator takes information about both risk factors and clinical signs, and so it effectively uses what could be strictly classed as both diagnostic and prognostic information. According to the current NICE guideline (which was based on an evidence review of individual risk factors and clinical signs), babies should get treatment based on a combined assessment of risk factors and clinical signs; it is then possible to prompt investigations/receive treatment without any clinical signs if the risk is very high. Because of the development of this tool since the original guideline, the aim of the review is to</li></ul>
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		<p>determine whether the tool (or other similar tools identified in the course of the review) is good enough (accurate enough) to be used to assess babies instead of current methods where clinicians make a judgment based on individual risk factors and clinical signs that they have identified.</p>
<p>4.</p>	<p>Searches</p>	<ul style="list-style-type: none"> <li>• The following databases will be searched:</li> <li>• Cochrane Central Register of Controlled Trials (CENTRAL)</li> <li>• Cochrane Database of Systematic Reviews (CDSR)</li> <li>• Embase</li> <li>• MEDLINE (including ‘in process’ and ‘E-pub ahead of print’)</li> <li>• Database of Abstracts of Reviews of Effect (DARE)</li> </ul> <p>Searches will be restricted by:</p> <ul style="list-style-type: none"> <li>• English language</li> <li>• Human studies</li> <li>• Conference abstracts</li> </ul> <p>Other searches:</p> <ul style="list-style-type: none"> <li>• None</li> </ul> <p>The searches will be re-run 6 weeks before final submission of the review and further studies retrieved for inclusion.</p>

		The full search strategies for MEDLINE database will be published in the final review. No date restrictions have been applied for this question.
5.	Condition or domain being studied	Neonatal infection is a significant cause of mortality and morbidity in neonates. It may be early-onset (within 72 hours of birth) or late-onset (more than 72 hours after birth). Neonatal infection can lead to life-threatening sepsis, which accounts for 10% of all neonatal deaths. To reduce mortality from early-onset neonatal infection, the current NICE guideline recommends antibiotic prophylaxis during labour and neonatal antibiotic treatment to be based on multiple risk factors, clinical indicators and red flags collectively.
6.	Population	<p>Inclusion:</p> <ul style="list-style-type: none"> <li>• Unborn or newborn babies under 72 hours</li> <li>• Pregnant women</li> </ul> <p>Exclusion:</p> <ul style="list-style-type: none"> <li>• Babies with suspected or confirmed non-bacterial infections.</li> <li>• Babies with suspected or confirmed syphilis.</li> <li>• Babies with localised infections.</li> <li>• Babies with late-onset neonatal infection (onset of infection after 72 hours of age). Studies including babies with early- and late-onset infection will be included if data for early- and late-onset is presented separately.</li> <li>• Babies with suspected or confirmed bacterial infection resulting from therapeutic interventions such as surgery. Babies with a history of</li> </ul>

		<p>surgery which was not the cause of the infection will not be excluded.</p> <ul style="list-style-type: none"> <li>• Babies with suspected or confirmed meningitis who are not receiving care in neonatal units (covered by the NICE guideline on bacterial meningitis and meningococcal septicaemia)</li> <li>• Women with pre-labour rupture of membranes at term (covered in the NICE intrapartum care guideline)</li> </ul>
7.	Intervention/Exposure/Test	<ul style="list-style-type: none"> <li>• Any validated risk tool using multiple predictors to predict the risk of development or the presence of early-onset neonatal infection. For example: the neonatal early-onset sepsis calculator (Kaiser Permanente)</li> <li>• If sufficient evidence is not found on risk prediction tools for early-onset neonatal infection, a review of individual maternal and fetal risk factors, and individual risk factors in the baby will be carried out.</li> </ul>
8.	Comparator/Reference standard/Confounding factors	<p>Reference standard (predictive models):</p> <ul style="list-style-type: none"> <li>• culture-proven infection from a sample taken within 72 hours of birth where available or within the study-defined period for early onset neonatal infection</li> <li>• antibiotics for suspected bloodstream infection (in neonate)</li> </ul>
9.	Types of study to be included	<p>Prospective or retrospective observational cohorts or cross-sectional studies which evaluate risk prediction tools. Studies will only be included if they include data on model validation (internal or external validation)</p> <p>Systematic reviews of the above study types</p>

10.	Other exclusion criteria	<ul style="list-style-type: none"> <li>• Studies that do not report results specifically for early-onset neonatal infection (based on study definition of early-onset neonatal infection)</li> <li>• Non-Organisation for Economic Cooperation and Development (OECD) countries</li> <li>• Non-English language studies</li> </ul>
11.	Context	<ul style="list-style-type: none"> <li>• NICE guideline CG149 Neonatal infection will be updated by this question.</li> </ul>
12.	Primary outcomes (critical outcomes)	<ul style="list-style-type: none"> <li>• For each outcome, accuracy measures will be reported where available, for example:</li> <li>• Odds ratios/hazard ratios</li> <li>• Model fit, including discrimination (C statistic, area under ROC curve) and calibration (r squared)</li> <li>• Sensitivity, specificity, positive and negative predictive values</li> </ul>
13.	Secondary outcomes (important outcomes)	Not applicable. The committee did not wish to distinguish between critical and important outcomes as they considered all of the specified outcomes important for decision making.
14.	Data extraction (selection and coding)	All references identified by the searches and from other sources will be uploaded into EPPI reviewer and de-duplicated. 10% of the abstracts will be reviewed by two reviewers, with any disagreements resolved by discussion or, if necessary, a third independent reviewer.

		<p>The full text of potentially eligible studies will be retrieved and will be assessed in line with the criteria outlined above. A standardised form will be used to extract data from studies (see <a href="#">Developing NICE guidelines: the manual</a> section 6.4). Study investigators may be contacted for missing data where time and resources allow.</p> <p>This review will make use of the priority screening functionality within the EPPI-reviewer software.</p>
15.	Risk of bias (quality) assessment	Risk of bias will be assessed using the PROBAST checklist as described in <a href="#">Developing NICE guidelines: the manual</a> .
16.	Strategy for data synthesis	<ul style="list-style-type: none"> <li>For details please see section 6 of <a href="#">Developing NICE guidelines: the manual</a></li> </ul>
17.	Analysis of sub-groups	Results will be stratified according to whether the population included term or preterm neonates (where data allows).
18.	Type and method of review	<input type="checkbox"/> Intervention <input checked="" type="checkbox"/> Diagnostic <input checked="" type="checkbox"/> Prognostic <input type="checkbox"/> Qualitative <input type="checkbox"/> Epidemiologic <input type="checkbox"/> Service delivery <input type="checkbox"/> Other (please specify)
19.	Language	English

20.	Country	England		
21.	Anticipated or actual start date	02/09/2019		
22.	Anticipated completion date	12/08/2020		
23.	Stage of review at time of this submission	<b>Review stage</b>	<b>Started</b>	<b>Completed</b>
		Preliminary searches	<input type="checkbox"/>	<input type="checkbox"/>
		Piloting of the study selection process	<input type="checkbox"/>	<input type="checkbox"/>
		Formal screening of search results against eligibility criteria	<input type="checkbox"/>	<input type="checkbox"/>
		Data extraction	<input type="checkbox"/>	<input type="checkbox"/>

		Risk of bias (quality) assessment	<input type="checkbox"/>	<input type="checkbox"/>
		Data analysis	<input type="checkbox"/>	<input type="checkbox"/>
24.	Named contact	<p><b>5a. Named contact</b>          Guideline Updates Team</p> <p><b>5b Named contact e-mail</b>          NIupdate@nice.org.uk</p> <p><b>5e Organisational affiliation of the review</b>          National Institute for Health and Care Excellence (NICE)</p>		
25.	Review team members	<p>From the Guideline Updates Team:</p> <ul style="list-style-type: none"> <li>• Dr Kathryn Hopkins</li> <li>• Dr Clare Dadswell</li> <li>• Mr Gabriel Rogers</li> <li>• Mr Fadi Chehadah</li> <li>• Mr Wesley Hubbard</li> </ul>		
26.	Funding sources/sponsor	<p>This systematic review is being completed by the Centre for Guidelines which receives funding from NICE.</p>		
27.	Conflicts of interest	<p>All guideline committee members and anyone who has direct input into NICE guidelines (including the evidence review team and expert witnesses) must</p>		

		declare any potential conflicts of interest in line with NICE's code of practice for declaring and dealing with conflicts of interest. Any relevant interests, or changes to interests, will also be declared publicly at the start of each guideline committee meeting. Before each meeting, any potential conflicts of interest will be considered by the guideline committee Chair and a senior member of the development team. Any decisions to exclude a person from all or part of a meeting will be documented. Any changes to a member's declaration of interests will be recorded in the minutes of the meeting. Declarations of interests will be published with the final guideline.
28.	Collaborators	Development of this systematic review will be overseen by an advisory committee who will use the review to inform the development of evidence-based recommendations in line with section 3 of <a href="#">Developing NICE guidelines: the manual</a> . Members of the guideline committee are available on the NICE website: <a href="https://www.nice.org.uk/guidance/indevelopment/gid-ng10111">https://www.nice.org.uk/guidance/indevelopment/gid-ng10111</a>
29.	Other registration details	None
30.	Reference/URL for published protocol	None
31.	Dissemination plans	NICE may use a range of different methods to raise awareness of the guideline. These include standard approaches such as: <ul style="list-style-type: none"> <li>• notifying registered stakeholders of publication</li> <li>• publicising the guideline through NICE's newsletter and alerts</li> <li>• issuing a press release or briefing as appropriate, posting news articles on the NICE website, using social media channels, and publicising the guideline within NICE.</li> </ul>
32.	Keywords	Early onset neonatal infection, risk factors

33.	Details of existing review of same topic by same authors	None	1 2 3
34.	Current review status	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	4 5 6 7 8 9
35..	Additional information	None	10
36.	Details of final publication	<a href="http://www.nice.org.uk">www.nice.org.uk</a>	11 12

## A32 Review protocol for clinical prediction models - part B (test and treat RCTs)

ID	Field	Content
0.	PROSPERO registration number	
1.	Review title	Risk factors for early-onset neonatal infection

2.	Review question	What is the accuracy of clinical prediction models for early-onset neonatal infection and what is their effectiveness in guiding management in the baby?
3.	Objective	<p>To identify risk factors for early-onset neonatal infection that should be used to guide management in the UK:</p> <ul style="list-style-type: none"> <li>• covers maternal risk factors associated with pre-pregnancy, antenatal, intrapartum and postnatal periods (including previous pregnancy history, antenatal events, gestational age and GBS carriage when known (GBS screening is not currently recommended by the UK national screening committee)) and fetal risk factors</li> <li>• includes symptoms and signs in the mother</li> <li>• covers events relating to the baby after birth (postnatal events) and signs of sibling infection up to 72 hours after birth</li> <li>• includes consideration of how soon after birth symptoms, signs or other indicators should raise suspicion of early-onset neonatal infection (for example, 0, 12, 24, 36, 48, or 72 hours; although 0-24 hours probably most likely)</li> <li>• includes which symptoms and signs (individually or in combination) should lead to antibiotic prophylaxis and/or treatment</li> </ul> <p>This review has been divided into 2 parts. Part A (outlined in a separate review protocol) will assess the predictive accuracy of risk prediction tools. Part B</p>

		(outlined in this protocol) will assess the effectiveness of these tools in guiding management.
4.	Searches	<p>The following databases will be searched:</p> <ul style="list-style-type: none"> <li>• Cochrane Central Register of Controlled Trials (CENTRAL)</li> <li>• Cochrane Database of Systematic Reviews (CDSR)</li> <li>• Embase</li> <li>• MEDLINE (including 'in process' and 'E-pub ahead of print')</li> <li>• Database of Abstracts of Reviews of Effect (DARE)</li> </ul> <p>Searches will be restricted by:</p> <ul style="list-style-type: none"> <li>• English language</li> <li>• Human studies</li> <li>• Conference abstracts</li> </ul> <p>Other searches:</p> <p>None</p>

		<p>The searches will be re-run 6 weeks before final submission of the review and further studies retrieved for inclusion.</p> <p>The full search strategies for MEDLINE database will be published in the final review. No date restrictions have been applied for this question.</p>
5.	Condition or domain being studied	<p>Neonatal infection is a significant cause of mortality and morbidity in neonates. It may be early-onset (within 72 hours of birth) or late-onset (more than 72 hours after birth). Neonatal infection can lead to life-threatening sepsis, which accounts for 10% of all neonatal deaths. To reduce mortality from early-onset neonatal infection, the current NICE guideline recommends antibiotic prophylaxis during labour and neonatal antibiotic treatment to be based on multiple risk factors, clinical indicators and red flags collectively.</p>
6.	Population	<p>Inclusion:</p> <ul style="list-style-type: none"> <li>• Unborn or newborn babies under 72 hours</li> <li>• Pregnant women</li> </ul> <p>Exclusion:</p> <ul style="list-style-type: none"> <li>• Babies with suspected or confirmed non-bacterial infections.</li> <li>• Babies with suspected or confirmed syphilis.</li> <li>• Babies with localised infections.</li> <li>• Babies with late-onset neonatal infection (onset of infection after 72 hours of age). Studies including babies with early- and late-onset</li> </ul>

		<p>infection will be included if data for early- and late-onset is presented separately.</p> <ul style="list-style-type: none"> <li>• Babies with suspected or confirmed bacterial infection resulting from therapeutic interventions such as surgery. Babies with a history of surgery which was not the cause of the infection will not be excluded.</li> <li>• Babies with suspected or confirmed meningitis who are not receiving care in neonatal units (covered by the NICE guideline on bacterial meningitis and meningococcal septicaemia)</li> <li>• Women with pre-labour rupture of membranes at term (covered in the NICE intrapartum care guideline)</li> </ul>
7.	Intervention	<p>Any risk tool* for early-onset neonatal infection identified in Part A of the protocol (any validated risk tool using multiple predictors to predict the risk of development or the presence of early-onset neonatal infection) followed by treatment (for example provision of antibiotics or further testing) according to risk stratification by the tool results.</p> <p>*For example: the neonatal early-onset sepsis calculator (Kaiser Permanente)</p> <p>If sufficient evidence is not found on risk prediction tools for early-onset neonatal infection (parts A and B, of which this protocol is part B), a review of individual maternal and fetal risk factors, and individual risk factors in the baby will be carried out.</p>
8.	Comparator	<ul style="list-style-type: none"> <li>• standard care: treatment according to risk stratification based on clinician experience or existing clinical protocols (for example, existing NICE guidance)</li> </ul>

		<ul style="list-style-type: none"> <li>• Comparisons between risk tools followed by treatment according to risk stratification by tool results will also be included.</li> </ul>
9.	Types of study to be included	<p>'Test and treat' randomised controlled trials which assess the effectiveness of treatment based on the results of risk prediction tools</p> <p>Systematic reviews of test and treat RCTs</p>
10.	Other exclusion criteria	<ul style="list-style-type: none"> <li>• Studies that do not report results specifically for early-onset neonatal infection (based on study definition of early-onset neonatal infection)</li> <li>• Non-Organisation for Economic Cooperation and Development (OECD) countries</li> <li>• Non-English language studies</li> </ul>
11.	Context	NICE guideline CG149 Neonatal infection will be updated by this question.
12.	Primary outcomes (critical outcomes)	<p>Neonatal outcomes:</p> <ul style="list-style-type: none"> <li>• culture-proven infection from sample taken within 72 hours of birth where available or within the study-defined period for early-onset neonatal infection</li> <li>• antibiotics for suspected bloodstream infection (within 72 hours of birth or within the study-defined period for early-onset neonatal infection)</li> <li>• Mortality (at different time points – peri-natal mortality (stillborn or within 7 days from birth) or greater than 7 days from birth)</li> </ul>

		<ul style="list-style-type: none"> <li>• respiratory distress within 72 hours of birth or within the study-defined period for early-onset neonatal infection</li> <li>• health-related quality of life, measured using a validated tool (during the neonatal period and at the latest time point reported in study)</li> <li>• hospital length of stay</li> <li>• number of babies prescribed antibiotic treatment</li> </ul> <p>Family outcomes:</p> <ul style="list-style-type: none"> <li>• psychological distress in baby’s family as measured using a validated scale (e.g. parental stressor scale NICU; modified Rutter Malaise Inventory) (during the neonatal period and at the latest time point reported in study)</li> </ul>
13.	Secondary outcomes (important outcomes)	Not applicable. The committee did not wish to distinguish between critical and important outcomes as they considered all of the specified outcomes important for decision making.
14.	Data extraction (selection and coding)	<p>All references identified by the searches and from other sources will be uploaded into EPPI reviewer and de-duplicated. 10% of the abstracts will be reviewed by two reviewers, with any disagreements resolved by discussion or, if necessary, a third independent reviewer.</p> <p>The full text of potentially eligible studies will be retrieved and will be assessed in line with the criteria outlined above. A standardised form will be used to extract data from studies (see <a href="#">Developing NICE guidelines: the manual</a> section 6.4).</p>

		<p>Study investigators may be contacted for missing data where time and resources <a href="#">allow</a>.</p> <p><a href="#">This review will make use of the priority screening functionality within the EPPI-reviewer software.</a></p>
15.	Risk of bias (quality) assessment	<p><a href="#">Risk of bias will be assessed using the Cochrane Risk of bias 2.0 checklist as described in Developing NICE guidelines: the manual.</a></p>
16.	Strategy for data synthesis	<ul style="list-style-type: none"> <li>• For details please see section 6 of <a href="#">Developing NICE guidelines: the manual</a></li> </ul>
17.	Analysis of sub-groups	<p><a href="#">If heterogeneity is found between results for term and preterm neonates (subgroup differences <math>p &lt; 0.05</math>) then results will be stratified by where possible</a></p>
18.	Type and method of review	<p><input checked="" type="checkbox"/> <a href="#">Intervention</a></p> <p><input type="checkbox"/> <a href="#">Diagnostic</a></p> <p><input type="checkbox"/> <a href="#">Prognostic</a></p> <p><input type="checkbox"/> <a href="#">Qualitative</a></p> <p><input type="checkbox"/> <a href="#">Epidemiologic</a></p> <p><input type="checkbox"/> <a href="#">Service Delivery</a></p> <p><input type="checkbox"/> <a href="#">Other (please specify)</a></p>

19.	Language	English		
20.	Country	England		
21.	Anticipated or actual start date	02/09/2019		
22.	Anticipated completion date	12/08/2020		
23.	Stage of review at time of this submission	<b>Review stage</b>	<b>Started</b>	<b>Completed</b>
		Preliminary searches	<input type="checkbox"/>	<input type="checkbox"/>
		Piloting of the study selection process	<input type="checkbox"/>	<input type="checkbox"/>
		Formal screening of search results against eligibility criteria	<input type="checkbox"/>	<input type="checkbox"/>
		Data extraction	<input type="checkbox"/>	<input type="checkbox"/>
		Risk of bias (quality) assessment	<input type="checkbox"/>	<input type="checkbox"/>
		Data analysis	<input type="checkbox"/>	<input type="checkbox"/>

24.	Named contact	<p><b>5a. Named contact</b>          Guideline Updates Team</p> <p><b>5b Named contact e-mail</b>          NIupdate@nice.org.uk</p> <p><b>5e Organisational affiliation of the review</b>          National Institute for Health and Care Excellence (NICE)</p>
25.	Review team members	<p>From the Guideline Updates Team:</p> <ul style="list-style-type: none"> <li>• Dr Kathryn Hopkins</li> <li>• Dr Clare Dadswell</li> <li>• Mr Gabriel Rogers</li> <li>• Mr Fadi Chehadah</li> <li>• Mr Wesley Hubbard</li> </ul>
26.	Funding sources/sponsor	<p>This systematic review is being completed by the Centre for Guidelines which receives funding from NICE.</p>
27.	Conflicts of interest	<p>All guideline committee members and anyone who has direct input into NICE guidelines (including the evidence review team and expert witnesses) must declare any potential conflicts of interest in line with NICE's code of practice for declaring and dealing with conflicts of interest. Any relevant interests, or changes to interests, will also be declared publicly at the start of each guideline committee meeting. Before each meeting, any potential conflicts of interest will be considered by the guideline committee Chair and a senior member of the development team. Any decisions to exclude a person from all or part of a meeting will be documented. Any changes to a member's declaration of interests will be recorded in the minutes of the meeting. Declarations of interests will be published with the final guideline.</p>

28.	Collaborators	Development of this systematic review will be overseen by an advisory committee who will use the review to inform the development of evidence-based recommendations in line with section 3 of Developing NICE guidelines: the manual. Members of the guideline committee are available on the NICE website: <a href="https://www.nice.org.uk/guidance/indevelopment/gid-ng10111">https://www.nice.org.uk/guidance/indevelopment/gid-ng10111</a>
29.	Other registration details	None
30.	Reference/URL for published protocol	None
31.	Dissemination plans	NICE may use a range of different methods to raise awareness of the guideline. These include standard approaches such as: <ul style="list-style-type: none"> <li>• notifying registered stakeholders of publication</li> <li>• publicising the guideline through NICE's newsletter and alerts</li> <li>• issuing a press release or briefing as appropriate, posting news articles on the NICE website, using social media channels, and publicising the guideline within NICE.</li> </ul>
32.	Keywords	Early onset neonatal infection, risk factors
33.	Details of existing review of same topic by same authors	None
34.	Current review status	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

		□	1
			2
35.	Additional information	None	
36.	Details of final publication	<a href="http://www.nice.org.uk">www.nice.org.uk</a>	4
			5

### A63 Review protocol for maternal risk factors

ID	Field	Content
0.	PROSPERO registration number	[Complete this section with the PROSPERO registration number once allocated]
1.	Review title	Maternal and fetal risk factors for early-onset infection
2.	Review question	Which maternal and fetal risk factors for early-onset neonatal infection should be used to guide management?
3.	Objective	<p>To identify risk factors for early-onset neonatal infection/sepsis that should be used to guide management in the UK</p> <ul style="list-style-type: none"> <li>• includes symptoms and signs in the mother and fetus (including previous pregnancy history)</li> <li>• This review follows on from a review of clinical prediction models for early-onset neonatal infection. Evidence from this review did not support a strong positive recommendation for any risk prediction model for all population groups, therefore a review of individual risk factors is required.</li> </ul>

		<ul style="list-style-type: none"> <li>• This is a prognostic review because it investigates maternal and fetal risk factors that are predictive of future infection in the neonate that should guide management.</li> </ul>
4.	Searches	<p>The following databases will be searched:</p> <ul style="list-style-type: none"> <li>• Cochrane Database of Systematic Reviews (CDSR)</li> <li>• Embase</li> <li>• MEDLINE (including 'in process' and 'E-pub ahead of print')</li> <li>• Database of Abstracts of Reviews of Effect (DARE)</li> </ul> <p>Searches will be restricted by:</p> <ul style="list-style-type: none"> <li>• English language</li> <li>• Human studies</li> <li>• Conference abstracts</li> </ul> <p>Other searches:</p> <p>None</p> <p>The searches will be re-run 6 weeks before final submission of the review and further studies retrieved for inclusion.</p> <p>The full search strategies for MEDLINE database will be published in the final review.</p> <p>No date restrictions have been applied for this question.</p>

5.	Condition or domain being studied	Neonatal infection is a significant cause of mortality and morbidity in newborn babies. Early-onset neonatal infection occurs less than 72 hours after birth and can lead to life-threatening sepsis, which accounts for 10% of all neonatal deaths.
6.	Population	<p>Inclusion:</p> <ul style="list-style-type: none"> <li>• Unborn or newborn babies under 72 hours</li> <li>• Pregnant women</li> </ul> <p>Exclusion:</p> <ul style="list-style-type: none"> <li>• Babies with suspected or confirmed non-bacterial infections.</li> <li>• Babies with suspected or confirmed syphilis.</li> <li>• Babies with localised infections only.</li> <li>• Babies with suspected or confirmed bacterial infection resulting from therapeutic interventions such as surgery. Babies with a history of surgery which was not the cause of the infection will not be excluded.</li> <li>• Babies with suspected or confirmed meningitis who are not receiving care in neonatal units (covered by the NICE guideline on bacterial meningitis and meningococcal septicaemia)</li> <li>• Women with pre-labour rupture of membranes at term (covered in the NICE intrapartum care guideline)</li> </ul>
7.	Risk factors	<ul style="list-style-type: none"> <li>• Invasive group B streptococcal (GBS) infection in a previous baby</li> </ul>

		<ul style="list-style-type: none"><li>• Maternal GBS colonisation, bacteriuria, detection (including vaginal or rectal swab) or infection in the current pregnancy</li><li>• Maternal GBS colonisation, bacteriuria, detection (including vaginal or rectal swab) or infection in a previous pregnancy (including where the baby was well)</li><li>• Suspected or confirmed infection in another baby in the case of a multiple pregnancy</li><li>• Maternal suspected bacterial infection in the puerperium period</li><li>• Maternal perineal infections</li><li>• Maternal obesity</li><li>• Behavioural and hygienic factors (for example adherence to infection control measures by medical professionals and parents/carers)</li><li>• Maternal carriage of Methicillin-resistant Staphylococcus aureus (MRSA)</li><li>• Preterm prelabour rupture of membranes</li><li>• Suspected or confirmed rupture of membranes for more than 18 hours in a preterm birth</li><li>• Gestational age</li><li>• Intrapartum fever higher than 38°C, or confirmed or suspected chorioamnionitis</li><li>• Parenteral antibiotic treatment given to the woman for confirmed or suspected invasive bacterial infection (such as septicaemia) at any time</li></ul>
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		<p>during labour, or in the 24-hour periods before and after the birth [This does not refer to intrapartum antibiotic prophylaxis]</p> <ul style="list-style-type: none"> <li>• Intrapartum antibiotic prophylaxis (including the time before birth that it is received)</li> </ul>
8.	Reference standard	<ul style="list-style-type: none"> <li>• culture-proven infection from a sample taken within 72 hours of birth where available or within the study-defined period for early onset neonatal infection</li> <li>• antibiotics for suspected bloodstream infection (in neonate) given within 72 hours of birth where available or within the study-defined period for early onset neonatal infection</li> </ul>
9.	Types of study to be included	<p>Predictive accuracy studies (cohort) reporting data from which a 2*2 contingency table can be calculated (True positives, false negatives, true negatives, false positives).</p> <p>Multivariate cohort studies that report adjusted measures of association (adjusted risk ratios, odds ratios or hazard ratios) will be included only for risk factors where no predictive accuracy data is available.</p> <p>Predictive accuracy studies were prioritised over multivariate cohort studies (association studies) as they provide data that is more directly relatable to outcomes that are important to patients and their families. This approach is also consistent with the approach taken for this review question in the 2012 version of the NICE guideline on Neonatal infection.</p> <p>Systematic reviews of included studies types</p>
10.	Other exclusion criteria	<ul style="list-style-type: none"> <li>• Non-English language studies</li> </ul>

		<ul style="list-style-type: none"> <li>• Non-Organisation for Economic Cooperation and Development (OECD) countries</li> <li>• Conference abstracts, theses, dissertations.</li> <li>• Case-control studies will be excluded</li> </ul>
11.	Context	NICE guideline CG149 Neonatal infection will be updated by this question. Care is usually provided in hospitals with facilities to care for mothers and neonates.
12.	Primary outcomes (critical outcomes)	<p>Outcomes for predictive accuracy studies:</p> <ul style="list-style-type: none"> <li>• Sensitivity</li> <li>• Specificity</li> <li>• Positive and negative predictive values</li> <li>• Positive and negative likelihood ratios</li> </ul> <p>If association studies are included due to a lack of predictive accuracy data (see section 9 for details):</p> <ul style="list-style-type: none"> <li>• Adjusted Risk ratios, Odds ratios, hazard ratios</li> </ul>
13.	Secondary outcomes (important outcomes)	Not applicable
14.	Data extraction (selection and coding)	All references identified by the searches and from other sources will be uploaded into EPPI reviewer and de-duplicated. 10% of the abstracts will be reviewed by two

		<p>reviewers, with any disagreements resolved by discussion or, if necessary, a third independent reviewer.</p> <p>The full text of potentially eligible studies will be retrieved and will be assessed in line with the criteria outlined above. Data will be extracted from the included studies into a standardised form for assessment of study quality and evidence synthesis. Extracted information will include: study setting; study population and participant demographics and baseline characteristics; details of the intervention and comparator used; study methodology; recruitment and study completion rates; outcomes and times of measurement and information for assessment of the risk of bias. Study investigators may be contacted for missing data where time and resources allow.</p> <p>This review will make use of the priority screening functionality within the EPPI-reviewer software.</p>
15.	Risk of bias (quality) assessment	<p>Risk of bias will be assessed using the QUIPS checklist as described in Developing NICE guidelines: the manual. The ROBIS checklist will be used to assess systematic reviews.</p>
16.	Strategy for data synthesis	<p>Meta-analyses of predictive test accuracy data will be conducted for all factors that are reported by more than one study, with reference to the Cochrane Handbook for systematic reviews on diagnostic test accuracy (the same principles for meta-analysis will be followed as for diagnostic test accuracy studies).</p> <p>Random-effects models will be fitted for all analyses. A bivariate model will be fitted when 5 or more studies are available to be meta-analysed. A univariate model will be fitted when there are fewer than 5 studies available.</p>

		<ul style="list-style-type: none"> <li>• Bivariate meta-analyses will be performed in R using the ‘mada’ package</li> <li>• Univariate meta-analysis will be performed in excel.</li> </ul> <p>Modified GRADE will be used to assess certainty in the evidence base.</p> <p>Heterogeneity will be assessed by considering whether studies are sufficiently similar in their populations, reference standards and adjustment for confounding factors to allow meaningful pooling of data to take place. If meta-analysis is conducted, <math>I^2</math> will be used as a statistical measure of heterogeneity.</p> <p>In cases where heterogeneity make meta-analysis inappropriate, data for each study will be presented as separate lines in the GRADE profile.</p> <p>Meta-analysis will not be carried out for data from multivariate association studies as it is very unlikely that data from different studies will have adjusted for identical confounding factors as well as being heterogenous in terms of their population,</p>
17.	Analysis of sub-groups	<p><b>Stratifications</b></p> <ul style="list-style-type: none"> <li>• term babies and preterm babies</li> <li>• multiple births</li> </ul>
18.	Type and method of review	<ul style="list-style-type: none"> <li><input type="checkbox"/> Intervention</li> <li><input type="checkbox"/> Diagnostic</li> <li><input checked="" type="checkbox"/> Prognostic</li> <li><input type="checkbox"/> Qualitative</li> </ul>

		<input type="checkbox"/> Epidemiologic <input type="checkbox"/> Service Delivery <input type="checkbox"/> Other (please specify)		
19.	Language	English		
20.	Country	England		
21.	Anticipated or actual start date	01/11/2019		
22.	Anticipated completion date	12/08/2020		
23.	Stage of review at time of this submission	<b>Review stage</b>	<b>Started</b>	<b>Completed</b>
		Preliminary searches	<input type="checkbox"/>	<input type="checkbox"/>
		Piloting of the study selection process	<input type="checkbox"/>	<input type="checkbox"/>

		Formal screening of search results against eligibility criteria	<input type="checkbox"/>	<input type="checkbox"/>
		Data extraction	<input type="checkbox"/>	<input type="checkbox"/>
		Risk of bias (quality) assessment	<input type="checkbox"/>	<input type="checkbox"/>
		Data analysis	<input type="checkbox"/>	<input type="checkbox"/>
24.	Named contact	<p><b>5a. Named contact</b> Guideline Updates Team</p> <p><b>5b Named contact e-mail</b> Nlupdate@nice.org.uk</p> <p><b>5e Organisational affiliation of the review</b> National Institute for Health and Care Excellence (NICE)</p>		
25.	Review team members	<p>From the Guideline Updates Team:</p> <ul style="list-style-type: none"> <li>• Dr Kathryn Hopkins</li> <li>• Dr Clare Dadswell</li> <li>• Mr Fadi Chehadah</li> </ul>		

		<ul style="list-style-type: none"> <li>• Mr Gabriel Rogers</li> <li>• Mr Wesley Hubbard</li> </ul>
26.	Funding sources/sponsor	This systematic review is being completed by the Guideline Updates Team which receives funding from NICE.
27.	Conflicts of interest	All guideline committee members and anyone who has direct input into NICE guidelines (including the evidence review team and expert witnesses) must declare any potential conflicts of interest in line with NICE's code of practice for declaring and dealing with conflicts of interest. Any relevant interests, or changes to interests, will also be declared publicly at the start of each guideline committee meeting. Before each meeting, any potential conflicts of interest will be considered by the guideline committee Chair and a senior member of the development team. Any decisions to exclude a person from all or part of a meeting will be documented. Any changes to a member's declaration of interests will be recorded in the minutes of the meeting. Declarations of interests will be published with the final guideline.
28.	Collaborators	Development of this systematic review will be overseen by an advisory committee who will use the review to inform the development of evidence-based recommendations in line with section 3 of <a href="#">Developing NICE guidelines: the manual</a> . Members of the guideline committee are available on the NICE website: <a href="https://www.nice.org.uk/guidance/indevelopment/gid-ng10111">https://www.nice.org.uk/guidance/indevelopment/gid-ng10111</a>
29.	Other registration details	None
30.	Reference/URL for published protocol	None
31.	Dissemination plans	NICE may use a range of different methods to raise awareness of the guideline. These include standard approaches such as:

		<ul style="list-style-type: none"> <li>• notifying registered stakeholders of publication</li> <li>• publicising the guideline through NICE's newsletter and alerts</li> <li>• issuing a press release or briefing as appropriate, posting news articles on the NICE website, using social media channels, and publicising the guideline within NICE.</li> </ul>
32.	Keywords	Late onset neonatal infection, maternal risk factors
33.	Details of existing review of same topic by same authors	None
34.	Current review status	<input checked="" type="checkbox"/> Ongoing <input type="checkbox"/> Completed but not published <input type="checkbox"/> Completed and published <input type="checkbox"/> Completed, published and being updated <input type="checkbox"/> Discontinued
35..	Additional information	None
36.	Details of final publication	<a href="http://www.nice.org.uk">www.nice.org.uk</a>

## A14 Review protocol for neonatal risk factors

ID	Field	Content
0.	PROSPERO registration number	CRD42019162610
1.	Review title	Neonatal risk factors and clinical indicators of early-onset infection
2.	Review question	Which risk factors in the baby (including symptoms and signs) should raise suspicion of early-onset infection?
3.	Objective	<p>To identify risk factors for early-onset neonatal infection that should be used to guide management in the UK</p> <ul style="list-style-type: none"> <li>• covers events relating to the baby after birth (postnatal events)</li> <li>• includes consideration of how soon after birth symptoms, signs or other indicators should raise suspicion of early-onset neonatal infection</li> <li>• includes which symptoms and signs (individually or in combination) should lead to antibiotic treatment</li> </ul> <p>The review is partly prognostic and partly diagnostic because it covers factors that affect a baby's risk of future infection as well as signs and symptoms of current infection. Both prognostic and diagnostic factors guide management decisions in practice – a baby could be treated for infection on the basis of risk factors alone if the risk of developing infection is very high, or because of a suspected infection based on signs and symptoms.</p>

4.	Searches	<p>The following databases will be searched:</p> <ul style="list-style-type: none"><li>• Cochrane Database of Systematic Reviews (CDSR)</li><li>• Embase</li><li>• MEDLINE (including 'in process' and 'E-pub ahead of print')</li><li>• Database of Abstracts of Reviews of Effect (DARE)</li></ul> <p>Searches will be restricted by:</p> <ul style="list-style-type: none"><li>• English language</li><li>• Human studies</li><li>• Conference abstracts</li></ul> <p>Other searches:</p> <p>None</p> <p>The searches will be re-run 6 weeks before final submission of the review and further studies retrieved for inclusion.</p> <p>The full search strategies for MEDLINE database will be published in the final review. No date restrictions have been applied for this question because although the question is an update of one from a previous version of the guideline, the search was carried out in conjunction with the searches for review question 5.1 and 5.2 which are new questions..</p>
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5.	Condition or domain being studied	Neonatal infection is a significant cause of mortality and morbidity in newborn babies. Early-onset neonatal infection occurs less than 72 hours after birth and can lead to life-threatening sepsis, which accounts for 10% of all neonatal deaths.
6.	Population	<p>Inclusion:</p> <ul style="list-style-type: none"> <li>• Newborn babies under 72 hours, or study definition for 'early onset' infection</li> </ul> <p>Exclusion:</p> <ul style="list-style-type: none"> <li>• Babies with suspected or confirmed non-bacterial infections.</li> <li>• Babies with suspected or confirmed syphilis.</li> <li>• Babies with localised infections.</li> <li>• Babies with suspected or confirmed bacterial infection resulting from therapeutic interventions such as surgery. Babies with a history of surgery which was not the cause of the infection will not be excluded.</li> <li>• Babies with suspected or confirmed meningitis who are not receiving care in neonatal units (covered by the NICE guideline on bacterial meningitis and meningococcal septicaemia)</li> <li>• Women with pre-labour rupture of membranes at term (covered in the NICE intrapartum care guideline)</li> </ul>
7.	Risk factors	<p><b>Signs and symptoms (diagnostic)</b></p> <ul style="list-style-type: none"> <li>• Altered behaviour or responsiveness</li> <li>• Altered muscle tone (for example, floppiness)</li> </ul>

		<ul style="list-style-type: none"><li>• Feeding difficulties (for example, feed refusal)</li><li>• Feed intolerance, including vomiting, excessive gastric aspirates and abdominal distension</li><li>• Abnormal heart rate (bradycardia or tachycardia)</li><li>• Signs of respiratory distress</li><li>• Reduced oxygen saturation level</li><li>• Jaundice</li><li>• Apnoea</li><li>• Seizures</li><li>• Need for cardio-pulmonary resuscitation</li><li>• Need for mechanical ventilation</li><li>• Temperature abnormality (lower than 36°C or higher than 38°C) unexplained by environmental factors</li><li>• Signs of shock</li><li>• Unexplained excessive bleeding, thrombocytopenia, or abnormal coagulopathy (International Normalised Ratio greater than 2.0)</li><li>• Oliguria</li><li>• Altered glucose homeostasis (hypoglycaemia or hyperglycaemia)</li><li>• Metabolic acidosis (base deficit of 10 mmol/litre or greater)</li><li>• Local signs of infection (for example, affecting the skin or eye)</li></ul>
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		<ul style="list-style-type: none"> <li>• Signs of neonatal encephalopathy</li> </ul> <p><b>Risk factors (prognostic)</b></p> <ul style="list-style-type: none"> <li>• Gestational age</li> <li>• Colonisation with Group B streptococcus (GBS) or Methicillin-resistant Staphylococcus aureus (MRSA) in the baby</li> <li>• Persistent fetal circulation (persistent pulmonary hypertension)</li> </ul>
8.	Comparator/Reference standard/Confounding factors	<ul style="list-style-type: none"> <li>• culture-proven infection from a sample taken within 72 hours of birth where available or within the study-defined period for early onset neonatal infection</li> <li>• antibiotics for suspected bloodstream infection (in neonate) given within 72 hours of birth where available or within the study-defined period for early onset neonatal infection</li> </ul>
9.	Types of study to be included	<p>Diagnostic or predictive accuracy studies (cohort or cross sectional) reporting data from which a 2*2 contingency table can be calculated (True positives, false negatives, true negatives, false positives).</p> <p>Multivariate association studies that report adjusted measures of association (adjusted risk ratios, odds ratios or hazard ratios) will be included only for risk factors or signs and symptoms where no accuracy (diagnostic or predictive) data is available.</p> <p>Diagnostic or predictive accuracy studies were prioritised over multivariate association studies as they provide data that is more directly relatable to outcomes that are important to patients and their families. This approach is also consistent with the</p>

		<p>approach taken for a similar question on early onset infection in the 2012 version of the NICE guideline on Neonatal infection.</p> <p>Systematic reviews of included studies types</p>
10.	Other exclusion criteria	<ul style="list-style-type: none"> <li>• Non-English language studies</li> <li>• Non-Organisation for Economic Cooperation and Development (OECD) countries</li>   <li>• Conference abstracts, theses, dissertations</li> <li>• Case control studies</li> </ul>
11.	Context	<p>NICE guideline CG149 Neonatal infection will be updated by this question. Care is usually provided in neonatal units or neonatal intensive care units.</p>
12.	Primary outcomes (critical outcomes)	<p>Outcomes for diagnostic/prognostic accuracy studies:</p> <ul style="list-style-type: none"> <li>• Sensitivity</li> <li>• Specificity</li> <li>• Positive and negative likelihood ratios</li> </ul> <p>If association studies are included due to a lack of diagnostic or predictive accuracy data (see section 9 for details):</p> <ul style="list-style-type: none"> <li>• Adjusted risk ratios, odds ratios, hazard ratios</li> </ul>

13.	Secondary outcomes (important outcomes)	Not applicable
14.	Data extraction (selection and coding)	<p>All references identified by the searches and from other sources will be uploaded into EPPI reviewer and de-duplicated. 10% of the abstracts will be reviewed by two reviewers, with any disagreements resolved by discussion or, if necessary, a third independent reviewer.</p> <p>The full text of potentially eligible studies will be retrieved and will be assessed in line with the criteria outlined above. Data will be extracted from the included studies into a standardised form for assessment of study quality and evidence synthesis. Extracted information will include: study setting; study population and participant demographics and baseline characteristics; details of the intervention and comparator used; study methodology; recruitment and study completion rates; outcomes and times of measurement and information for assessment of the risk of bias. Study investigators may be contacted for missing data where time and resources allow.</p> <p>This review will make use of the priority screening functionality within the EPPI-reviewer software.</p>
15.	Risk of bias (quality) assessment	<p>Risk of bias will be assessed for diagnostic accuracy studies using the QUADAS-2 checklist and diagnostic association studies will be assessed using the Joanna Briggs institute checklist for cross sectional studies.</p> <p>Risk of bias for predictive accuracy studies and prognostic association (cohort) studies will be assessed using the QUIPs checklist.</p> <p>The ROBIS checklist will be used to assess systematic reviews.</p>

16.	Strategy for data synthesis	<p>Meta-analyses of predictive or diagnostic test accuracy data will be conducted for all factors that are reported by more than one study, with reference to the Cochrane Handbook for systematic reviews on diagnostic test accuracy (the same principles for meta-analysis of predictive test accuracy studies will be followed as for diagnostic test accuracy studies).</p> <p>Random-effects models will be fitted for all analyses. A bivariate model will be fitted when 5 or more studies are available to be meta-analysed. A univariate model will be fitted when there are fewer than 5 studies available.</p> <ul style="list-style-type: none"><li>• Bivariate meta-analyses will be performed in R using the ‘mada’ package</li><li>• Univariate meta-analysis will be performed in excel.</li></ul> <p>Modified GRADE will be used to assess certainty in the evidence base.</p> <p>Heterogeneity will be assessed by considering whether studies are sufficiently similar in their populations, reference standards and adjustment for confounding factors to allow meaningful pooling of data to take place. If meta-analysis is conducted, <math>I^2</math> will be used as a statistical measure of heterogeneity.</p> <p>In cases where heterogeneity make meta-analysis in appropriate, data for each study will be presented as separate lines in the GRADE profile.</p> <p>Meta-analysis will not be carried out for data from multivariate association studies as it is very unlikely that data from different studies will have adjusted for identical confounding factors as well as being heterogenous in terms of their population,</p>
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17.	Analysis of sub-groups	<ul style="list-style-type: none"> <li>• term babies and preterm babies</li> <li>• multiple births</li> <li>• admission to neonatal unit</li> </ul>		
18.	Type and method of review	<input type="checkbox"/> Intervention <input checked="" type="checkbox"/> Diagnostic <input checked="" type="checkbox"/> Prognostic <input type="checkbox"/> Qualitative <input type="checkbox"/> Epidemiologic <input type="checkbox"/> Service Delivery <input type="checkbox"/> Other (please specify)		
19.	Language	English		
20.	Country	England		
21.	Anticipated or actual start date	24/06/2018		
22.	Anticipated completion date	12/08/2020		
23.	Stage of review at time of this submission	<b>Review stage</b>	<b>Started</b>	<b>Completed</b>

		Preliminary searches	<input type="checkbox"/>	<input type="checkbox"/>
		Piloting of the study selection process	<input type="checkbox"/>	<input type="checkbox"/>
		Formal screening of search results against eligibility criteria	<input type="checkbox"/>	<input type="checkbox"/>
		Data extraction	<input type="checkbox"/>	<input type="checkbox"/>
		Risk of bias (quality) assessment	<input type="checkbox"/>	<input type="checkbox"/>
		Data analysis	<input type="checkbox"/>	<input type="checkbox"/>
24.	Named contact	<b>5a. Named contact</b> Guideline Updates Team  <b>5b Named contact e-mail</b> NIupdate@nice.org.uk		

		<b>5e Organisational affiliation of the review</b> National Institute for Health and Care Excellence (NICE)
25.	Review team members	From the Guideline Updates Team: <ul style="list-style-type: none"> <li>• Dr Kathryn Hopkins</li> <li>• Dr Clare Dadswell</li> <li>• Mr Fadi Chehadah</li> <li>• Mr Gabriel Rogers</li> <li>• Mr Wesley Hubbard</li> </ul>
26.	Funding sources/sponsor	This systematic review is being completed by the Guideline Updates Team which receives funding from NICE.
27.	Conflicts of interest	All guideline committee members and anyone who has direct input into NICE guidelines (including the evidence review team and expert witnesses) must declare any potential conflicts of interest in line with NICE's code of practice for declaring and dealing with conflicts of interest. Any relevant interests, or changes to interests, will also be declared publicly at the start of each guideline committee meeting. Before each meeting, any potential conflicts of interest will be considered by the guideline committee Chair and a senior member of the development team. Any decisions to exclude a person from all or part of a meeting will be documented. Any changes to a member's declaration of interests will be recorded in the minutes of the meeting. Declarations of interests will be published with the final guideline.
28.	Collaborators	Development of this systematic review will be overseen by an advisory committee who will use the review to inform the development of evidence-based recommendations in line with section 3 of <a href="#">Developing NICE guidelines: the manual</a> . Members of the guideline committee are available on the NICE website: <a href="https://www.nice.org.uk/guidance/indevelopment/gid-ng10111">https://www.nice.org.uk/guidance/indevelopment/gid-ng10111</a>
29.	Other registration details	None

30.	Reference/URL for published protocol	None
31.	Dissemination plans	<p>NICE may use a range of different methods to raise awareness of the guideline. These include standard approaches such as:</p> <ul style="list-style-type: none"> <li>• notifying registered stakeholders of publication</li> <li>• publicising the guideline through NICE's newsletter and alerts</li> <li>• issuing a press release or briefing as appropriate, posting news articles on the NICE website, using social media channels, and publicising the guideline within NICE.</li> </ul>
32.	Keywords	Late onset neonatal infection, neonate risk factors
33.	Details of existing review of same topic by same authors	None
34.	Current review status	<input checked="" type="checkbox"/> Ongoing <input type="checkbox"/> Completed but not published <input type="checkbox"/> Completed and published <input type="checkbox"/> Completed, published and being updated <input type="checkbox"/> Discontinued
35..	Additional information	None

36.	Details of final publication	<a href="http://www.nice.org.uk">www.nice.org.uk</a>
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## Appendix B – Literature search strategies

Literature search strategies for prognostic accuracy models and maternal and neonatal risk factors are all included in the appendices below.

### B.1 Clinical search: Clinical prediction models

The search was conducted on 14<sup>th</sup> August 2019. Given the broad range of publication types included in the review protocol, no in-house publication type filters were used. The following databases were searched: Medline, Medline In Process, Medline E-pub Ahead of print, Embase, (all via the Ovid platform), Cochrane Database of Systematic Reviews, CENTRAL (all via the Wiley platform), and the DARE database (via the CRD platform).

#### Medline. Medline In Process, Medline E-pub

- 1 exp Infant, Newborn/
- 2 Term Birth/
- 3 Infant Care/
- 4 Perinatal Care/
- 5 Intensive Care Units, Neonatal/
- 6 Intensive Care, Neonatal/
- 7 Infant Health/
- 8 (newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*).tw.
- 9 ((premature or pre-mature\* or preterm or pre-term) adj4 (child\* or infant\* or baby\* or babies\* or offspring)).tw.
- 10 or/1-9
- 11 exp Bacterial Infections/
- 12 ((bacter\* or strep\* or staph\* or GNB) adj4 (infect\* or diseas\* or contaminat\* or mening\* or pneumon\* or nosocomial\*)).tw.
- 13 exp Sepsis/
- 14 (sepsis or septic?emia\* or py?emia\* or pyho?emia\*).tw.
- 15 (septic\* adj4 shock\*).tw.
- 16 or/11-15
- 17 exp Streptococcus/
- 18 exp Staphylococcus/
- 19 (streptococc\* or staphylococc\*).tw.
- 20 (GBS or MRSA or NRCS-A or MSSA).tw.
- 21 (met?icillin-resistant adj3 aureus).tw.
- 22 exp Escherichia coli/
- 23 ((Escheric\* or E) adj2 coli).tw.
- 24 exp Listeria/
- 25 listeria\*.tw.
- 26 exp Klebsiella/
- 27 klebsiella\*.tw.
- 28 exp Pseudomonas/
- 29 (pseudomonas or chryseomonas or flavimonas).tw.
- 30 Enterobacteriaceae/
- 31 (enterobact\* or sodalis or paracolobactrum or ewingella or leclercia).tw.
- 32 ((enteric or coliform) adj2 bac\*).tw.
- 33 exp Neisseria/
- 34 neisseria\*.tw.
- 35 exp Haemophilus influenzae/
- 36 ((h?emophil\* or H or bacter\* or bacill\* or mycobacter\* or coccobac\*) adj2 (influenz\* or pfeiffer\* or meningitidis)).tw.

37 exp Serratia/  
38 serratia\*.tw.  
39 exp Cronobacter/  
40 (cronobact\* or sakazaki\* or malonatic\*).tw.  
41 exp Acinetobacter/  
42 (acinetobact\* or herellea\* or mima or baumannii\* or genomosp\* or calcoacetic\*).tw.  
43 exp Fusobacterium/  
44 (fusobact\* or sphaerophor\* or necrophorum or nucleatum).tw.  
45 exp Enterococcus/  
46 enterococc\*.tw.  
47 or/17-46  
48 16 or 47  
49 10 and 48  
50 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*) adj4 infect\*).tw.  
51 ((premature or pre-mature\* or preterm or pre-term) adj4 (child\* or infant\* or baby\* or babies\* or offspring) adj4 infect\*).tw.  
52 50 or 51  
53 49 or 52  
54 (bacter?emia\* or bacill?emia\*).tw.  
55 (blood\* adj4 (infect\* or contamin\* or invas\* or invad\*)).tw.  
56 54 or 55  
57 10 and 56  
58 53 or 57  
59 Risk Assessment/mt [Methods]  
60 ((risk\* or predict\* or probab\* or prognos\* or quantitativ\*) adj2 (model\* or tool\* or algorithm\* or rul\*)).tw.  
61 (diagnos\* adj2 (model\* or algorithm\*)).tw.  
62 ((sepsis\* or septic\* or Bayes\* or EOS or LOS) adj4 calculator\*).tw.  
63 (NEOSC or EOSCAL\* or SRC).tw.  
64 (Kaiser adj2 Permanente).tw.  
65 (Kaiser adj10 calculator\*).tw.  
66 ((sepsis or septic\*) adj4 risk\* adj4 scor\*).tw.  
67 SRS.tw.  
68 ((sepsis\* or septic\*) adj4 (metascore\* or meta-score\*)).tw.  
69 Diagnosis, Computer-Assisted/  
70 Algorithms/  
71 ((computer\* or vital signs\* or math\* or manag\* or clinic\* or medic\* or stratif\* or prevent\* or therap\*) adj4 algorithm\*).tw.  
72 RALIS.tw.  
73 (computer\* adj4 (analys\* or template\*)).tw.  
74 Decision Support Techniques/  
75 (decision\* adj4 (aid\* or analys\* or support\* or assist\*)).tw.  
76 CDSS\*.tw.  
77 or/59-76  
78 58 and 77  
79 Animals/ not Humans/  
80 78 not 79  
81 limit 80 to english language

## Embase

1 newborn/  
2 term birth/

- 3 infant care/
- 4 perinatal care/
- 5 neonatal intensive care unit/
- 6 newborn intensive care/
- 7 child health/
- 8 (newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*).tw.
- 9 ((premature or pre-mature\* or preterm or pre-term) adj4 (child\* or infant\* or baby\* or babies\* or offspring)).tw.
- 10 or/1-9
- 11 exp bacterial infection/
- 12 ((bacter\* or strep\* or staph\* or GNB) adj4 (infect\* or diseas\* or contaminat\* or mening\* or pneumon\* or nosocomial\*)).tw.
- 13 exp sepsis/
- 14 (sepsis or septic?emia\* or py?emia\* or pyho?emia\*).tw.
- 15 (septic\* adj4 shock\*).tw.
- 16 or/11-15
- 17 exp Streptococcus/
- 18 exp Staphylococcus/
- 19 (streptococc\* or staphylococc\*).tw.
- 20 (GBS or MRSA or NRCS-A or MSSA).tw.
- 21 (met?icillin-resistant adj3 aureus).tw.
- 22 exp Escherichia coli/
- 23 ((Escheric\* or E) adj2 coli).tw.
- 24 exp Listeria/
- 25 listeria\*.tw.
- 26 exp Klebsiella/
- 27 klebsiella\*.tw.
- 28 exp Pseudomonas/
- 29 (pseudomonas or chryseomonas or flavimonas).tw.
- 30 Enterobacteriaceae/
- 31 (enterobact\* or sodalis or paracolobactrum or ewingella or leclercia).tw.
- 32 ((enteric or coliform) adj2 bac\*).tw.
- 33 exp Neisseria/
- 34 neisseria\*.tw.
- 35 exp Haemophilus influenzae/
- 36 ((h?emophil\* or H or bacter\* or bacill\* or mycobacter\* or coccobac\*) adj2 (influenz\* or pfeiffer\* or meningitidis)).tw.
- 37 exp Serratia/
- 38 serratia\*.tw.
- 39 exp cronobacter/
- 40 (cronobact\* or sakazaki\* or malonatic\*).tw.
- 41 exp Acinetobacter/
- 42 (acinetobact\* or herellea\* or mima or baumannii\* or genomosp\* or calcoacetic\*).tw.
- 43 exp Fusobacterium/
- 44 (fusobact\* or sphaerophor\* or necrophorum or nucleatum).tw.
- 45 exp Enterococcus/
- 46 enterococc\*.tw.
- 47 or/17-46
- 48 16 or 47
- 49 10 and 48
- 50 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*) adj4 infect\*).tw.
- 51 ((premature or pre-mature\* or preterm or pre-term) adj4 (child\* or infant\* or baby\* or babies\* or offspring) adj4 infect\*).tw.
- 52 50 or 51
- 53 49 or 52
- 54 (bacter?emia\* or bacill?emia\*).tw.

- 55 (blood\* adj4 (infect\* or contamin\* or invas\* or invad\*)).tw.
- 56 54 or 55
- 57 10 and 56
- 58 53 or 57
- 59 \*risk assessment/
- 60 ((risk\* or predict\* or probab\* or prognos\* or quantitativ\*) adj2 (model\* or tool\* or algorithm\* or rul\*)).tw.
- 61 (diagnos\* adj2 (model\* or algorithm\*)).tw.
- 62 ((sepsis\* or septic\* or Bayes\* or EOS or LOS) adj4 calculator\*).tw.
- 63 (NEOSC or EOSCAL\* or SRC).tw.
- 64 (Kaiser adj2 Permanente).tw.
- 65 (Kaiser adj10 calculator\*).tw.
- 66 ((sepsis or septic\*) adj4 risk\* adj4 scor\*).tw.
- 67 SRS.tw.
- 68 ((sepsis\* or septic\*) adj4 (metascore\* or meta-score\*)).tw.
- 69 computer assisted diagnosis/
- 70 algorithm/
- 71 ((computer\* or vital signs\* or math\* or manag\* or clinic\* or medic\* or stratif\* or prevent\* or therap\*) adj4 algorithm\*).tw.
- 72 RALIS.tw.
- 73 (computer\* adj4 (analys\* or template\*)).tw.
- 74 exp decision support system/
- 75 (decision\* adj4 (aid\* or analys\* or support\* or assist\*)).tw.
- 76 CDSS\*.tw.
- 77 or/59-76
- 78 58 and 77
- 79 nonhuman/ not human/
- 80 78 not 79
- 81 limit 80 to english language
- 82 limit 81 to (conference abstract or conference paper or "conference review")
- 83 81 not 82

### **Cochrane Database of Systematic Reviews, CENTRAL**

- #1 MeSH descriptor: [Infant, Newborn] explode all trees
- #2 MeSH descriptor: [Term Birth] this term only
- #3 MeSH descriptor: [Infant Care] this term only
- #4 MeSH descriptor: [Perinatal Care] this term only
- #5 MeSH descriptor: [Intensive Care Units, Neonatal] this term only
- #6 MeSH descriptor: [Intensive Care, Neonatal] this term only
- #7 MeSH descriptor: [Infant Health] this term only
- #8 ((newborn\* or new born\* or new-born or neonat\* or neo-nat\* or perinat\* or perinat\*)):ti,ab,kw
- #9 ((premature or pre-mature\* or preterm or pre-term) near/4 (child\* or infant\* or baby\* or babies\* or offspring)):ti,ab,kw
- #10 {or #1-#9}
- #11 MeSH descriptor: [Bacterial Infections] explode all trees
- #12 ((bacter\* or strep\* or staph\* or GNB) near/4 (infect\* or diseas\* or contaminat\* or mening\* or pneumon\* or nosocomial\*)):ti,ab,kw
- #13 MeSH descriptor: [Sepsis] explode all trees
- #14 ((sepsis or septic?emia\* or py?emia\* or pyho?emia\*)):ti,ab,kw
- #15 ((septic\* near/4 shock\*)):ti,ab,kw
- #16 {or #11-#15}
- #17 MeSH descriptor: [Streptococcus] explode all trees
- #18 MeSH descriptor: [Staphylococcus] explode all trees

- #19 ((streptococc\* or staphylococc\*)):ti,ab,kw
- #20 ((GBS or MRSA or NRCS-A or MSSA)):ti,ab,kw
- #21 ((met?icillin-resistant near/3 aureus)):ti,ab,kw
- #22 MeSH descriptor: [Escherichia coli] explode all trees
- #23 ((Escheric\* or E) near/2 (coli)):ti,ab,kw
- #24 MeSH descriptor: [Listeria] explode all trees
- #25 (Listeria\*):ti,ab,kw
- #26 MeSH descriptor: [Klebsiella] explode all trees
- #27 (klebsiella\*):ti,ab,kw
- #28 MeSH descriptor: [Pseudomonas] explode all trees
- #29 ((pseudomonas or chryseomonas or flavimonas)):ti,ab,kw
- #30 MeSH descriptor: [Enterobacteriaceae] this term only
- #31 ((enterobact\* or sodalis or paracolobactrum or ewingella or leclercia)):ti,ab,kw
- #32 ((enteric or coliform) near/2 (bac\*)):ti,ab,kw
- #33 MeSH descriptor: [Neisseria] explode all trees
- #34 (neisseria\*):ti,ab,kw
- #35 MeSH descriptor: [Haemophilus influenzae] explode all trees
- #36 ((h?emophil\* or H or bacter\* or bacill\* or mycobacter\* or coccobac\*) near/2 (influenz\* or pfeiffer\* or meningitidis)):ti,ab,kw
- #37 MeSH descriptor: [Serratia] explode all trees
- #38 (serratia\*):ti,ab,kw
- #39 MeSH descriptor: [Cronobacter] explode all trees
- #40 ((cronobact\* or sakazaki\* or malonatic\*)):ti,ab,kw
- #41 MeSH descriptor: [Acinetobacter] explode all trees
- #42 ((acinetobact\* or herellea\* or mima or baumannii\* or genomosp\* or calcoacetic\*)):ti,ab,kw
- #43 MeSH descriptor: [Fusobacterium] explode all trees
- #44 ((fusobact\* or sphaerophor\* or necrophorum or nucleatum)):ti,ab,kw
- #45 MeSH descriptor: [Enterococcus] explode all trees
- #46 (enterococc\*):ti,ab,kw
- #47 {or #17-#46}
- #48 #16 or #47
- #49 #10 and #48
- #50 ((newborn\* or new born\* or new-born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*) near/4 (infect\*)):ti,ab,kw
- #51 ((premature or pre-mature\* or preterm or pre-term) near/4 (child\* or infant\* or baby\* or babies\* or offspring) near/4 (infect\*)):ti,ab,kw
- #52 #50 or #51
- #53 #49 or #52
- #54 ((bacter?emia\* or bacill?emia\*)):ti,ab,kw
- #55 ((blood\*) near/4 (infect\* or contamin\* or invas\* or invad\*)):ti,ab,kw
- #56 #54 or #55
- #57 #10 and #56
- #58 #53 or #57
- #59 MeSH descriptor: [Risk Assessment] this term only and with qualifier(s): [methods - MT]
- #60 ((risk\* or predict\* or probab\* or prognos\* or quantitativ\*) near/2 (model\* or tool\* or algorithm\* or rul\*)):ti,ab,kw
- #61 ((diagnos\*) near/2 (model\* or algorithm\*)):ti,ab,kw
- #62 ((sepsis\* or septic\* or Bayes\* or EOS or LOS) near/4 (calculator\*)):ti,ab,kw
- #63 ((NEOSC or EOSCAL\* or SRC)):ti,ab,kw
- #64 ((Kaiser) near/2 (Permanente)):ti,ab,kw
- #65 ((Kaiser) near/10 (calculator\*)):ti,ab,kw
- #66 ((sepsis or septic\*) near/4 (risk\*) near/4 (scor\*)):ti,ab,kw
- #67 (SRS):ti,ab,kw
- #68 ((sepsis\* or septic\*) near/4 (metascore\* or meta-score\*)):ti,ab,kw

- #69 MeSH descriptor: [Diagnosis, Computer-Assisted] this term only
- #70 MeSH descriptor: [Algorithms] this term only
- #71 ((computer\* or vital signs\* or math\* or manag\* or clinic\* or medic\* or stratif\* or prevent\* or therap\*) near/4 (algorithm\*)):ti,ab,kw
- #72 (RALIS):ti,ab,kw
- #73 ((computer\*) near/4 (analys\* or template\*)):ti,ab,kw
- #74 MeSH descriptor: [Decision Support Techniques] this term only
- #75 ((decision\*) near/4 (aid\* or analys\* or support\* or assist\*)):ti,ab,kw
- #76 (CDSS\*):ti,ab,kw
- #77 {or #59-#76}
- #78 #58 and #77
- #79 (conference):pt
- #80 ((clinicaltrials or trialsearch)):so
- #81 #79 or #80
- #82 #78 not #81

## DARE

- 1 MeSH DESCRIPTOR Infant, Newborn EXPLODE ALL TREES
- 2 MeSH DESCRIPTOR Term Birth
- 3 MeSH DESCRIPTOR Infant Care
- 4 MeSH DESCRIPTOR Perinatal Care
- 5 MeSH DESCRIPTOR Intensive Care Units, Neonatal
- 6 MeSH DESCRIPTOR Intensive Care, Neonatal
- 7 MeSH DESCRIPTOR Infant Health
- 8 (((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*)))
- 9 (((premature or pre-mature\* or preterm or pre-term) NEAR4 (child\* or infant\* or baby\* or babies\* or offspring)))
- 10 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9
- 11 MeSH DESCRIPTOR Bacterial Infections EXPLODE ALL TREE
- 12 (((bacter\* or strep\* or staph\* or GNB) NEAR4 (infect\* or diseas\* or contaminat\* or mening\* or pneumon\* or nosocomial\*)))
- 13 MeSH DESCRIPTOR Sepsis EXPLODE ALL TREES
- 14 (((sepsis or septic?emia\* or py?emia\* or pyho?emia\*)))
- 15 (((septic\* NEAR4 shock\*)))
- 16 #11 OR #12 OR #13 OR #14 OR #15
- 17 MeSH DESCRIPTOR Streptococcus EXPLODE ALL TREES
- 18 MeSH DESCRIPTOR Staphylococcus EXPLODE ALL TREES
- 19 (((streptococc\* or staphylococc\*)))
- 20 (((GBS or MRSA or NRCS-A or MSSA)))
- 21 (((met?icillin-resistant NEAR3 aureus)))
- 22 MeSH DESCRIPTOR Escherichia coli EXPLODE ALL TREES
- 23 (((Escheric\* or E) NEAR2 (coli)))
- 24 MeSH DESCRIPTOR Listeria EXPLODE ALL TREES
- 25 ((listeria\*))
- 26 MeSH DESCRIPTOR Klebsiella EXPLODE ALL TREES
- 27 ((klebsiella\*))
- 28 MeSH DESCRIPTOR Pseudomonas EXPLODE ALL TREES
- 29 ((pseudomonas or chryseomonas or flavimonas))
- 30 MeSH DESCRIPTOR Enterobacteriaceae EXPLODE ALL TREES
- 31 (enterobact\* or sodalis or paracolobactrum or ewingella or leclercia)
- 32 ((enteric or coliform) NEAR2 (bac\*))
- 33 MeSH DESCRIPTOR Neisseria EXPLODE ALL TREES
- 34 (neisseria\*)
- 35 MeSH DESCRIPTOR Haemophilus influenzae EXPLODE ALL TREES

36 ((h?emophil\* or H or bacter\* or bacill\* or mycobacter\* or coccobac\*) NEAR2  
(influenz\* or pfeiffer\* or meningitidis))  
37 MeSH DESCRIPTOR Serratia EXPLODE ALL TREES  
38 (serratia\*)  
39 MeSH DESCRIPTOR Cronobacter EXPLODE ALL TREES  
40 (cronobact\* or sakazaki\* or malonatic\*)  
41 MeSH DESCRIPTOR Acinetobacter EXPLODE ALL TREES  
42 ((acinetobact\* or herellea\* or mima or baumannii\* or genomosp\* or calcoacetic\*))  
43 MeSH DESCRIPTOR Fusobacterium EXPLODE ALL TREES  
44 ((fusobact\* or sphaerophor\* or necrophorum or nucleatum))  
45 MeSH DESCRIPTOR Enterococcus EXPLODE ALL TREES  
46 (enterococc\*)  
47 #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR  
#27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35 OR #36 OR #37 OR  
#38 OR #39 OR #40 OR #41 OR #42 OR #43 OR #44 OR #45 OR #46  
48 #16 OR #47  
49 #10 AND #48  
50 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*) NEAR4  
(infect\*))  
51 ((premature or pre-mature\* or preterm or pre-term) NEAR4 (child\* or infant\* or baby\*  
or babies\* or offspring) NEAR4 (infect\*))  
52 #50 OR #51  
53 #49 OR #52  
54 ((bacter?emia\* or bacill?emia\*))  
55 ((blood\*) NEAR4 (infect\* or contamin\* or invas\* or invad\*))  
56 #54 OR #55  
57 #10 AND #56  
58 #53 OR #57  
59 MeSH DESCRIPTOR Risk Assessment WITH QUALIFIER MT  
60 ((risk\* or predict\* or probab\* or prognos\* or quantitativ\*) NEAR2 (model\* or tool\* or  
algorithm\* or rul\*))  
61 ((diagnos\*) NEAR2 (model\* or algorithm\*))  
62 ((sepsis\* or septic\* or Bayes\* or EOS or LOS) NEAR4 (calculator\*))  
63 (NEOSC or EOSCAL\* or SRC)  
64 ((Kaiser) NEAR2 (Permanente))  
65 ((Kaiser) NEAR10 (calculator\*))  
66 ((sepsis or septic\*) NEAR4 (risk\*) NEAR4 (scor\*))  
67 (SRS)  
68 ((sepsis\* or septic\*) NEAR4 (metascore\* or meta-score\*))  
69 MeSH DESCRIPTOR Diagnosis, Computer-Assisted  
70 MeSH DESCRIPTOR Algorithms  
71 ((computer\* or vital signs\* or math\* or manag\* or clinic\* or medic\* or stratif\* or  
prevent\* or therap\*) NEAR4 (algorithm\*))  
72 (RALIS)  
73 ((computer\*) NEAR4 (analys\* or template\*))  
74 MeSH DESCRIPTOR Decision Support Techniques  
75 ((decision\*) NEAR4 (aid\* or analys\* or support\* or assist\*))  
76 (CDSS)  
77 #59 OR #60 OR #61 OR #62 OR #63 OR #64 OR #65 OR #66 OR #67 OR #68 OR  
#69 OR #70 OR #71 OR #72 OR #73 OR #74 OR #75 OR #76  
78 #58 AND #77  
79 \* IN DARE  
  
80 #78 AND #79

## B.2 Clinical search: Maternal and neonatal risk factors

The search was conducted on 28<sup>th</sup> November 2019. A single search strategy was developed for review questions 1.1 and 1.2. The following databases were searched: Medline, Medline In Process, Medline E-pub Ahead of print, Embase, (all via the Ovid platform), Cochrane Database of Systematic Reviews, (via the Wiley platform), and the DARE database (via the CRD platform).

The search focused on unique risk factors for review questions 1.1 and 1.2 not previously considered for review questions 5.1 and 5.2.

### Population and risk factor terms

The search terms used to identify information on population and risk factors are reproduced below for all databases. The population and risk factor terms were combined as 'And' to identify papers that discussed both.

#### Medline, Medline in Process & Medline E-pub Ahead of Print

- 1 exp Infant, Newborn/
- 2 Term Birth/
- 3 Infant Care/
- 4 Perinatal Care/
- 5 Intensive Care Units, Neonatal/
- 6 Intensive Care, Neonatal/
- 7 Infant Health/
- 8 (newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*).tw.
- 9 ((premature\* or pre-mature\* or preterm\* or pre-term\*) adj4 (child\* or infant\* or baby\* or babies\* or offspring)).tw.
- 10 or/1-9
- 11 exp Bacterial Infections/
- 12 ((bacter\* or strep\* or staph\* or GNB) adj4 (infect\* or diseas\* or contaminat\* or mening\* or pneumon\* or nosocomial\*)).tw.
- 13 exp Sepsis/
- 14 (sepsis or septic?emia\* or py?emia\* or pyho?emia\*).tw.
- 15 (septic\* adj4 shock\*).tw. (
- 16 (bacter?emia\* or bacill?emia\*).tw.

- 17 (blood\* adj4 (infect\* or contamin\* or invas\* or invad\*)).tw.
- 18 or/11-17
- 19 exp Streptococcus/
- 20 exp Staphylococcus/
- 21 (streptococc\* or staphylococc\*).tw.
- 22 (GBS or MRSA or NRCS-A or MSSA).tw.
- 23 (met?icillin-resistant adj3 aureus).tw.
- 24 exp Escherichia coli/
- 25 ((Escheric\* or E) adj2 coli).tw.
- 26 exp Listeria/
- 27 listeria\*.tw.
- 28 exp Klebsiella/
- 29 klebsiella\*.tw.
- 30 exp Pseudomonas/
- 31 (pseudomonas or chryseomonas or flavimonas).tw.
- 32 Enterobacteriaceae/
- 33 (enterobact\* or sodalis or paracolobactrum or ewingella or leclercia).tw.
- 34 ((enteric or coliform) adj2 bac\*).tw.
- 35 exp Neisseria/
- 36 neisseria\*.tw.
- 37 exp Haemophilus influenzae/
- 38 ((h?emophil\* or H or bacter\* or bacill\* or mycobacter\* or coccobac\*) adj2 (influenz\* or pfeiffer\* or meningitidis)).tw.
- 39 exp Serratia/
- 40 serratia\*.tw.
- 41 exp Cronobacter/
- 42 (cronobact\* or sakazaki\* or malonatic\*).tw.
- 43 exp Acinetobacter/
- 44 (acinetobact\* or herellea\* or mima or baumannii\* or genomosp\* or calcoacetic\*).tw.
- 45 exp Fusobacterium/

- 46 (fusobact\* or sphaerophor\* or necrophorum or nucleatum).tw.  
47 exp Enterococcus/  
48 enterococc\*.tw.  
49 or/19-48  
50 18 or 49  
51 10 and 50  
52 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*) adj4 infect\*).tw.  
53 ((premature\* or pre-mature\* or preterm\* or pre-term\*) adj4 (child\* or infant\* or baby\* or babies\* or offspring) adj4 infect\*).tw.  
54 52 or 53  
55 51 or 54  
56 exp Fetal Membranes, Premature Rupture/  
57 ((preterm\* or pre-term\* or premature\* or pre-mature\* or prelabor\* or pre-labor\* or pre) adj4 (ruptur\* or membrane\* or disrupt\* or erupt\* or sever or severed or tear\* or breach\*).tw.  
58 (prom or proms or pprom\*).tw.  
59 Gestational Age/  
60 ((gestat\* or f?etal\* or f?etus\*) adj4 (age\* or aging\* or matur\*).tw.  
61 Fever/di, dg [Diagnosis, Diagnostic Imaging]  
62 ((intrapartum\* or intra-partum\* or labo?r\* or deliver\* or childbirth\* or child-birth\* or congenit\* or conatal\*) adj4 (fever\* or deliriu\* or pyrexia\* or hyperthermia\*).tw.  
63 Chorioamnionitis/  
64 (chorioamnionit\* or amnioniti\* or funisiti\*).tw.  
65 (parenteral\* adj4 (antibacter\* or anti-bacter\* or antibiotic\* or anti-biotic\* or antimycobact\* or anti-mycobact\* or bacteriocid\*).tw.  
66 Antibiotic Prophylaxis/  
67 ((antibacter\* or anti-bacter\* or antibiotic\* or anti-biotic\* or antimycobact\* or anti-mycobact\* or bacteriocid\*) adj4 (prophyla\* or premedic\* or pre-medic\* or prevent\*).tw.  
68 Brain Diseases/  
69 ((brain\* or intracranial\* or intra-cranial\* or encephalon\*) adj4 (diseas\* or disorder\* or defect\* or illness\* or inflam\* or syndrom\*).tw.  
70 encephalopath\*.tw.  
71 Persistent Fetal Circulation Syndrome/

- 72 ((persist\* or misalign\* or mis-align\*) adj4 (f?etal\* or f?etus\* or pulmonar\*) adj4 (circulat\* or hypertens\* or vein\*)).tw.
- 73 (PPHN or PFC or ACD MPV or ACDMPV).tw.
- 74 or/56-73
- 75 55 and 74
- 76 Animals/ not Humans/
- 77 75 not 76
- 78 limit 77 to english language

#### Embase

- 1 newborn/
- 2 term birth/
- 3 infant care/
- 4 perinatal care/
- 5 neonatal intensive care unit/
- 6 newborn intensive care/
- 7 child health/
- 8 (newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*).tw.
- 9 ((premature\* or pre-mature\* or preterm\* or pre-term\*) adj4 (child\* or infant\* or baby\* or babies\* or offspring)).tw.
- 10 or/1-9
- 11 exp bacterial infection/
- 12 ((bacter\* or strep\* or staph\* or GNB) adj4 (infect\* or diseas\* or contaminat\* or mening\* or pneumon\* or nosocomial\*)).tw.
- 13 exp sepsis/
- 14 (sepsis or septic?emia\* or py?emia\* or pyho?emia\*).tw.
- 15 (septic\* adj4 shock\*).tw.
- 16 (bacter?emia\* or bacill?emia\*).tw.
- 17 (blood\* adj4 (infect\* or contamin\* or invas\* or invad\*)).tw.
- 18 or/11-17

- 19 exp Streptococcus/
- 20 exp Staphylococcus/
- 21 (streptococc\* or staphylococc\*).tw.
- 22 (GBS or MRSA or NRCS-A or MSSA).tw.
- 23 (met?icillin-resistant adj3 aureus).tw.
- 24 exp Escherichia coli/
- 25 ((Escheric\* or E) adj2 coli).tw.
- 26 exp Listeria/
- 27 listeria\*.tw.
- 28 exp Klebsiella/
- 29 klebsiella\*.tw.
- 30 exp Pseudomonas/
- 31 (pseudomonas or chryseomonas or flavimonas).tw.
- 32 Enterobacteriaceae/
- 33 (enterobact\* or sodalis or paracolobactrum or ewingella or leclercia).tw.
- 34 ((enteric or coliform) adj2 bac\*).tw.
- 35 exp Neisseria/
- 36 neisseria\*.tw.
- 37 exp Haemophilus influenzae/
- 38 ((h?emophil\* or H or bacter\* or bacill\* or mycobacter\* or coccobac\*) adj2 (influenz\* or pfeiffer\* or meningitidis)).tw.
- 39 exp Serratia/
- 40 serratia\*.tw.
- 41 exp Cronobacter/
- 42 (cronobact\* or sakazaki\* or malonatic\*).tw.
- 43 exp Acinetobacter/
- 44 (acinetobact\* or herellea\* or mima or baumannii\* or genomosp\* or calcoacetic\*).tw.
- 45 exp Fusobacterium/
- 46 (fusobact\* or sphaerophor\* or necrophorum or nucleatum).tw.
- 47 exp Enterococcus/

- 48 enterococc\*.tw.
- 49 or/19-48
- 50 18 or 49
- 51 10 and 50
- 52 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*) adj4 infect\*).tw.
- 53 ((premature\* or pre-mature\* or preterm\* or pre-term\*) adj4 (child\* or infant\* or baby\* or babies\* or offspring) adj4 infect\*).tw.
- 54 52 or 53
- 55 51 or 54
- 56 exp premature fetus membrane rupture/
- 57 ((preterm\* or pre-term\* or premature\* or pre-mature\* or prelabor\* or pre-labor\* or pre) adj4 (ruptur\* or membrane\* or disrupt\* or erupt\* or sever or severed or tear\* or breach\*).tw.
- 58 (prom or proms or pprom\*).tw.
- 59 gestational age/
- 60 ((gestat\* or f?etal\* or f?etus\*) adj4 (age\* or aging\* or matur\*).tw.
- 61 fever/di [Diagnosis]
- 62 ((intrapartum\* or intra-partum\* or labo?r\* or deliver\* or childbirth\* or child-birth\* or congenit\* or conatal\*) adj4 (fever\* or deliriu\* or pyrexia\* or hyperthermia\*).tw.
- 63 exp chorioamnionitis/
- 64 (chorioamnionit\* or amnioniti\* or funisiti\*).tw.
- 65 (parenteral\* adj4 (antibacter\* or anti-bacter\* or antibiotic\* or anti-biotic\* or antimycobact\* or anti-mycobact\* or bacteriocid\*).tw.
- 66 antibiotic prophylaxis/
- 67 ((antibacter\* or anti-bacter\* or antibiotic\* or anti-biotic\* or antimycobact\* or anti-mycobact\* or bacteriocid\*) adj4 (prophyla\* or premedic\* or pre-medic\* or prevent\*).tw.
- 68 brain disease/
- 69 ((brain\* or intracranial\* or intra-cranial\* or encephalon\*) adj4 (diseas\* or disorder\* or defect\* or illness\* or inflam\* or syndrom\*).tw.
- 70 encephalopath\*.tw.
- 71 persistent pulmonary hypertension/
- 72 ((persist\* or misalign\* or mis-align\*) adj4 (f?etal\* or f?etus\* or pulmonar\*) adj4 (circulat\* or hypertens\* or vein\*).tw.

- 73 (PPHN or PFC or ACD MPV or ACDMPV).tw.
- 74 or/56-73
- 75 55 and 74
- 76 nonhuman/ not human/
- 77 75 not 76
- 78 limit 77 to english language

#### CDSR

- #1 MeSH descriptor: [Infant, Newborn] explode all trees
- #2 MeSH descriptor: [Term Birth] this term only
- #3 MeSH descriptor: [Infant Care] this term only
- #4 MeSH descriptor: [Perinatal Care] this term only
- #5 MeSH descriptor: [Intensive Care Units, Neonatal] this term only
- #6 MeSH descriptor: [Intensive Care, Neonatal] this term only
- #7 MeSH descriptor: [Infant Health] this term only
- #8 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*)):ti,ab,kw
- #9 ((premature\* or pre-mature\* or preterm\* or pre-term\*) near/4 (child\* or infant\* or baby\* or babies\* or offspring)):ti,ab,kw
- #10 {or #1-#9}
- #11 MeSH descriptor: [Bacterial Infections] explode all trees
- #12 ((bacter\* or strep\* or staph\* or GNB) near/4 (infect\* or diseas\* or contaminat\* or mening\* or pneumon\* or nosocomial\*)):ti,ab,kw
- #13 MeSH descriptor: [Sepsis] explode all trees
- #14 (sepsis or septic?emia\* or py?emia\* or pyho?emia\*):ti,ab,kw
- #15 (septic\* near/4 shock\*):ti,ab,kw
- #16 (bacter?emia\* or bacill?emia\*):ti,ab,kw
- #17 ((blood\*) near/4 (infect\* or contamin\* or invas\* or invad\*)):ti,ab,kw
- #18 {or #11-#17}
- #19 MeSH descriptor: [Streptococcus] explode all trees
- #20 MeSH descriptor: [Staphylococcus] explode all trees

- #21 (streptococc\* or staphylococc\*):ti,ab,kw
- #22 (GBS or MRSA or NRCS-A or MSSA):ti,ab,kw
- #23 (met?icillin-resistant near/3 aureus):ti,ab,kw
- #24 MeSH descriptor: [Escherichia coli] explode all trees
- #25 ((Escheric\* or E) near/2 (coli)):ti,ab,kw
- #26 MeSH descriptor: [Listeria] explode all trees
- #27 (listeria\*):ti,ab,kw
- #28 MeSH descriptor: [Klebsiella] explode all trees
- #29 (klebsiella\*):ti,ab,kw
- #30 MeSH descriptor: [Pseudomonas] explode all trees
- #31 (pseudomonas or chryseomonas or flavimonas):ti,ab,kw
- #32 MeSH descriptor: [Enterobacteriaceae] explode all trees
- #33 (enterobact\* or sodalis or paracolobactrum or ewingella or leclercia):ti,ab,kw
- #34 ((enteric or coliform) near/2 (bac\*)):ti,ab,kw
- #35 MeSH descriptor: [Neisseria] explode all trees
- #36 (neisseria\*):ti,ab,kw
- #37 MeSH descriptor: [Haemophilus influenzae] explode all trees
- #38 ((h?emophil\* or H or bacter\* or bacill\* or mycobacter\* or coccobac\*) near/2 (influenz\* or pfeiffer\* or meningitidis)):ti,ab,kw
- #39 MeSH descriptor: [Serratia] explode all trees
- #40 (serratia\*):ti,ab,kw
- #41 MeSH descriptor: [Cronobacter] explode all trees
- #42 (cronobact\* or sakazaki\* or malonatic\*):ti,ab,kw
- #43 MeSH descriptor: [Acinetobacter] explode all trees
- #44 (acinetobact\* or herellea\* or mima or baumanni\* or genomosp\* or calcoacetic\*):ti,ab,kw
- #45 MeSH descriptor: [Fusobacterium] explode all trees
- #46 (fusobact\* or sphaerophor\* or necrophorum or nucleatum):ti,ab,kw 296
- #47 MeSH descriptor: [Enterococcus] explode all trees
- #48 (enterococc\*):ti,ab,kw

- #49 {or #19-#48}
- #50 #18 or #49
- #51 #10 and #50
- #52 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*) near/4 (infect\*)):ti,ab,kw
- #53 ((premature\* or pre-mature\* or "preterm\*" or "pre-term\*") near/4 (child\* or infant\* or baby\* or babies\* or offspring) near/4 (infect\*)):ti,ab,kw
- #54 #52 or #53
- #55 #51 or #54
- #56 MeSH descriptor: [Fetal Membranes, Premature Rupture] explode all trees
- #57 ((preterm\* or pre-term\* or premature\* or pre-mature\* or prelabor\* or pre-labor\* or pre) near/4 (ruptur\* or membrane\* or disrupt\* or erupt\* or sever or severed or tear\* or breach\*)):ti,ab,kw
- #58 (prom or proms or pprom\*):ti,ab,kw
- #59 MeSH descriptor: [Gestational Age] this term only
- #60 ((gestat\* or f?etal\* or f?etus\*) near/4 (age\* or aging\* or matur\*)):ti,ab,kw
- #61 MeSH descriptor: [Fever] this term only and with qualifier(s): [diagnostic imaging - DG, diagnosis - DI]
- #62 ((intrapartum\* or intra-partum\* or labo?r\* or deliver\* or childbirth\* or child-birth\* or congenit\* or conatal\*) near/4 (fever\* or deliriu\* or pyrexia\* or hyperthermia\*)):ti,ab,kw
- #63 MeSH descriptor: [Chorioamnionitis] this term only
- #64 (chorioamnionit\* or amnioniti\* or funisiti\*):ti,ab,kw
- #65 ((parenteral\*) near/4 (antibacter\* or anti-bacter\* or antibiotic\* or anti-biotic\* or antimycobact\* or anti-mycobact\* or bacteriocid\*)):ti,ab,kw
- #66 MeSH descriptor: [Antibiotic Prophylaxis] this term only
- #67 ((antibacter\* or anti-bacter\* or antibiotic\* or anti-biotic\* or antimycobact\* or anti-mycobact\* or bacteriocid\*) near/4 (prophyla\* or premedic\* or pre-medic\* or prevent\*)):ti,ab,kw
- #68 MeSH descriptor: [Brain Diseases] this term only
- #69 ((brain\* or intracranial\* or intra-cranial\* or encephalon\*) near/4 (diseas\* or disorder\* or defect\* or illness\* or inflam\* or syndrom\*)):ti,ab,kw
- #70 (encephalopath\*):ti,ab,kw
- #71 MeSH descriptor: [Persistent Fetal Circulation Syndrome] this term only

- #72 ((persist\* or misalign\* or mis-align\*) near/4 (f?etal\* or f?etus\* or pulmonar\*) near/4 (circulat\* or hypertens\* or vein\*)):ti,ab,kw
- #73 (PPHN or PFC or ACD MPV or ACDMPV):ti,ab,kw
- #74 {or #56-#73}
- #75 #55 and #74

#### DARE

- 1 MeSH DESCRIPTOR Infant, Newborn EXPLODE ALL TREES
- 2 MeSH DESCRIPTOR Term Birth
- 3 MeSH DESCRIPTOR Infant Care
- 4 MeSH DESCRIPTOR Perinatal Care
- 5 MeSH DESCRIPTOR Intensive Care Units, Neonatal
- 6 MeSH DESCRIPTOR Intensive Care, Neonatal
- 7 MeSH DESCRIPTOR Infant Health
- 8 (newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*)
- 9 ((premature or pre-mature\* or preterm or pre-term) NEAR4 (child\* or infant\* or baby\* or babies\* or offspring))
- 10 (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9)
- 11 MeSH DESCRIPTOR Bacterial Infections EXPLODE ALL TREES
- 12 ((bacter\* or strep\* or staph\* or GNB) NEAR4 (infect\* or diseas\* or contaminat\* or mening\* or pneumon\* or nosocomial\*))
- 13 MeSH DESCRIPTOR Sepsis EXPLODE ALL TREES
- 14 (sepsis or septic?emia\* or py?emia\* or pyho?emia\*)
- 15 ((septic\* NEAR4 shock\*))
- 16 (bacter?emia\* or bacill?emia\*)
- 17 ((blood\*) NEAR4 (infect\* or contamin\* or invas\* or invad\*))
- 18 (#11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17)

- 19 MeSH DESCRIPTOR Streptococcus EXPLODE ALL TREES
- 20 MeSH DESCRIPTOR Staphylococcus EXPLODE ALL TREES
- 21 (streptococc\* or staphylococc\*)
- 22 (GBS or MRSA or NRCS-A or MSSA)
- 23 ((met?icillin-resistant NEAR3 aureus))
- 24 MeSH DESCRIPTOR Escherichia coli EXPLODE ALL TREES
- 25 ((Escheric\* or E) NEAR2 (coli))
- 26 MeSH DESCRIPTOR listeria EXPLODE ALL TREES
- 27 (listeria\*)
- 28 MeSH DESCRIPTOR Klebsiella EXPLODE ALL TREES
- 29 (klebsiella\*)
- 30 MeSH DESCRIPTOR Pseudomonas EXPLODE ALL TREES
- 31 (pseudomonas or chryseomonas or flavimonas)
- 32 MeSH DESCRIPTOR Enterobacteriaceae EXPLODE ALL TREES
- 33 (enterobact\* or sodalis or paracolobactrum or ewingella or leclercia)
- 34 ((enteric or coliform) NEAR2 (bac\*))
- 35 MeSH DESCRIPTOR Neisseria EXPLODE ALL TREES
- 36 (neisseria\*)
- 37 MeSH DESCRIPTOR Haemophilus influenzae EXPLODE ALL TREES
- 38 ((h?emophil\* or H or bacter\* or bacill\* or mycobacter\* or coccobac\*) NEAR2 (influenz\* or pfeiffer\* or meningitidis))
- 39 MeSH DESCRIPTOR Serratia EXPLODE ALL TREES
- 40 (serratia\*)
- 41 MeSH DESCRIPTOR Cronobacter EXPLODE ALL TREES
- 42 (cronobact\* or sakazaki\* or malonatic\*)
- 43 MeSH DESCRIPTOR Acinetobacter EXPLODE ALL TREES

- 44 (acinetobact\* or herellea\* or mima or baumanni\* or genomosp\* or calcoacetic\*)
- 45 MeSH DESCRIPTOR Fusobacterium EXPLODE ALL TREES
- 46 (fusobact\* or sphaerophor\* or necrophorum or nucleatum)
- 47 MeSH DESCRIPTOR Enterococcus EXPLODE ALL TREES
- 48 (enterococc\*)
- 49 (#19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35 OR #36 OR #37 OR #38 OR #39 OR #40 OR #41 OR #42 OR #43 OR #44 OR #45 OR #46 OR #47 OR #48)
- 50 (#18 OR #49)
- 51 (#10 AND #50)
- 52 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*) NEAR4 (infect\*))
- 53 ((premature or pre-mature\* or preterm or pre-term) NEAR4 (child\* or infant\* or baby\* or babies\* or offspring) NEAR4 (infect\*))
- 54 (#52 OR #53)
- 55 (#51 OR #54)
- 56 MeSH DESCRIPTOR Fetal Membranes, Premature Rupture EXPLODE ALL TREES
- 57 ((preterm\* or pre-term\* or premature\* or pre-mature\* or prelabor\* or pre-labor\* or pre) NEAR4 (ruptur\* or membrane\* or disrupt\* or erupt\* or sever or severed or tear\* or breach\*))
- 58 (prom or proms or pprom\*)
- 59 MeSH DESCRIPTOR Gestational Age
- 60 ((gestat\* or f?etal\* or f?etus\*) NEAR4 (age\* or aging\* or matur\*))
- 61 MeSH DESCRIPTOR Fever WITH QUALIFIER DI
- 62 MeSH DESCRIPTOR Fever WITH QUALIFIER DG
- 63 ((intrapartum\* or intra-partum\* or labo?r\* or deliver\* or childbirth\* or child-birth\* or congenit\* or conatal\*) NEAR4 (fever\* or deliriu\* or pyrexia\* or hyperthermia\*))
- 64 MeSH DESCRIPTOR Chorioamnionitis
- 65 (chorioamnionit\* or amnioniti\* or funisiti\*)

- 66 ((parenteral\*) NEAR4 (antibacter\* or anti-bacter\* or antibiotic\* or anti-biotic\* or antimycobact\* or anti-mycobact\* or bacteriocid\*))
- 67 MeSH DESCRIPTOR Antibiotic Prophylaxis
- 68 ((antibacter\* or anti-bacter\* or antibiotic\* or anti-biotic\* or antimycobact\* or anti-mycobact\* or bacteriocid\*) NEAR4 (prophyla\* or premedic\* or pre-medic\* or prevent\*))
- 69 MeSH DESCRIPTOR Brain Diseases
- 70 ((brain\* or intracranial\* or intra-cranial\* or encephalon\*) NEAR4 (diseas\* or disorder\* or defect\* or illness\* or inflam\* or syndrom\*))
- 71 (encephalopath\*)
- 72 MeSH DESCRIPTOR Persistent Fetal Circulation Syndrome
- 73 ((persist\* or misalign\* or mis-align\*) NEAR4 (f?etal\* or f?etus\* or pulmonar\*) NEAR4 (circulat\* or hypertens\* or vein\*))
- 74 (PPHN or PFC or ACD MPV or ACDMPV)
- 75 #56 OR #57 OR #58 OR #59 OR #60 OR #61 OR #62 OR #63 OR #64 OR #65 OR #66 OR #67 OR #68 OR #69 OR #70 OR #71 OR #72 OR #73 OR #74
- 76 #55 AND #75
- 77 \* IN DARE
- 78 #76 AND #77

#### Search Filters

The following search filters were combined as 'And' with the population and risk factor terms for the Medline databases and Embase. CDSR and DARE are systematic review databases so did not require the addition of a filter.

The Medline versions of the filters are reproduced below. Embase has validated translations of these that were used in the search.

#### Systematic Review

- 1 MEDLINE or pubmed).tw.
- 2 systematic review.tw.
- 3 systematic review.pt.

- 4 meta-analysis.pt.
- 5 intervention\$.ti.
- 6 or/1-5

#### Observational studies

The in-house observational studies filter was adapted to focus on cross-sectional studies this was then supplemented with the McMaster diagnostic and prognostic filters.

- 1 Cohort Studies/
- 2 Prospective Studies/
- 3 Retrospective Studies/
- 4 Cross-Sectional Studies/
- 5 cohort:.mp.
- 6 predictor:.tw.
- 7 cross sectional.tw.
- 8 prospective\*.tw.
- 9 retrospective\*.tw.
- 10 sensitiv:.mp.
- 11 predictive value:.mp.
- 12 accurac:.tw.
- 13 prognosis.sh.
- 14 diagnosed.tw.
- 15 death.tw.
- 16 exp models, statistical/
- 17 or/1-16

#### Risk terms

Following combination of population, risk factor and filter terms (if an appropriate database) the number of results were still considered too high. Additional risk terms were combined as 'And' with the other sections of the search strategy to reduce numbers.

The Medline risk terms are listed below. These were translated across all databases used in the search:

- 1 exp Risk/
- 2 exp Risk Management/
- 3 Pregnancy, High Risk/
- 4 risk\*.tw.
- 5 exp Health Status Indicators/
- 6 ((health\* or illness\* or wellness\* or wellbeing\* or well-being\*) adj4 (indicat\* or index\* or indices\* or apprais\* or barometer\* or gaug\* or mark\* or warn\* or ratio or ratios)).tw.
- 7 (sever\* adj4 illness\*).tw.
- 8 exp "Signs and Symptoms"/
- 9 ((symptom\* or sign or signs or manifest\* or phenomenon\*) adj8 (infect\* or diseas\* or contaminat\* or mening\* or pneumon\* or nosocomial\*)).tw.
- 10 or/1-9

#### Virus terms

The following terms were combined as 'Not' with the other sections of the search strategy to remove any papers focused on viral illness.

The Medline virus terms are listed below. These were translated across all databases used in the search:

- 1 exp Virus Diseases/
- 2 exp Viruses/
- 3 (virus\* or viral\* or retrovir\* or arbovir\* or lentivir\* or deltaretrovir\* or adenovir\*).tw.
- 4 HIV\*.tw.
- 5 (cytomegalovir\* or CMV\*).tw.
- 6 herpes\*.tw.
- 7 (papillomavir\* or HPV\*).tw.
- 8 ((hepatitis\* or hepatitid\*) adj2 (A or B or C or D or E)).tw.

- 9 (parechovir\* or echovir\*).tw.
- 10 (yellow\* adj2 fever\*).tw.
- 11 rhinovir\*.tw.
- 12 (coronavir\* or deltacoronavir\*).tw.
- 13 rotavir\*.tw.
- 14 (enterovir\* or coxsackie\*).tw.
- 15 exp Malaria/
- 16 (malaria\* or paludism\*).tw.
- 17 exp Syphilis/
- 18 (syphili\* or neurosyphili\* or neuro-syphili\*).tw.
- 19 or/1-18

Risk factors included in the search for review questions 5.1 and 5.2

The risk factors searched for as part of review questions 5.1 and 5.2 were considered for this evidence review and results from that search considered as part of the analysis. As a result of this they were removed from this search. This was to ensure there was no duplication of effort and there was a unique set of results for this search.

The following risk factors were combined as 'Not' with the other sections of the search strategy. The Medline risk factor terms are listed below. These were translated across all databases used in the search:

- 1 ((previous or preceding or earlier or prior or antecedent) adj4 (child\* or infant\* or baby\* or babies\* or offspring or delivery or deliveries)).tw.
- 2 ((later or next or succeeding) adj4 (child\* or infant\* or baby\* or babies\* or offspring or delivery or deliveries)).tw.
- 3 (Infectious Disease Transmission, Vertical/ or Carrier State/) and (Streptococcal Infections/ or Methicillin-Resistant Staphylococcus aureus/)
- 4 ((vertical\* or maternal\* or mother\* or mum\* or mom\* or parental\* or fetomaternal\* or fetomaternal\* or woman\* or women\* or pregnan\* or gestat\* or parturition\* or birth\* or childbirth\* or labo?r\*) adj4 (GBS\* or group B\* or MRSA\* or met?icillin-resist\*) adj4 (transmission\* or transmit\* or transfer\* or infect\* or diseas\* or contaminat\* or coloni?ation\* or contagio\* or bacteriuria\* or carrier\* or carriage or heterozygo\*)).tw.

- 5 exp Pregnancy, Multiple/
- 6 ((multiple or twin or triplet or quadruplet or quintuplet or superfetation) adj4 (pregnan\* or gestat\* or parturition\* or birth\* or childbirth\* or labo?r\* or delivery or deliveries)).tw.
- 7 Wound Infection/
- 8 (wound\* adj4 (infect\* or diseas\* or contaminat\* or coloni?ation\* or contagio\* or sepsis)).tw.
- 9 Postpartum Period/
- 10 (postpartum or post-partum or puerperium or puerperal).tw.
- 11 ((perineal or perineum) adj4 (infect\* or diseas\* or contaminat\* or coloni?ation\* or contagio\*)).tw.
- 12 exp Obesity/
- 13 ((obesity or obese or overweight or over-weight) adj8 risk\*).tw.
- 14 exp Hygiene/
- 15 exp Sanitation/
- 16 (hygien\* or saniti?e\* or sanitation\* or sanitary\*).tw.
- 17 exp Maternal Behavior/
- 18 ((behavio?r\* or attitud\*) adj4 (factor\* or aspect\* or consider\* or circumstanc\* or component\* or influenc\* or feature\*)).tw.
- 19 Illness Behavior/
- 20 ((alter\* or chang\* or illness\*) adj4 (behavio?r\* or respons\* or feedback\*) adj8 risk\*).tw.
- 21 Muscle Hypotonia/
- 22 (flop\* or flaccid\* or hypoton\* or hypomyotoni\*).tw.
- 23 ((alter\* or chang\* or poor\* or decreas\* or atonic\* or feeble or insuffic\* or meag\* or weak\* or unsatisfact\* or imperfect\* or impair\* or declin\* or reduc\* or diminish\*) adj4 musc\*).tw.
- 24 Feeding Behavior/
- 25 ((feed\* or bottle\* or breast\*) adj4 (behavio?r\* or difficult\* or refus\* or intoleran\* or declin\* or ignor\* or withdraw\* or problem\*)).tw.
- 26 exp Vomiting/
- 27 (vomit\* or emesis\*).tw.
- 28 ((gastric\* or nasogastric\* or naso-gastric\*) adj4 (aspirat\* or suction\*)).tw.
- 29 (abdom?n\* adj4 disten\*).tw.

- 30 Arrhythmias, Cardiac/ or Atrial Fibrillation/ or Atrial Flutter/ or Cardiac Complexes, Premature/ or Parasytostole/ or Ventricular Fibrillation/ or Ventricular Flutter/  
31 (arrhythmia\* or dysrhythmia\*).tw.  
32 ((abnormal\* or anomal\* or atypical\* or irregular\* or uncommon\* or unexpect\*) adj4 (heart\* or cardiac\* or vascular\*) adj2 (rate\* or pace\* or measure\* or rhythm\* or beat\*)).tw.  
33 Bradycardia/ or Tachycardia/  
34 (bradycardia\* or bradyarrhythmia\* or tachycardia\* or tachyarrhythmia\*).tw.  
35 Respiratory Distress Syndrome, Newborn/  
36 ((respirat\* or breath\*) adj4 (distres\* or troubl\* or discomfort\*)).tw.  
37 exp Hypoxia/  
38 (hypoxia\* or hypoxic\* or hypoxem\* or anoxia\* or anoxem\*).tw.  
39 (oxygen\* adj4 (deficien\* or reduc\* or saturat\* or concentrat\* or measur\*)).tw.  
40 exp Cyanosis/  
41 exp Oximetry/  
42 (cyanos?s\* or cyanotic\* or oximet\*).tw.  
43 exp Jaundice, Neonatal/  
44 (jaundice\* or icterus\*).tw.  
45 exp Apnea/  
46 apn?ea\*.tw.  
47 Seizures/  
48 ((seizure\* or convuls\* or paroxysm\*) adj8 risk\*).tw.  
49 exp Cardiopulmonary Resuscitation/  
50 (((cardiopulmon\* or cardio-pulmon\* or mouth-to-mouth\*) adj4 resuscitat\*) or CPR).tw.  
51 exp Respiration, Artificial/  
52 ((artificial\* or mechanic\* or automat\* or machine\* or control\*) adj4 (respirat\* or ventilat\* or breath\* or oxygenat\*)).tw.  
53 exp Body Temperature/  
54 ((body\* or organ\* or skin\* or high\* or low\* or excess\* or reduc\*) adj4 temperat\*).tw.  
55 ("36\*" or "38\*") adj2 (C or celsius).tw.  
56 ("96\*" or "100\*") adj2 (F or fahrenheit).tw.  
57 exp Shock/

- 58 (shock not (septic or sepsis)).tw.
- 59 (circulat\* adj4 (collaps\* or fail\*)).tw.
- 60 ((pale\* or cold\* or clammy or chill\* or blanch\*) adj4 skin\*).tw.
- 61 Sweat/ or Sweating/
- 62 (sweat\* or perspir\*).tw.
- 63 ((rapid\* or shallow\* or accelerat\* or hollow\* or flat\*) adj4 (breath\* or respirat\*)).tw.
- 64 (weakness\* or fragilit\*).tw.
- 65 Dizziness/
- 66 (dizz\* or orthostas\* or lighthead\* or light-head\*).tw.
- 67 Thirst/
- 68 thirst\*.tw.
- 69 Yawning/
- 70 (yawn\* or sigh or sighs).tw.
- 71 exp Hemorrhage/
- 72 (bleed\* or h?emorrhag\*).tw.
- 73 (blood\* adj4 (loss or effus\* or excess\*)).tw.
- 74 exp Thrombocytopenia/
- 75 (thrombocytop?enia\* or thrombop?enia\*).tw.
- 76 Blood Coagulation/
- 77 ((coagulat\* or clot or clott\*) adj8 risk\*).tw.
- 78 Oliguria/
- 79 oliguria\*.tw.
- 80 ((decreas\* or diminish\* or dwindle\* or reduc\* or wane) adj4 urin\*).tw.
- 81 Homeostasis/
- 82 (homeostas\* or homeostat\* or autoregulat\* or auto-regulat\*).tw.
- 83 exp Hypoglycemia/
- 84 exp Hyperglycemia/
- 85 (hypoglyc?emi\* or hyperglyc?emi\*).tw.
- 86 ((low\* or high\*) adj4 blood\* adj4 (sugar\* or glucose\*)).tw.

- 87 exp Acidosis/  
88 acidosis?.tw.  
89 ((local\* or region\* or limit\*) adj4 (infect\* or contamin\* or invas\*)).tw.  
90 ((previous\* or preced\* or earlier or prior\* or anteceden\* or histor\* or past\*) adj4 (surg\* or operat\*)).tw.  
91 exp Catheters/ or Catheterization/ or Catheterization, Central Venous/ or exp Catheterization, Peripheral/  
92 ((catheter\* or cannula\*) adj4 (present\* or presence\* or exist\* or attend\* or current\*)).tw.  
93 ((indwell\* or in-dwell\*) adj4 (devic\* or apparat\* or applan\* or equip\* or gadget\* or machine\* or mechanism\*)).tw.  
94 (premat\* adj8 risk\*).tw.  
95 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*) adj4 (admiss\* or admit\*)).tw.  
96 ((previous\* or preced\* or earlier or prior\* or anteceden\* or histor\* or past\*) adj4 (GBS\* or group B\*) adj4 (infect\* or contamin\* or invas\*)).tw.  
97 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\* or infant\* or baby\* or babies\*) adj4 (GBS\* or group B\* or MRSA\* or met?icillin-resist\*) adj4 (contaminat\* or coloni?ation\* or contagio\*)).tw.  
98 or/1-97

### B.3 Economic search: Health Economics literature search strategy

#### Sources searched to identify economic evaluations

- MEDLINE (Ovid)
- MEDLINE in Process (Ovid)
- Medline E-pubs (Ovid)
- Embase (Ovid)
- EconLit (Ovid)

A single search was performed to identify published economic evaluations of relevance to any of the questions in this guideline update in July 2019. Search filters to retrieve economic evaluations and quality of life papers were appended to the population and intervention terms to identify relevant evidence. Searches were not undertaken for qualitative RQs. Searches were re-run in July 2020 where the filters were added to the population terms.

#### Health economics search strategy

<b>Database: Medline (Ovid)</b>
---------------------------------

- 1 exp Infant, Newborn/ (607120)
- 2 Term Birth/ (2958)
- 3 Infant Care/ (9209)
- 4 Perinatal Care/ (4613)
- 5 Intensive Care Units, Neonatal/ (14748)
- 6 Intensive Care, Neonatal/ (5673)
- 7 Infant Health/ (783)
- 8 (newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*).tw. (394580)
- 9 ((premature\* or pre-mature\* or preterm\* or pre-term\*) adj4 (child\* or infant\* or baby\* or babies\* or offspring)).tw. (50922)
- 10 or/1-9 (791905)
- 11 exp Bacterial Infections/ (886598)
- 12 ((bacter\* or strep\* or staph\* or GNB) adj4 (infect\* or diseas\* or contaminat\* or mening\* or pneumon\* or nosocomial\*)).tw. (148920)
- 13 exp Sepsis/ (123123)
- 14 (sepsis or septic?emia\* or py?emia\* or pyho?emia\*).tw. (100090)
- 15 (septic\* adj4 shock\*).tw. (19697)
- 16 (bacter?emia\* or bacill?emia\*).tw. (26877)
- 17 (blood\* adj4 (infect\* or contamin\* or invas\* or invad\*)).tw. (38725)
- 18 or/11-17 (1097119)
- 19 exp Streptococcus/ (78627)
- 20 exp Staphylococcus/ (104852)
- 21 (streptococc\* or staphylococc\*).tw. (206696)
- 22 (GBS or MRSA or NRCS-A or MSSA).tw. (27020)
- 23 (met?icillin-resistant adj3 aureus).tw. (23563)
- 24 exp Escherichia coli/ (278943)
- 25 (((Escheric\* or E) adj2 coli) or ecoli\*).tw. (289781)
- 26 exp Listeria/ (15143)
- 27 listeria\*.tw. (18688)

- 28 exp Klebsiella/ (19836)
- 29 klebsiella\*.tw. (26962)
- 30 exp Pseudomonas/ (71592)
- 31 (pseudomonas or chryseomonas or flavimonas).tw. (85911)
- 32 Enterobacteriaceae/ (18945)
- 33 (enterobact\* or sodalis or paracolobactrum or ewingella or leclercia).tw. (30291)
- 34 ((enteric or coliform) adj2 bac\*).tw. (5982)
- 35 exp Neisseria/ (20482)
- 36 neisseria\*.tw. (18785)
- 37 exp Haemophilus influenzae/ (13731)
- 38 ((h?emophil\* or H or bacter\* or bacill\* or mycobacter\* or coccobac\*) adj2 (influenz\* or pfeiffer\* or meningitidis)).tw. (19500)
- 39 exp Serratia/ (6599)
- 40 serratia\*.tw. (8439)
- 41 exp Cronobacter/ (655)
- 42 (cronobact\* or sakazaki\* or malonatic\*).tw. (958)
- 43 exp Acinetobacter/ (9822)
- 44 (acinetobact\* or herellea\* or mima or baumannii\* or genomosp\* or calcoacetic\*).tw. (15154)
- 45 exp Fusobacterium/ (3796)
- 46 (fusobact\* or sphaerophor\* or necrophorum or nucleatum).tw. (5425)
- 47 exp Enterococcus/ (19718)
- 48 enterococc\*.tw. (26150)
- 49 or/19-48 (765874)
- 50 18 or 49 (1614537)
- 51 10 and 50 (65444)
- 52 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*) adj4 infect\*).tw. (16079)
- 53 ((premature\* or pre-mature\* or preterm\* or pre-term\*) adj4 (child\* or infant\* or baby\* or babies\* or offspring) adj4 infect\*).tw. (946)

54 52 or 53 (16770)  
55 51 or 54 (74853)  
56 Economics/ (27206)  
57 exp "Costs and Cost Analysis"/ (237006)  
58 Economics, Dental/ (1911)  
59 exp Economics, Hospital/ (24558)  
60 exp Economics, Medical/ (14206)  
61 Economics, Nursing/ (3999)  
62 Economics, Pharmaceutical/ (2941)  
63 Budgets/ (11315)  
64 exp Models, Economic/ (15053)  
65 Markov Chains/ (14321)  
66 Monte Carlo Method/ (28322)  
67 Decision Trees/ (11133)  
68 econom\$.tw. (238765)  
69 cba.tw. (9764)  
70 cea.tw. (20532)  
71 cua.tw. (999)  
72 markov\$.tw. (17997)  
73 (monte adj carlo).tw. (29925)  
74 (decision adj3 (tree\$ or analys\$)).tw. (13431)  
75 (cost or costs or costing\$ or costly or costed).tw. (460618)  
76 (price\$ or pricing\$).tw. (33468)  
77 budget\$.tw. (23716)  
78 expenditure\$.tw. (49355)  
79 (value adj3 (money or monetary)).tw. (2096)  
80 (pharmacoeconomic\$ or (pharmaco adj economic\$)).tw. (3485)  
81 or/56-80 (926379)

- 82 "Quality of Life"/ (194718)
- 83 quality of life.tw. (229884)
- 84 "Value of Life"/ (5706)
- 85 Quality-Adjusted Life Years/ (12284)
- 86 quality adjusted life.tw. (10842)
- 87 (qaly\$ or qald\$ or qale\$ or qtime\$).tw. (8901)
- 88 disability adjusted life.tw. (2741)
- 89 daly\$.tw. (2486)
- 90 Health Status Indicators/ (23409)
- 91 (sf36 or sf 36 or short form 36 or shortform 36 or sf thirtysix or sf thirty six or shortform thirtysix or shortform thirty six or short form thirtysix or short form thirty six).tw. (22454)
- 92 (sf6 or sf 6 or short form 6 or shortform 6 or sf six or sfsix or shortform six or short form six).tw. (1323)
- 93 (sf12 or sf 12 or short form 12 or shortform 12 or sf twelve or sftwelve or shortform twelve or short form twelve).tw. (4902)
- 94 (sf16 or sf 16 or short form 16 or shortform 16 or sf sixteen or sfsixteen or shortform sixteen or short form sixteen).tw. (29)
- 95 (sf20 or sf 20 or short form 20 or shortform 20 or sf twenty or sftwenty or shortform twenty or short form twenty).tw. (381)
- 96 (euroqol or euro qol or eq5d or eq 5d).tw. (9001)
- 97 (qol or hql or hqol or hrqol).tw. (44126)
- 98 (hye or hyes).tw. (60)
- 99 health\$ year\$ equivalent\$.tw. (38)
- 100 utilit\$.tw. (171457)
- 101 (hui or hui1 or hui2 or hui3).tw. (1304)
- 102 disutili\$.tw. (396)
- 103 rosser.tw. (94)
- 104 quality of wellbeing.tw. (14)
- 105 quality of well-being.tw. (381)
- 106 qwb.tw. (190)

- 107 willingness to pay.tw. (4500)
- 108 standard gamble\$.tw. (783)
- 109 time trade off.tw. (1037)
- 110 time tradeoff.tw. (238)
- 111 tto.tw. (899)
- 112 or/82-111 (493012)
- 113 81 or 112 (1350947)
- 114 55 and 113 (3480)
- 115 limit 114 to ed=20190716-20200724 (226)
- 116 animals/ not humans/ (4686781)
- 117 115 not 116 (213)
- 118 limit 117 to english language (208)

**Database: MiP (Ovid)**

- 1 exp Infant, Newborn/ (0)
- 2 Term Birth/ (0)
- 3 Infant Care/ (0)
- 4 Perinatal Care/ (0)
- 5 Intensive Care Units, Neonatal/ (0)
- 6 Intensive Care, Neonatal/ (0)
- 7 Infant Health/ (0)
- 8 (newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*).tw. (32462)
- 9 ((premature\* or pre-mature\* or preterm\* or pre-term\*) adj4 (child\* or infant\* or baby\* or babies\* or offspring)).tw. (4347)
- 10 or/1-9 (34405)
- 11 exp Bacterial Infections/ (0)
- 12 ((bacter\* or strep\* or staph\* or GNB) adj4 (infect\* or diseas\* or contaminat\* or mening\* or pneumon\* or nosocomial\*)).tw. (17517)
- 13 exp Sepsis/ (0)

- 14 (sepsis or septic?emia\* or py?emia\* or pyho?emia\*).tw. (12331)
- 15 (septic\* adj4 shock\*).tw. (2749)
- 16 (bacter?emia\* or bacill?emia\*).tw. (2792)
- 17 (blood\* adj4 (infect\* or contamin\* or invas\* or invad\*)).tw. (4519)
- 18 or/11-17 (35377)
- 19 exp Streptococcus/ (0)
- 20 exp Staphylococcus/ (0)
- 21 (streptococc\* or staphylococc\*).tw. (22112)
- 22 (GBS or MRSA or NRCS-A or MSSA).tw. (4384)
- 23 (met?icillin-resistant adj3 aureus).tw. (3264)
- 24 exp Escherichia coli/ (0)
- 25 (((Escheric\* or E) adj2 coli) or ecoli\*).tw. (21337)
- 26 exp Listeria/ (0)
- 27 listeria\*.tw. (2351)
- 28 exp Klebsiella/ (0)
- 29 klebsiella\*.tw. (4101)
- 30 exp Pseudomonas/ (0)
- 31 (pseudomonas or chryseomonas or flavimonas).tw. (10779)
- 32 Enterobacteriaceae/ (0)
- 33 (enterobact\* or sodalis or paracolobactrum or ewingella or leclercia).tw. (4282)
- 34 ((enteric or coliform) adj2 bac\*).tw. (585)
- 35 exp Neisseria/ (0)
- 36 neisseria\*.tw. (1256)
- 37 exp Haemophilus influenzae/ (0)
- 38 ((h?emophil\* or H or bacter\* or bacill\* or mycobacter\* or coccobac\*) adj2 (influenz\* or pfeiffer\* or meningitidis)).tw. (1064)
- 39 exp Serratia/ (0)
- 40 serratia\*.tw. (829)

- 41 exp Cronobacter/ (0)
- 42 (cronobact\* or sakazaki\* or malonatic\*).tw. (168)
- 43 exp Acinetobacter/ (0)
- 44 (acinetobact\* or herellea\* or mima or baumanni\* or genomosp\* or calcoacetic\*).tw. (2747)
- 45 exp Fusobacterium/ (0)
- 46 (fusobact\* or sphaerophor\* or necrophorum or nucleatum).tw. (821)
- 47 exp Enterococcus/ (0)
- 48 enterococc\*.tw. (3589)
- 49 or/19-48 (59520)
- 50 18 or 49 (83682)
- 51 10 and 50 (2543)
- 52 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*) adj4 infect\*).tw. (1246)
- 53 ((premature\* or pre-mature\* or preterm\* or pre-term\*) adj4 (child\* or infant\* or baby\* or babies\* or offspring) adj4 infect\*).tw. (81)
- 54 52 or 53 (1309)
- 55 51 or 54 (3367)
- 56 Economics/ (0)
- 57 exp "Costs and Cost Analysis"/ (0)
- 58 Economics, Dental/ (0)
- 59 exp Economics, Hospital/ (0)
- 60 exp Economics, Medical/ (0)
- 61 Economics, Nursing/ (0)
- 62 Economics, Pharmaceutical/ (0)
- 63 Budgets/ (0)
- 64 exp Models, Economic/ (0)
- 65 Markov Chains/ (1)
- 66 Monte Carlo Method/ (2)
- 67 Decision Trees/ (0)

- 68 econom\$.tw. (47080)
- 69 cba.tw. (456)
- 70 cea.tw. (2004)
- 71 cua.tw. (198)
- 72 markov\$.tw. (5795)
- 73 (monte adj carlo).tw. (17215)
- 74 (decision adj3 (tree\$ or analys\$)).tw. (2609)
- 75 (cost or costs or costing\$ or costly or costed).tw. (99726)
- 76 (price\$ or pricing\$).tw. (6047)
- 77 budget\$.tw. (5074)
- 78 expenditure\$.tw. (6509)
- 79 (value adj3 (money or monetary)).tw. (364)
- 80 (pharmacoeconomic\$ or (pharmaco adj economic\$)).tw. (502)
- 81 or/56-80 (172313)
- 82 "Quality of Life"/ (0)
- 83 quality of life.tw. (40043)
- 84 "Value of Life"/ (0)
- 85 Quality-Adjusted Life Years/ (0)
- 86 quality adjusted life.tw. (1728)
- 87 (qaly\$ or qald\$ or qale\$ or qtime\$).tw. (1455)
- 88 disability adjusted life.tw. (523)
- 89 daly\$.tw. (479)
- 90 Health Status Indicators/ (0)
- 91 (sf36 or sf 36 or short form 36 or shortform 36 or sf thirtysix or sf thirty six or shortform thirtysix or shortform thirty six or short form thirtysix or short form thirty six).tw. (2735)
- 92 (sf6 or sf 6 or short form 6 or shortform 6 or sf six or sfsix or shortform six or short form six).tw. (779)
- 93 (sf12 or sf 12 or short form 12 or shortform 12 or sf twelve or sftwelve or shortform twelve or short form twelve).tw. (773)

- 94 (sf16 or sf 16 or short form 16 or shortform 16 or sf sixteen or sfsixteen or shortform sixteen or short form sixteen).tw. (5)
- 95 (sf20 or sf 20 or short form 20 or shortform 20 or sf twenty or sftwenty or shortform twenty or short form twenty).tw. (20)
- 96 (euroqol or euro qol or eq5d or eq 5d).tw. (1711)
- 97 (qol or hql or hqol or hrqol).tw. (7636)
- 98 (hye or hyes).tw. (8)
- 99 health\$ year\$ equivalent\$.tw. (2)
- 100 utilit\$.tw. (32031)
- 101 (hui or hui1 or hui2 or hui3).tw. (203)
- 102 disutili\$.tw. (60)
- 103 rosser.tw. (4)
- 104 quality of wellbeing.tw. (9)
- 105 quality of well-being.tw. (29)
- 106 qwb.tw. (13)
- 107 willingness to pay.tw. (957)
- 108 standard gamble\$.tw. (62)
- 109 time trade off.tw. (119)
- 110 time tradeoff.tw. (11)
- 111 tto.tw. (145)
- 112 or/82-111 (74419)
- 113 81 or 112 (236895)
- 114 55 and 113 (231)
- 115 limit 114 to dt=20190716-20200724 (89)
- 116 animals/ not humans/ (1)
- 117 115 not 116 (89)
- 118 limit 117 to english language (89)

**Database: Medline E-pubs (Ovid)**

- 1 exp Infant, Newborn/ (0)
- 2 Term Birth/ (0)
- 3 Infant Care/ (0)
- 4 Perinatal Care/ (0)
- 5 Intensive Care Units, Neonatal/ (0)
- 6 Intensive Care, Neonatal/ (0)
- 7 Infant Health/ (0)
- 8 (newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*).tw. (6371)
- 9 ((premature\* or pre-mature\* or preterm\* or pre-term\*) adj4 (child\* or infant\* or baby\* or babies\* or offspring)).tw. (1421)
- 10 or/1-9 (6871)
- 11 exp Bacterial Infections/ (0)
- 12 ((bacter\* or strep\* or staph\* or GNB) adj4 (infect\* or diseas\* or contaminat\* or mening\* or pneumon\* or nosocomial\*)).tw. (2219)
- 13 exp Sepsis/ (0)
- 14 (sepsis or septic?emia\* or py?emia\* or pyho?emia\*).tw. (1706)
- 15 (septic\* adj4 shock\*).tw. (361)
- 16 (bacter?emia\* or bacill?emia\*).tw. (347)
- 17 (blood\* adj4 (infect\* or contamin\* or invas\* or invad\*)).tw. (688)
- 18 or/11-17 (4700)
- 19 exp Streptococcus/ (0)
- 20 exp Staphylococcus/ (0)
- 21 (streptococc\* or staphylococc\*).tw. (2264)
- 22 (GBS or MRSA or NRCS-A or MSSA).tw. (468)
- 23 (met?icillin-resistant adj3 aureus).tw. (345)
- 24 exp Escherichia coli/ (0)
- 25 (((Escheric\* or E) adj2 coli) or ecoli\*).tw. (2275)
- 26 exp Listeria/ (0)
- 27 listeria\*.tw. (198)

- 28 exp Klebsiella/ (0)
- 29 klebsiella\*.tw. (476)
- 30 exp Pseudomonas/ (0)
- 31 (pseudomonas or chryseomonas or flavimonas).tw. (1004)
- 32 Enterobacteriaceae/ (0)
- 33 (enterobact\* or sodalis or paracolobactrum or ewingella or leclercia).tw. (460)
- 34 ((enteric or coliform) adj2 bac\*).tw. (64)
- 35 exp Neisseria/ (0)
- 36 neisseria\*.tw. (177)
- 37 exp Haemophilus influenzae/ (0)
- 38 ((h?emophil\* or H or bacter\* or bacill\* or mycobacter\* or coccobac\*) adj2 (influenz\* or pfeiffer\* or meningitidis)).tw. (149)
- 39 exp Serratia/ (0)
- 40 serratia\*.tw. (72)
- 41 exp Cronobacter/ (0)
- 42 (cronobact\* or sakazaki\* or malonatic\*).tw. (14)
- 43 exp Acinetobacter/ (0)
- 44 (acinetobact\* or herellea\* or mima or baumannii\* or genomosp\* or calcoacetic\*).tw. (290)
- 45 exp Fusobacterium/ (0)
- 46 (fusobact\* or sphaerophor\* or necrophorum or nucleatum).tw. (112)
- 47 exp Enterococcus/ (0)
- 48 enterococc\*.tw. (403)
- 49 or/19-48 (6238)
- 50 18 or 49 (9619)
- 51 10 and 50 (455)
- 52 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*) adj4 infect\*).tw. (255)
- 53 ((premature\* or pre-mature\* or preterm\* or pre-term\*) adj4 (child\* or infant\* or baby\* or babies\* or offspring) adj4 infect\*).tw. (16)

54 52 or 53 (268)  
55 51 or 54 (651)  
56 Economics/ (0)  
57 exp "Costs and Cost Analysis"/ (0)  
58 Economics, Dental/ (0)  
59 exp Economics, Hospital/ (0)  
60 exp Economics, Medical/ (0)  
61 Economics, Nursing/ (0)  
62 Economics, Pharmaceutical/ (0)  
63 Budgets/ (0)  
64 exp Models, Economic/ (0)  
65 Markov Chains/ (0)  
66 Monte Carlo Method/ (0)  
67 Decision Trees/ (0)  
68 econom\$.tw. (6645)  
69 cba.tw. (61)  
70 cea.tw. (331)  
71 cua.tw. (17)  
72 markov\$.tw. (718)  
73 (monte adj carlo).tw. (1219)  
74 (decision adj3 (tree\$ or analys\$)).tw. (519)  
75 (cost or costs or costing\$ or costly or costed).tw. (13246)  
76 (price\$ or pricing\$).tw. (954)  
77 budget\$.tw. (555)  
78 expenditure\$.tw. (1143)  
79 (value adj3 (money or monetary)).tw. (65)  
80 (pharmacoeconomic\$ or (pharmaco adj economic\$)).tw. (51)  
81 or/56-80 (21922)

82	"Quality of Life"/ (0)
83	quality of life.tw. (7520)
84	"Value of Life"/ (0)
85	Quality-Adjusted Life Years/ (0)
86	quality adjusted life.tw. (388)
87	(qaly\$ or qald\$ or qale\$ or qtime\$).tw. (329)
88	disability adjusted life.tw. (101)
89	daly\$.tw. (88)
90	Health Status Indicators/ (0)
91	(sf36 or sf 36 or short form 36 or shortform 36 or sf thirtysix or sf thirty six or shortform thirtysix or shortform thirty six or short form thirtysix or short form thirty six).tw. (479)
92	(sf6 or sf 6 or short form 6 or shortform 6 or sf six or sfsix or shortform six or short form six).tw. (50)
93	(sf12 or sf 12 or short form 12 or shortform 12 or sf twelve or sftwelve or shortform twelve or short form twelve).tw. (180)
94	(sf16 or sf 16 or short form 16 or shortform 16 or sf sixteen or sfsixteen or shortform sixteen or short form sixteen).tw. (1)
95	(sf20 or sf 20 or short form 20 or shortform 20 or sf twenty or sftwenty or shortform twenty or short form twenty).tw. (4)
96	(euroqol or euro qol or eq5d or eq 5d).tw. (407)
97	(qol or hql or hqol or hrqol).tw. (1460)
98	(hye or hyes).tw. (1)
99	health\$ year\$ equivalent\$.tw. (0)
100	utilit\$.tw. (4989)
101	(hui or hui1 or hui2 or hui3).tw. (18)
102	disutili\$.tw. (12)
103	rosser.tw. (0)
104	quality of wellbeing.tw. (0)
105	quality of well-being.tw. (9)
106	qwb.tw. (3)

- 107 willingness to pay.tw. (184)
- 108 standard gamble\$.tw. (7)
- 109 time trade off.tw. (20)
- 110 time tradeoff.tw. (2)
- 111 tto.tw. (18)
- 112 or/82-111 (12826)
- 113 81 or 112 (32909)
- 114 55 and 113 (55)
- 115 limit 114 to english language (55)

**Database: Embase (Ovid)**

- 1 newborn/ (526097)
- 2 term birth/ (3569)
- 3 infant care/ (1049)
- 4 perinatal care/ (14198)
- 5 neonatal intensive care unit/ (10192)
- 6 newborn intensive care/ (26405)
- 7 child health/ (27137)
- 8 (newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*).tw. (536460)
- 9 ((premature\* or pre-mature\* or preterm\* or pre-term\*) adj4 (child\* or infant\* or baby\* or babies\* or offspring)).tw. (68782)
- 10 or/1-9 (841089)
- 11 exp bacterial infection/ (838120)
- 12 ((bacter\* or strep\* or staph\* or GNB) adj4 (infect\* or diseas\* or contaminat\* or mening\* or pneumon\* or nosocomial\*)).tw. (208658)
- 13 exp sepsis/ (263922)
- 14 (sepsis or septic?emia\* or py?emia\* or pyho?emia\*).tw. (168012)

- 15 (septic\* adj4 shock\*).tw. (36223)
- 16 (bacter?emia\* or bacill?emia\*).tw. (40194)
- 17 (blood\* adj4 (infect\* or contamin\* or invas\* or invad\*)).tw. (61015)
- 18 or/11-17 (1201558)
- 19 exp Streptococcus/ (128274)
- 20 exp Staphylococcus/ (209430)
- 21 (streptococc\* or staphylococc\*).tw. (262126)
- 22 (GBS or MRSA or NRCS-A or MSSA).tw. (46092)
- 23 (met?icillin-resistant adj3 aureus).tw. (34157)
- 24 exp Escherichia coli/ (361361)
- 25 (((Escheric\* or E) adj2 coli) or ecoli\*).tw. (339772)
- 26 exp Listeria/ (24096)
- 27 listeria\*.tw. (22102)
- 28 exp Klebsiella/ (59561)
- 29 klebsiella\*.tw. (42289)
- 30 exp Pseudomonas/ (144052)
- 31 (pseudomonas or chryseomonas or flavimonas).tw. (118130)
- 32 Enterobacteriaceae/ (23812)
- 33 (enterobact\* or sodalis or paracolobactrum or ewingella or leclercia).tw. (42447)
- 34 ((enteric or coliform) adj2 bac\*).tw. (7285)
- 35 exp Neisseria/ (32218)
- 36 neisseria\*.tw. (22936)
- 37 exp Haemophilus influenzae/ (29007)
- 38 ((h?emophil\* or H or bacter\* or bacill\* or mycobacter\* or coccobac\*) adj2 (influenz\* or pfeiffer\* or meningitidis)).tw. (24329)
- 39 exp Serratia/ (14280)
- 40 serratia\*.tw. (10397)
- 41 exp cronobacter/ (817)

42 (cronobact\* or sakazaki\* or malonatic\*).tw. (1214)  
43 exp Acinetobacter/ (27955)  
44 (acinetobact\* or herellea\* or mima or baumanni\* or genomosp\* or calcoacetic\*).tw. (23888)  
45 exp Fusobacterium/ (7678)  
46 (fusobact\* or sphaerophor\* or necrophorum or nucleatum).tw. (7403)  
47 exp Enterococcus/ (49841)  
48 enterococc\*.tw. (37571)  
49 or/19-48 (967441)  
50 18 or 49 (1894492)  
51 10 and 50 (70672)  
52 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*) adj4 infect\*).tw. (21945)  
53 ((premature\* or pre-mature\* or preterm\* or pre-term\*) adj4 (child\* or infant\* or baby\* or babies\* or offspring) adj4 infect\*).tw. (1283)  
54 52 or 53 (22885)  
55 51 or 54 (83775)  
56 exp Health Economics/ (845404)  
57 exp "Health Care Cost"/ (290992)  
58 exp Pharmacoeconomics/ (202216)  
59 Monte Carlo Method/ (40279)  
60 Decision Tree/ (13001)  
61 econom\$.tw. (368838)  
62 cba.tw. (12788)  
63 cea.tw. (34786)  
64 cua.tw. (1498)  
65 markov\$.tw. (30389)  
66 (monte adj carlo).tw. (48341)  
67 (decision adj3 (tree\$ or analys\$)).tw. (23602)  
68 (cost or costs or costing\$ or costly or costed).tw. (772396)

- 69 (price\$ or pricing\$).tw. (57398)
- 70 budget\$.tw. (38616)
- 71 expenditure\$.tw. (74588)
- 72 (value adj3 (money or monetary)).tw. (3455)
- 73 (pharmacoeconomic\$ or (pharmaco adj economic\$)).tw. (8625)
- 74 or/56-73 (1760062)
- 75 "Quality of Life"/ (469927)
- 76 Quality Adjusted Life Year/ (26663)
- 77 Quality of Life Index/ (2774)
- 78 Short Form 36/ (29036)
- 79 Health Status/ (127411)
- 80 quality of life.tw. (439622)
- 81 quality adjusted life.tw. (19747)
- 82 (qaly\$ or qald\$ or qale\$ or qtime\$).tw. (20178)
- 83 disability adjusted life.tw. (4103)
- 84 daly\$.tw. (4016)
- 85 (sf36 or sf 36 or short form 36 or shortform 36 or sf thirtysix or sf thirty six or shortform thirtysix or shortform thirty six or short form thirtysix or short form thirty six).tw. (41434)
- 86 (sf6 or sf 6 or short form 6 or shortform 6 or sf six or sfsix or shortform six or short form six).tw. (2420)
- 87 (sf12 or sf 12 or short form 12 or shortform 12 or sf twelve or sftwelve or shortform twelve or short form twelve).tw. (9462)
- 88 (sf16 or sf 16 or short form 16 or shortform 16 or sf sixteen or sfsixteen or shortform sixteen or short form sixteen).tw. (61)
- 89 (sf20 or sf 20 or short form 20 or shortform 20 or sf twenty or sftwenty or shortform twenty or short form twenty).tw. (455)
- 90 (euroqol or euro qol or eq5d or eq 5d).tw. (20619)
- 91 (qol or hql or hqol or hrqol).tw. (97056)
- 92 (hye or hyes).tw. (135)
- 93 health\$ year\$ equivalent\$.tw. (41)

94 utilit\$.tw. (289831)  
95 (hui or hui1 or hui2 or hui3).tw. (2300)  
96 disutili\$.tw. (924)  
97 rosser.tw. (124)  
98 quality of wellbeing.tw. (42)  
99 quality of well-being.tw. (486)  
100 qwb.tw. (253)  
101 willingness to pay.tw. (8837)  
102 standard gamble\$.tw. (1104)  
103 time trade off.tw. (1708)  
104 time tradeoff.tw. (291)  
105 tto.tw. (1683)  
106 or/75-105 (989974)  
107 74 or 106 (2593254)  
108 55 and 107 (5731)  
109 limit 108 to dc=20190716-20200724 (558)  
110 nonhuman/ not human/ (4649157)  
111 109 not 110 (522)  
112 limit 111 to english language (510)  
113 limit 112 to (conference abstract or conference paper or "conference review") (113)  
114 112 not 113 (397)

**Database: Econlit (Ovid)**

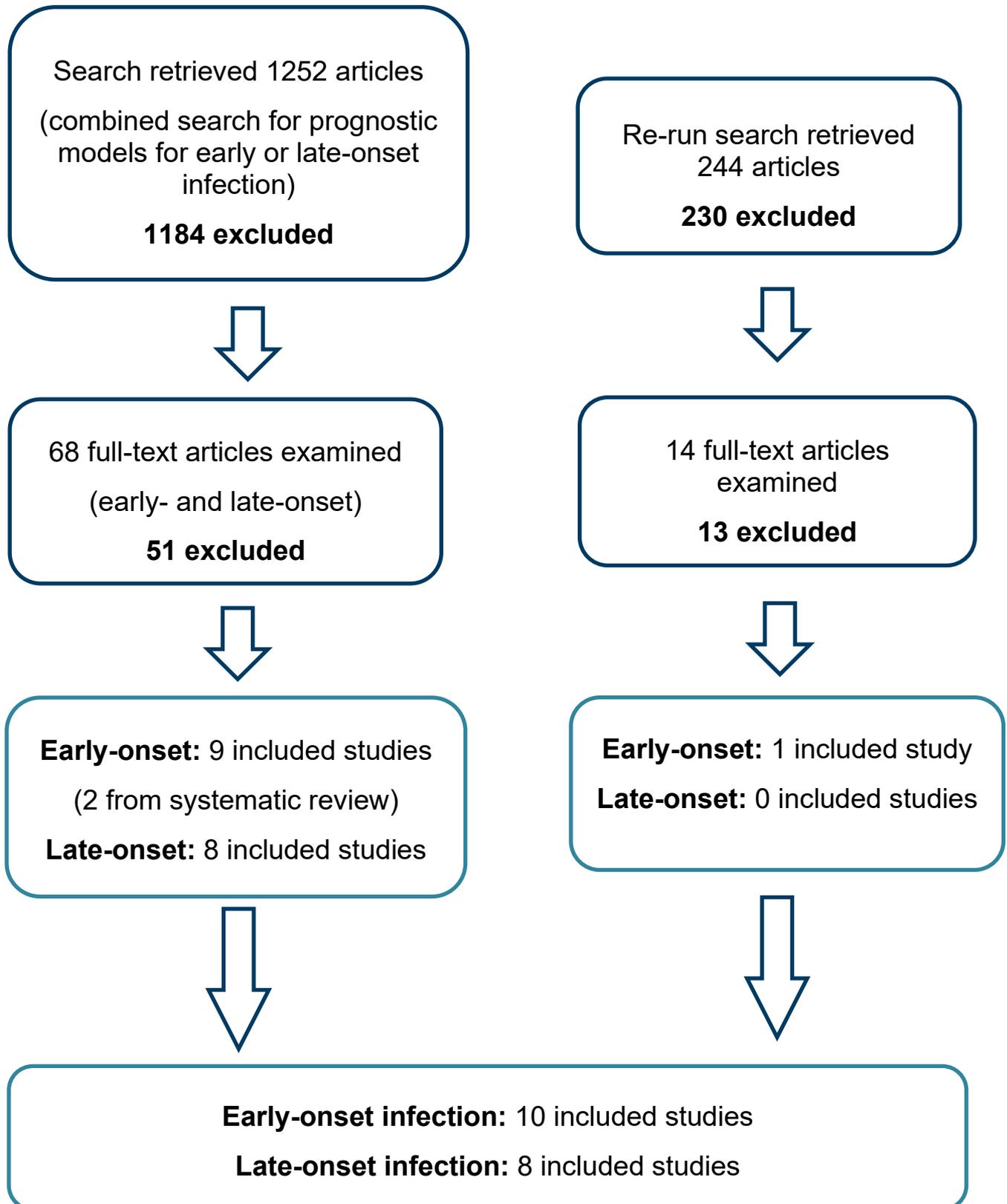
1 (newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*).tw. (732)  
2 ((premature\* or pre-mature\* or preterm\* or pre-term\*) adj4 (child\* or infant\* or baby\* or babies\* or offspring)).tw. (45)  
3 1 or 2 (767)  
4 ((bacter\* or strep\* or staph\* or GNB) adj4 (infect\* or diseas\* or contaminat\* or mening\* or pneumon\* or nosocomial\*)).tw. (49)

- 5 (sepsis or septic?emia\* or py?emia\* or pyho?emia\*).tw. (17)
- 6 (septic\* adj4 shock\*).tw. (1)
- 7 (bacter?emia\* or bacill?emia\*).tw. (3)
- 8 (blood\* adj4 (infect\* or contamin\* or invas\* or invad\*)).tw. (17)
- 9 (streptococc\* or staphylococc\*).tw. (18)
- 10 (GBS or MRSA or NRCS-A or MSSA).tw. (40)
- 11 (met?icillin-resistant adj3 aureus).tw. (8)
- 12 (((Escheric\* or E) adj2 coli) or ecoli\*).tw. (47)
- 13 listeria\*.tw. (6)
- 14 klebsiella\*.tw. (0)
- 15 (pseudomonas or chryseomonas or flavimonas).tw. (6)
- 16 (enterobact\* or sodalis or paracolobactrum or ewingella or leclercia).tw. (1)
- 17 ((enteric or coliform) adj2 bac\*).tw. (0)
- 18 neisseria\*.tw. (1)
- 19 ((h?emophil\* or H or bacter\* or bacill\* or mycobacter\* or coccobac\*) adj2 (influenz\* or pfeiffer\* or meningitidis)).tw. (14)
- 20 serratia\*.tw. (0)
- 21 (cronobact\* or sakazaki\* or malonatic\*).tw. (1)
- 22 (acinetobact\* or herellea\* or mima or baumannii\* or genomosp\* or calcoacetic\*).tw. (2)
- 23 (fusobact\* or sphaerophor\* or necrophorum or nucleatum).tw. (0)
- 24 enterococc\*.tw. (5)
- 25 or/4-24 (194)
- 26 ((newborn\* or new born\* or neonat\* or neo-nat\* or perinat\* or peri-nat\*) adj4 infect\*).tw. (11)
- 27 ((premature\* or pre-mature\* or preterm\* or pre-term\*) adj4 (child\* or infant\* or baby\* or babies\* or offspring) adj4 infect\*).tw. (1)
- 28 26 or 27 (12)
- 29 25 or 28 (205)
- 30 3 and 29 (15)
- 31 limit 30 to yr="2019 -Current" (1)

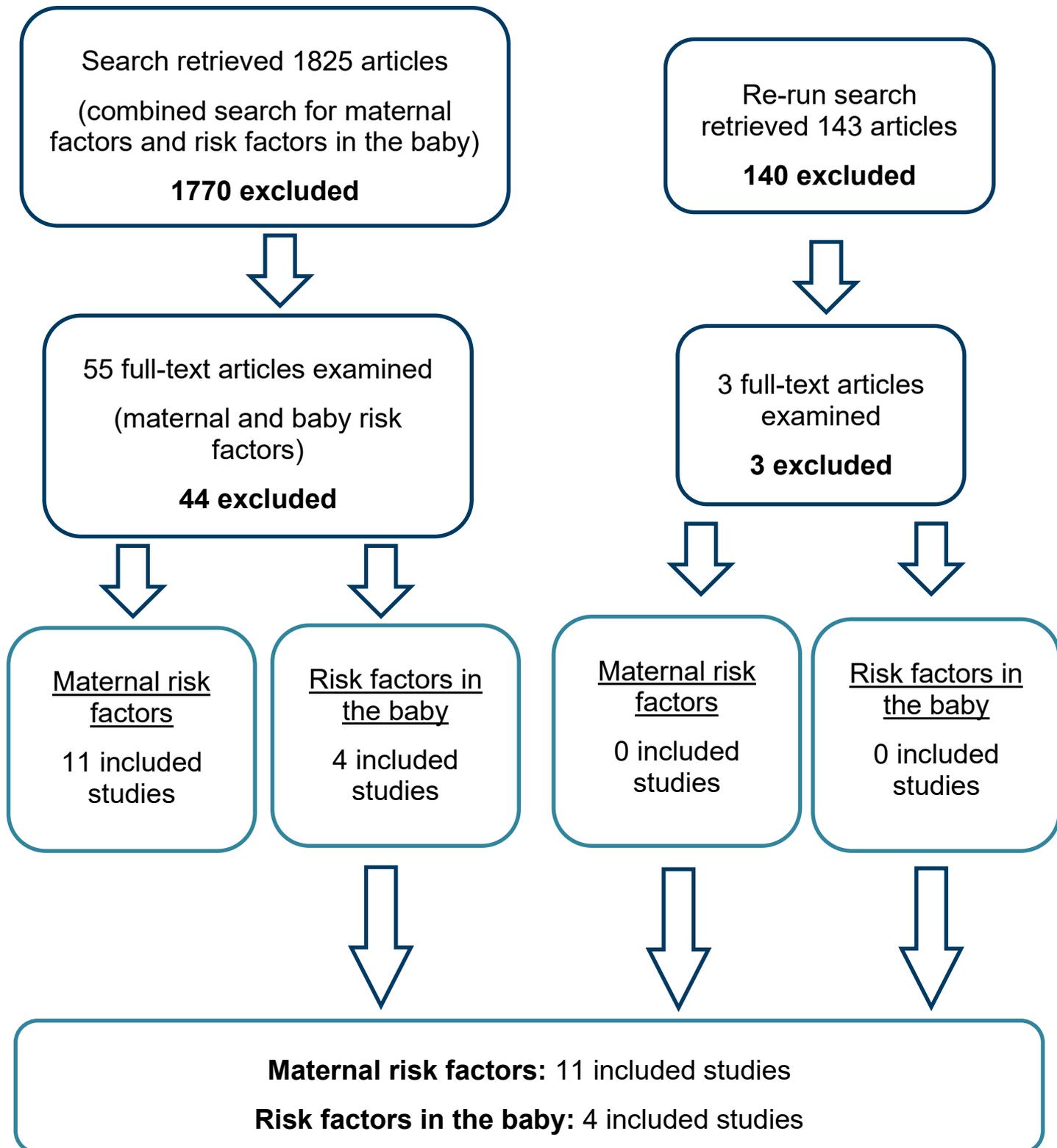


## Appendix C –Prognostic and diagnostic evidence study selection

### C.1 Clinical prediction models



## C.2 Maternal and neonatal risk factors



## 1 Appendix D –Prognostic and diagnostic evidence

### D.1 Clinical prediction models

#### Carola 2018

**Bibliographic Reference** Carola, David; Vasconcellos, Mansi; Sloane, Amy; McElwee, Dorothy; Edwards, Caroline; Greenspan, Jay; Aghai, Zubair H; Utility of Early-Onset Sepsis Risk Calculator for Neonates Born to Mothers with Chorioamnionitis.; The Journal of pediatrics; 2018; vol. 195; 48-52e1

#### 3 Study Characteristics

<b>Study design</b>	Retrospective cohort study
<b>Study details</b>	<p>Study location USA</p> <p>Study setting Level 3 NICU</p> <p>Study dates November 2006 - March 2017</p> <p>Duration of follow-up Not reported but investigated early-onset infection</p> <p>Associated studies Sloane 2019</p>
<b>Inclusion criteria</b>	<p>Neonates with gestational age <math>\geq 35</math> weeks</p> <p>Born to mothers with clinical chorioamnionitis diagnosis of chorioamnionitis was made by an obstetrician based on intrapartum fever (temperature <math>\geq 38^{\circ}\text{C}</math>) alone or in conjunction with maternal leukocytosis, uterine tenderness, foul-smelling amniotic fluid, and maternal or fetal tachycardia</p>
<b>Exclusion criteria</b>	None reported
<b>Sample characteristics</b>	<p>Sample size 896</p> <p>Female 51.6%</p> <p>Gestational age - weeks (SD) 39.4 (<math>\pm 1.3</math>)</p> <p>Birth weight - kg (SD) 3.35 (0.43)</p> <p>Group B streptococcus colonisation 24.4%</p> <p>Duration of rupture of membranes - hours (IQR) 13 (8-21)</p>

	Number with positive blood cultures (%) 5 (0.56%)
<b>Prognostic model</b>	Kaiser Permanente neonatal sepsis calculator

1

2 **Study arms**

**Diagnostic laboratory evaluation (Complete blood count and C-reactive protein values) (N = 896)**

CBC and CRP assessed 6-12 hours after birth. Abnormal CBC: white blood cell <5000/microlitre, an immature:total neutrophil (I:T) ratio  $\geq 0.2$ , or platelet count <100 000/microlitre. I:T ratio was calculated as described by Manroe et al with an I:T value of  $\geq 0.2$  considered elevated. Abnormal CRP level: >1 mg/dL

**Clinical signs for predicting early-onset infection (N = 896)**

Significant clinical symptoms were considered to be those categorized as “equivocal” or “clinical illness” by the EOS calculator

**Kaiser Permanente neonatal sepsis calculator (N = 896)**

Background incidence of early-onset infection set at 0.5/1000 live births (CDC national incidence)

**Risk of bias**

**Selection of participants**

*1.1 Were appropriate data sources used, e.g. cohort, RCT or nested case-control study data?*

Yes

*(Retrospective cohort)*

*1.2 Were all inclusions and exclusions of participants appropriate?*

Yes

*Overall risk of bias for selection of participants domain*

Low

*Concerns for applicability for selection of participants domain*

Low

**Predictors or their assessment**

*2.1 Were predictors defined and assessed in a similar way for all participants?*

Yes

*(EOS calculator)*

*2.2 Were predictor assessments made without knowledge of outcome data?*

No information

*(Unclear if investigators had knowledge of outcome when conducting EOS calculator. )*

*2.3 Are all predictors available at the time the model is intended to be used?*

Yes

*Overall risk of bias for predictors or their assessment domain*

Low

*Concerns for applicability for predictors or their assessment domain*

Low

**Outcome or its determination**

*3.1 Was the outcome determined appropriately?*

Yes

*3.2 Was a pre-specified or standard outcome definition used?*

Yes

*3.3 Were predictors excluded from the outcome definition?*

Yes

*3.4 Was the outcome defined and determined in a similar way for all participants?*

Yes

*3.5 Was the outcome determined without knowledge of predictor information?*

No information

*(Unclear if investigators had knowledge of both predictors and outcome )*

*3.6 Was the time interval between predictor assessment and outcome determination appropriate?*

Yes

*Overall risk of bias for outcome or its determination domain*

Low

*Concerns for applicability for outcome or its determination domain*

Low

**Analysis**

*4.1 Were there a reasonable number of participants with the outcome?*

No

*(N = 5 with event)*

*4.2 Were continuous and categorical predictors handled appropriately?*

Yes

*4.3 Were all enrolled participants included in the analysis?*

Yes

*4.4 Were participants with missing data handled appropriately?*

Yes

*4.5 Was selection of predictors based on univariable analysis avoided? - Development studies*

Not applicable

*4.6 Were complexities in the data (e.g. censoring, competing risks, sampling of control participants) accounted for appropriately?*

Yes

*4.7 Were relevant model performance measures evaluated appropriately?*

Not applicable

*4.8 Were model overfitting and optimism in model performance accounted for? - Development studies*

Not applicable

*4.9 Do predictors and their assigned weights in the final model correspond to the results from the reported multivariable analysis? - Development studies*

Not applicable

*Overall risk of bias for analysis domain*

Low

#### **Overall Risk of bias and Applicability**

*Risk of bias*

Low

*Concerns for applicability*

Some concerns

*Study based in USA – differences in GBS screening policy to the UK and possibly differences in incidence rate of infection (background incidence rate is needed for the calculator)*

1

## **Dhudasia 2018**

**Bibliographic Reference** Dhudasia MB; Mukhopadhyay S; Puopolo KM; Implementation of the Sepsis Risk Calculator at an Academic Birth Hospital.; Hospital pediatrics; 2018; vol. 8 (no. 5)

## **2 Study Characteristics**

<b>Study design</b>	Retrospective cohort study
<b>Study details</b>	<p><b>Study location</b> USA</p> <p><b>Study setting</b> teaching hospital within a university health care system with ~5000 annual deliveries, 52 postpartum mother-infant rooms, and a 50-bed, tertiary-care NICU</p> <p><b>Study dates</b> March 2014 - May 2015 and June 2015 - July 2015</p> <p><b>Duration of follow-up</b> 72 hours</p>
<b>Inclusion criteria</b>	Neonates with gestational age $\geq 36$ weeks gestation
<b>Sample characteristics</b>	<p><b>Sample size</b> 6090</p> <p><b>Female</b> 49%</p> <p><b>Gestational age - weeks (SD)</b> 39.3 (1.3)</p> <p><b>Birth weight &lt;2500 g</b> 4%</p>
<b>Prognostic model</b>	Kaiser Permanente neonatal sepsis calculator

1

## 2 Study arms

### **Kaiser Permanente neonatal sepsis calculator (N = 5692)**

Baseline incidence 0.5/1000 live births

### **Standard practice (N = 5692)**

based on guidelines provided in the Centers for Disease Control and Prevention (CDC) group B streptococcus (GBS) prevention guidelines<sup>16,17</sup> and those recommended by the American Academy of Pediatrics

3

## **Risk of bias**

### **Selection of participants**

*1.1 Were appropriate data sources used, e.g. cohort, RCT or nested case-control study data?*

Yes

*(Prospective cohort study)*

*1.2 Were all inclusions and exclusions of participants appropriate?*

Yes

*Overall risk of bias for selection of participants domain*

Low

*Concerns for applicability for selection of participants domain*

Low

**Predictors or their assessment**

*2.1 Were predictors defined and assessed in a similar way for all participants?*

Yes

*2.2 Were predictor assessments made without knowledge of outcome data?*

Yes

*2.3 Are all predictors available at the time the model is intended to be used?*

Probably yes

*Overall risk of bias for predictors or their assessment domain*

Low

*Concerns for applicability for predictors or their assessment domain*

Low

**Outcome or its determination**

*3.1 Was the outcome determined appropriately?*

Yes

*3.2 Was a pre-specified or standard outcome definition used?*

Yes

*3.3 Were predictors excluded from the outcome definition?*

Yes

*3.4 Was the outcome defined and determined in a similar way for all participants?*

Yes

*3.5 Was the outcome determined without knowledge of predictor information?*

Probably no

*3.6 Was the time interval between predictor assessment and outcome determination appropriate?*

Yes

*Overall risk of bias for outcome or its determination domain*

Low

*Concerns for applicability for outcome or its determination domain*

Low

**Analysis**

*4.1 Were there a reasonable number of participants with the outcome?*

Yes

*4.2 Were continuous and categorical predictors handled appropriately?*

Probably yes

*4.3 Were all enrolled participants included in the analysis?*

Yes

*4.4 Were participants with missing data handled appropriately?*

No information

*4.5 Was selection of predictors based on univariable analysis avoided? - Development studies*

Probably yes

*4.6 Were complexities in the data (e.g. censoring, competing risks, sampling of control participants) accounted for appropriately?*

Probably yes

*4.7 Were relevant model performance measures evaluated appropriately?*

Yes

*4.8 Were model overfitting and optimism in model performance accounted for? - Development studies*

Not applicable

*4.9 Do predictors and their assigned weights in the final model correspond to the results from the reported multivariable analysis? - Development studies*

Not applicable

*Overall risk of bias for analysis domain*

Low

**Overall Risk of bias and Applicability**

*Risk of bias*

Low

*Concerns for applicability*

Some concerns

*Study based in USA – differences in GBS screening policy to the UK and possibly differences in incidence rate of infection (background incidence rate is needed for the calculator)*

## Goel 2020

**Bibliographic Reference** Goel N.; Shrestha S.; Smith R.; Mehta A.; Ketty M.; Muxworthy H.; Abelian A.; Kirupaalar V.; Saeed S.; Jain S.; Asokkumar A.; Natti M.; Barnard I.; Pitchaikani P.K.; Banerjee S. ; Screening for early onset neonatal sepsis: NICE guidance-based practice versus projected application of the Kaiser Permanente sepsis risk calculator in the UK population; Archives of disease in childhood. Fetal and neonatal edition; 2019; vol. 105

### 1 Study Characteristics

<b>Study design</b>	Prospective cohort study
<b>Study details</b>	<p><b>Study location</b> Wales</p> <p><b>Study setting</b> 8 maternity hospitals (3 NICUs, 1 subregional NICU, 4 special care units)</p> <p><b>Study dates</b> February 2018 - April 2018</p> <p><b>Duration of follow-up</b> 72 hours</p>
<b>Inclusion criteria</b>	Neonates with gestational age $\geq 34$ weeks
<b>Exclusion criteria</b>	None reported
<b>Sample characteristics</b>	<p><b>Sample size</b> 3593</p> <p><b>Group B streptococcus colonisation</b> In mother: 200 (5.5%)</p> <p><b>Gestational age &lt;37 weeks</b> 252 (7%)</p> <p><b>Rupture of membranes &gt;18 hours</b> 573 (16)</p> <p><b>Maternal temperature <math>\geq 38</math> degrees</b> 194 (5%)</p>
<b>Prognostic model</b>	<p>Kaiser Permanente neonatal sepsis calculator</p> <p>NICE risk factors</p>

### 2 Study arms

#### NICE guidelines (N = 3593)

Neonates managed according to NICE guidelines using risk factors (red or non-red flags) to guide initiation of antibiotics

### **Kaiser Permanente neonatal sepsis calculator (N = 3593)**

Used retrospectively. Background incidence for early-onset infection set at 0.5/1000 live births (closest estimated incidence from studies of term and near-term infants in high-income countries including the UK)

#### **1 Risk of bias**

##### **Selection of participants**

*1.1 Were appropriate data sources used, e.g. cohort, RCT or nested case-control study data?*

Yes

*(Prospective cohort)*

*1.2 Were all inclusions and exclusions of participants appropriate?*

Yes

*Overall risk of bias for selection of participants domain*

Low

*Concerns for applicability for selection of participants domain*

Low

##### **Predictors or their assessment**

*2.1 Were predictors defined and assessed in a similar way for all participants?*

Yes

*2.2 Were predictor assessments made without knowledge of outcome data?*

Yes

*(Clinicians were blinded)*

*2.3 Are all predictors available at the time the model is intended to be used?*

Yes

*Overall risk of bias for predictors or their assessment domain*

Low

*Concerns for applicability for predictors or their assessment domain*

Low

##### **Outcome or its determination**

*3.1 Was the outcome determined appropriately?*

Yes

*3.2 Was a pre-specified or standard outcome definition used?*

Yes

*3.3 Were predictors excluded from the outcome definition?*

Yes

*3.4 Was the outcome defined and determined in a similar way for all participants?*

Yes

*3.5 Was the outcome determined without knowledge of predictor information?*

Yes

*3.6 Was the time interval between predictor assessment and outcome determination appropriate?*

Yes

*Overall risk of bias for outcome or its determination domain*

Low

*Concerns for applicability for outcome or its determination domain*

Low

### **Analysis**

*4.1 Were there a reasonable number of participants with the outcome?*

No

*4.2 Were continuous and categorical predictors handled appropriately?*

Yes

*4.3 Were all enrolled participants included in the analysis?*

Yes

*4.4 Were participants with missing data handled appropriately?*

Yes

*4.5 Was selection of predictors based on univariable analysis avoided? - Development studies*

Not applicable

*4.6 Were complexities in the data (e.g. censoring, competing risks, sampling of control participants) accounted for appropriately?*

Yes

*4.7 Were relevant model performance measures evaluated appropriately?*

Yes

*4.8 Were model overfitting and optimism in model performance accounted for? - Development studies*

Not applicable

*4.9 Do predictors and their assigned weights in the final model correspond to the results from the reported multivariable analysis? - Development studies*

Not applicable

*Overall risk of bias for analysis domain*

Low

**Overall Risk of bias and Applicability**

*Risk of bias*

Low

*Concerns for applicability*

Low

1

**Hershkovich-Shporen, 2019**

2

**Bibliographic Reference** Hershkovich-Shporen, C.; Ujirauli, N.; Oren, S.; Juster Reicher, A.D.A.; Gadassi, N.; Guri, A.; Flidel-Rimon, O.; Not all newborns born to mothers with clinical chorioamnionitis need to be treated; Journal of Maternal-Fetal and Neonatal Medicine; 2019

**Study Characteristics**

<b>Study design</b>	Prospective cohort study
<b>Study details</b>	<p><b>Study location</b> Israel</p> <p><b>Study setting</b> Kaplan Medical Centre - paediatric emergency department</p> <p><b>Study dates</b> May 2015 - April 2016</p> <p><b>Sources of funding</b> None reported</p>
<b>Inclusion criteria</b>	<p>Gestational age of 35 weeks or more</p> <p><b>Risk factors for early-onset neonatal sepsis</b> maternal group B Streptococcus (GBS) carrier, maternal fever 38 oC or more, preterm delivery (35–36.6 gestational age), rupture of membrane more than 18 h before delivery, clinical maternal chorioamnionitis, newborns born to mothers that were treated with intra-partum antibiotic prophylaxis</p> <p>Receiving antibiotics in the first 72 hours of life</p> <p>Symptoms of suspected early-onset sepsis</p> <p>Proven sepsis</p>
<b>Exclusion criteria</b>	None reported
<b>Sample characteristics</b>	<p><b>Sample size</b> 1341</p> <p><b>Female</b> 45%</p>

	Mean gestational age (SD) 38 weeks ± 1.7
	Mean birth weight (SD) 3184 ± 487 g
<b>Length of follow-up</b>	First 72 hours of life
<b>Prognostic model</b>	Kaiser Permanente neonatal sepsis calculator
<b>Reference factor(s)</b>	Positive blood culture for early-onset neonatal sepsis

### Study arms

#### Standard practice (N = 1341)

Symptomatic newborns and newborns to mothers with clinical chorioamnionitis are given antibiotic treatment and complete blood counts and blood cultures are drawn. The infant is treated with empiric antibiotic (ampicillin and gentamycin) therapy for 48 h if cultures are negative. When a pathogen is detected, antibiotic therapy is either continued or, if needed, modified

#### Kaiser Permanente neonatal sepsis calculator (N = 1341)

Kaiser Permanente neonatal sepsis calculator retrospectively applied based on the charts of each of the babies in the standard practice arm. Background incidence of 0.6/1000 (based on incidence in the centre between January 2008 - January 2015)

Section	Question	Answer
Selection of participants	1.1 Were appropriate data sources used, e.g. cohort, RCT or nested case-control study data?	Yes
	1.2 Were all inclusions and exclusions of participants appropriate?	No information <i>(Appropriate inclusion criteria. No information about exclusion criteria)</i>
	Overall risk of bias for selection of participants domain	Unclear <i>(No information about exclusion criteria)</i>
	Concerns for applicability for selection of participants domain	Low
Predictors or their assessment	2.1 Were predictors defined and assessed in a similar way for all participants?	Yes

Section	Question	Answer
	2.2 Were predictor assessments made without knowledge of outcome data?	Yes
	2.3 Are all predictors available at the time the model is intended to be used?	Yes
	Overall risk of bias for predictors or their assessment domain	Low
	Concerns for applicability for predictors or their assessment domain	Low
Outcome or its determination	3.1 Was the outcome determined appropriately?	Yes
	3.2 Was a pre-specified or standard outcome definition used?	No information <i>(No definition of proven sepsis)</i>
	3.3 Were predictors excluded from the outcome definition?	Probably yes
	3.4 Was the outcome defined and determined in a similar way for all participants?	No information <i>(No definition of proven sepsis)</i>
	3.5 Was the outcome determined without knowledge of predictor information?	No information
	3.6 Was the time interval between predictor assessment and outcome determination appropriate?	Yes
	Overall risk of bias for outcome or its determination domain	Unclear <i>(No definition of proven sepsis)</i>
	Concerns for applicability for outcome or its determination domain	Low
Analysis	4.1 Were there a reasonable number of participants with the outcome?	Yes

Section	Question	Answer
	4.2 Were continuous and categorical predictors handled appropriately?	Yes
	4.3 Were all enrolled participants included in the analysis?	Yes
	4.4 Were participants with missing data handled appropriately?	No information
	4.7 Were relevant model performance measures evaluated appropriately?	No information <i>(Limited information about analysis methods)</i>
	Overall risk of bias for analysis domain	Unclear <i>(Limited information about analysis methods)</i>
Overall Risk of bias and Applicability	Risk of bias	Unclear <i>(Limited information about analysis methods, no information about exclusion criteria, no definition of proven sepsis)</i>
	Concerns for applicability	Some concerns  <i>Study based in USA – differences in GBS screening policy to the UK and possibly differences in incidence rate of infection (background incidence rate is needed for the calculator)</i>

1

## Joshi 2019

### Bibliographic Reference

Joshi NS; Gupta A; Allan JM; Cohen RS; Aby JL; Kim JL; Benitz WE; Frymoyer A; Management of Chorioamnionitis-Exposed Infants in the Newborn Nursery Using a Clinical Examination-Based Approach.; Hospital pediatrics; 2019; vol. 9 (no. 4)

### 2 Study Characteristics

<b>Study design</b>	Prospective cohort study
<b>Study details</b>	Study location USA  Study setting academic, tertiary care children's hospital that offers obstetric and neonatal services

	<b>Study dates</b> August 2016 - August 2017  <b>Duration of follow-up</b> 72 hours
<b>Inclusion criteria</b>	Born to mothers with clinical chorioamnionitis diagnosed by the obstetric team and is treated with intravenous broad-spectrum antibiotics  Neonates with gestational age $\geq 34$ weeks  Well-appearing infants
<b>Exclusion criteria</b>	Known congenital anomaly requiring NICU admission
<b>Sample characteristics</b>	<b>Sample size</b> 319  <b>Female</b> 44.5%  <b>Birth weight - kg (SD)</b> 3.35 (3.06 - 3.66)  <b>Group B streptococcus colonisation</b> Maternal: 18%  <b>Rupture of membranes &gt;18 hours</b> 25%
<b>Prognostic model</b>	Kaiser Permanente neonatal sepsis calculator

1

## 2 Study arms

### **Kaiser Permanente neonatal sepsis calculator (N = 319)**

Baseline incidence of 0.6/1000 live births

### **Standard care (N = 277)**

Well-appearing infants remained with their mothers for skin-to-skin care for the first 2 hours after birth and were then admitted to the level II NICU for ongoing clinical monitoring. Laboratory testing and antibiotic treatment were not performed unless clinical signs of illness developed.

## 3 Risk of bias

4

### **Selection of participants**

*1.1 Were appropriate data sources used, e.g. cohort, RCT or nested case-control study data?*

Yes

*(Prospective cohort study)*

*1.2 Were all inclusions and exclusions of participants appropriate?*

Yes

*Overall risk of bias for selection of participants domain*

Low

*Concerns for applicability for selection of participants domain*

Low

**Predictors or their assessment**

*2.1 Were predictors defined and assessed in a similar way for all participants?*

Yes

*2.2 Were predictor assessments made without knowledge of outcome data?*

Yes

*2.3 Are all predictors available at the time the model is intended to be used?*

Yes

*Overall risk of bias for predictors or their assessment domain*

Low

*Concerns for applicability for predictors or their assessment domain*

Low

**Outcome or its determination**

*3.1 Was the outcome determined appropriately?*

Yes

*3.2 Was a pre-specified or standard outcome definition used?*

Yes

*3.3 Were predictors excluded from the outcome definition?*

Yes

*3.4 Was the outcome defined and determined in a similar way for all participants?*

Yes

*3.5 Was the outcome determined without knowledge of predictor information?*

Probably no

*3.6 Was the time interval between predictor assessment and outcome determination appropriate?*

Yes

*Overall risk of bias for outcome or its determination domain*

Low

*Concerns for applicability for outcome or its determination domain*

Low

**Analysis**

*4.1 Were there a reasonable number of participants with the outcome?*

Yes

*4.2 Were continuous and categorical predictors handled appropriately?*

Yes

*4.3 Were all enrolled participants included in the analysis?*

Yes

*4.4 Were participants with missing data handled appropriately?*

Probably yes

*4.5 Was selection of predictors based on univariable analysis avoided? - Development studies*

Not applicable

*4.6 Were complexities in the data (e.g. censoring, competing risks, sampling of control participants) accounted for appropriately?*

Probably yes

*4.7 Were relevant model performance measures evaluated appropriately?*

Yes

*4.8 Were model overfitting and optimism in model performance accounted for? - Development studies*

Not applicable

*4.9 Do predictors and their assigned weights in the final model correspond to the results from the reported multivariable analysis? - Development studies*

Not applicable

*Overall risk of bias for analysis domain*

Low

**Overall Risk of bias and Applicability**

*Risk of bias*

Low

*Concerns for applicability*

Some concerns

*Study based in USA – differences in GBS screening policy to the UK and possibly differences in incidence rate of infection (background incidence rate is needed for the calculator)*

## Money 2017

**Bibliographic Reference** Money, N; Newman, J; Demissie, S; Roth, P; Blau, J; Anti-microbial stewardship: antibiotic use in well-appearing term neonates born to mothers with chorioamnionitis.; Journal of perinatology : official journal of the California Perinatal Association; 2017; vol. 37 (no. 12); 1304-1309

### 1 Study Characteristics

<b>Study design</b>	Retrospective cohort study
<b>Study details</b>	<p><b>Study location</b> USA</p> <p><b>Study setting</b> 1 hospital</p> <p><b>Study dates</b> January 2009 - April 2016</p> <p><b>Duration of follow-up</b> Not reported but examined early-onset infection</p>
<b>Inclusion criteria</b>	<p>Born to mothers with clinical chorioamnionitis According to maternal ICD-9 codes</p> <p>Well-appearing infants</p>
<b>Exclusion criteria</b>	Syptomatic patients who required admission to the Neonatal Intensive Care Unit due to equivocal presentation or clinical illness
<b>Sample characteristics</b>	<p><b>Sample size</b> 362</p> <p><b>Female</b> 49.5%</p> <p><b>Mean age (SD)</b> Maternal: 26.8 (6.0)</p> <p><b>Gestational age - weeks (SD)</b> 39.5 (1.2)</p> <p><b>Birth weight - kg (SD)</b> 3.431 (0.438)</p> <p><b>Group B streptococcus colonisation</b> Maternal: 47 (13%)</p> <p><b>Duration of rupture of membranes - mean (SD)</b> 14.5 (8.8)</p>
<b>Prognostic model</b>	Kaiser Permanente neonatal sepsis calculator

2

### 3 Study arms

### **Current practice (N = 362)**

Term newborns born to mothers with chorioamnionitis are admitted to an Observation Nursery. Serial vital signs and physical exams are monitored along with continuous pulse oximetry. CDC and AAP recommendations are followed - sepsis evaluations and antibiotic therapy are prescribed for all patients.

### **Kaiser Permanente neonatal sepsis model (N = 362)**

Baseline incidence of early-onset infection set at 0.5/1000 (based on CDC national incidence)

## **1 Risk of bias**

### **Selection of participants**

*1.1 Were appropriate data sources used, e.g. cohort, RCT or nested case-control study data?*

Yes

*(Retrospective cohort)*

*1.2 Were all inclusions and exclusions of participants appropriate?*

No

*Only well-appearing infants were included (symptomatic patients excluded). Issues with subjective diagnosis of chorioamnionitis*

*Overall risk of bias for selection of participants domain*

High

*Concerns for applicability for selection of participants domain*

Low

### **Predictors or their assessment**

*2.1 Were predictors defined and assessed in a similar way for all participants?*

Yes

*2.2 Were predictor assessments made without knowledge of outcome data?*

No information

*(Unclear if investigators had knowledge of both predictors and outcome.)*

*2.3 Are all predictors available at the time the model is intended to be used?*

Yes

*Overall risk of bias for predictors or their assessment domain*

Low

*Concerns for applicability for predictors or their assessment domain*

Low

**Outcome or its determination**

*3.1 Was the outcome determined appropriately?*

Yes

*3.2 Was a pre-specified or standard outcome definition used?*

Yes

*(EOS calculator. )*

*3.3 Were predictors excluded from the outcome definition?*

Yes

*3.4 Was the outcome defined and determined in a similar way for all participants?*

Yes

*3.5 Was the outcome determined without knowledge of predictor information?*

No information

*3.6 Was the time interval between predictor assessment and outcome determination appropriate?*

Yes

*Overall risk of bias for outcome or its determination domain*

Low

*Concerns for applicability for outcome or its determination domain*

Low

**Analysis**

*4.1 Were there a reasonable number of participants with the outcome?*

No

*4.2 Were continuous and categorical predictors handled appropriately?*

Yes

*4.3 Were all enrolled participants included in the analysis?*

No

*(Symptomatic patients excluded.)*

*4.4 Were participants with missing data handled appropriately?*

No information

*4.5 Was selection of predictors based on univariable analysis avoided? - Development studies*

Not applicable

*4.6 Were complexities in the data (e.g. censoring, competing risks, sampling of control participants) accounted for appropriately?*

No information

*4.7 Were relevant model performance measures evaluated appropriately?*

Not applicable

*4.8 Were model overfitting and optimism in model performance accounted for? - Development studies*

Not applicable

*4.9 Do predictors and their assigned weights in the final model correspond to the results from the reported multivariable analysis? - Development studies*

Not applicable

*Overall risk of bias for analysis domain*

Low

### **Overall Risk of bias and Applicability**

*Risk of bias*

Moderate

*Review was limited to well appearing infants. Potential for subjectivity in diagnosing chorioamnionitis*

*Concerns for applicability*

Some concerns

*Study based in USA – differences in GBS screening policy to the UK and possibly differences in incidence rate of infection (background incidence rate is needed for the calculator)*

1

## **Popowski 2011**

**Bibliographic Reference** Popowski, Thomas; Goffinet, Francois; Maillard, Françoise; Schmitz, Thomas; Leroy, Sandrine; Kayem, Gilles; Maternal markers for detecting early-onset neonatal infection and chorioamnionitis in cases of premature rupture of membranes at or after 34 weeks of gestation: a two-center prospective study.; BMC pregnancy and childbirth; 2011; vol. 11; 26

### **2 Study Characteristics**

<b>Study design</b>	Prospective cohort study
<b>Study details</b>	Study location France
	Study setting 2 tertiary university referral centres
	Study dates January 2004 - February 2006

	<p>Duration of follow-up 72 hours</p> <p>Sources of funding Clinical research grant (CIRC: CRC 03134) and research fellowship grant from French Society of Perinatal Medicine</p>
<b>Inclusion criteria</b>	<p>Women with PROM at or after 34 weeks of gestation</p> <p>Singleton pregnancies</p>
<b>Exclusion criteria</b>	<p>Women in spontaneous labour at admission to the hospital</p> <p>Women who gave birth more than 72 hours after admission</p>
<b>Sample characteristics</b>	<p>Sample size 399</p> <p>Mean age (SD) Maternal: 31.7 (5.5)</p> <p>Gestational age - weeks (SD) 38.5 (1.6) (at inclusion in the study)</p> <p>Birth weight - kg (SD) 3.24 (4.71)</p>
<b>Prognostic model</b>	Unnamed prediction model

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## 2 Study arms

### C-reactive protein (N = 399)

neonatal CRP  $\geq 10$  mg/L

### Predictive model (N = 399)

Based on predictive factors: maternal white blood cell count, C-reactive protein concentration, pathogenic genital bacteria. Includes potential confounding factors: gestational age, antibiotic prescription at admission, type of management (expectant or active).

## 3 Risk of bias

### Selection of participants

*1.1 Were appropriate data sources used, e.g. cohort, RCT or nested case-control study data?*

Yes

*(Prospective cohort study. )*

*1.2 Were all inclusions and exclusions of participants appropriate?*

Yes

*Overall risk of bias for selection of participants domain*

Low

*Concerns for applicability for selection of participants domain*

Low

**Predictors or their assessment**

*2.1 Were predictors defined and assessed in a similar way for all participants?*

Yes

*2.2 Were predictor assessments made without knowledge of outcome data?*

Yes

*2.3 Are all predictors available at the time the model is intended to be used?*

Yes

*Overall risk of bias for predictors or their assessment domain*

Low

*Concerns for applicability for predictors or their assessment domain*

Low

**Outcome or its determination**

*3.1 Was the outcome determined appropriately?*

Yes

*3.2 Was a pre-specified or standard outcome definition used?*

Yes

*3.3 Were predictors excluded from the outcome definition?*

Yes

*3.4 Was the outcome defined and determined in a similar way for all participants?*

Yes

*3.5 Was the outcome determined without knowledge of predictor information?*

Yes

*3.6 Was the time interval between predictor assessment and outcome determination appropriate?*

Probably yes

*Overall risk of bias for outcome or its determination domain*

Low

*Concerns for applicability for outcome or its determination domain*

Low

## Analysis

4.1 *Were there a reasonable number of participants with the outcome?*

No

4.2 *Were continuous and categorical predictors handled appropriately?*

Yes

4.3 *Were all enrolled participants included in the analysis?*

Yes

4.4 *Were participants with missing data handled appropriately?*

Probably yes

4.5 *Was selection of predictors based on univariable analysis avoided? - Development studies*

Not applicable

4.6 *Were complexities in the data (e.g. censoring, competing risks, sampling of control participants) accounted for appropriately?*

Probably yes

4.7 *Were relevant model performance measures evaluated appropriately?*

No information

4.8 *Were model overfitting and optimism in model performance accounted for? - Development studies*

Not applicable

4.9 *Do predictors and their assigned weights in the final model correspond to the results from the reported multivariable analysis? - Development studies*

Not applicable

*Overall risk of bias for analysis domain*

Low

## Overall Risk of bias and Applicability

*Risk of bias*

Low

*Concerns for applicability*

Low

1

## Shakib 2015

**Bibliographic Reference** Shakib, Julie; Buchi, Karen; Smith, Elizabeth; Young, Paul C; Management of newborns born to mothers with chorioamnionitis: is it time for a kinder, gentler approach?.; Academic pediatrics; 2015; vol. 15 (no. 3); 340-4

## 1 Study Characteristics

<b>Study design</b>	Retrospective cohort study
<b>Study details</b>	<p>Study location USA</p> <p>Study setting University of Utah Hospital</p> <p>Study dates 2006 - mid-2013</p> <p>Duration of follow-up Not reported but examined early-onset infection</p>
<b>Inclusion criteria</b>	<p>Born to mothers with clinical chorioamnionitis based on a discharge ICD-9 diagnosis code of 762.7, 658.40, 658.41, or 658.43</p> <p>Neonates with gestational age <math>\geq 34</math> weeks</p>
<b>Exclusion criteria</b>	Admitted to NICU
<b>Sample characteristics</b>	<p>Sample size 698</p> <p>Group B streptococcus colonisation Mother: 65 (9.3%) (62% unknown) Neonate: 1 (0.22%)</p> <p>Rupture of membranes &gt;18 hours 20%</p> <p>Maternal temperature <math>\geq 38</math> degrees 40% &gt;37.5 degrees</p>
<b>Prognostic model</b>	Kaiser Permanente neonatal sepsis calculator

## 2 Study arms

### Current practice (N = 698)

University of Utah Hospital current management for neonates who are well-appearing with a gestational age of 34 or more weeks whose mothers had received a diagnosis of chorioamnionitis: A CBC and blood culture are obtained and intravenous ampicillin and gentamicin are initiated. This is discontinued at 48 hours if the blood culture is negative and the infant remains well appearing

### Kaiser Permanente neonatal sepsis calculator (N = 698)

No information on background incidence used for early-onset infection

## 3 Risk of bias

### Selection of participants

*1.1 Were appropriate data sources used, e.g. cohort, RCT or nested case-control study data?*

Yes

*(Retrospective cohort study. )*

*1.2 Were all inclusions and exclusions of participants appropriate?*

Yes

*Overall risk of bias for selection of participants domain*

Low

*Concerns for applicability for selection of participants domain*

Low

**Predictors or their assessment**

*2.1 Were predictors defined and assessed in a similar way for all participants?*

Yes

*2.2 Were predictor assessments made without knowledge of outcome data?*

No information

*2.3 Are all predictors available at the time the model is intended to be used?*

Yes

*Overall risk of bias for predictors or their assessment domain*

Low

*Concerns for applicability for predictors or their assessment domain*

Low

**Outcome or its determination**

*3.1 Was the outcome determined appropriately?*

Yes

*3.2 Was a pre-specified or standard outcome definition used?*

Yes

*3.3 Were predictors excluded from the outcome definition?*

Yes

*3.4 Was the outcome defined and determined in a similar way for all participants?*

Yes

*3.5 Was the outcome determined without knowledge of predictor information?*

No information

*3.6 Was the time interval between predictor assessment and outcome determination appropriate?*

No information

*Overall risk of bias for outcome or its determination domain*

Low

*Concerns for applicability for outcome or its determination domain*

Low

**Analysis**

*4.1 Were there a reasonable number of participants with the outcome?*

No

*(N = 1 culture-positive. )*

*4.2 Were continuous and categorical predictors handled appropriately?*

Yes

*4.3 Were all enrolled participants included in the analysis?*

Yes

*4.4 Were participants with missing data handled appropriately?*

Yes

*(No records were excluded because of missing data. )*

*4.5 Was selection of predictors based on univariable analysis avoided? - Development studies*

Not applicable

*4.6 Were complexities in the data (e.g. censoring, competing risks, sampling of control participants) accounted for appropriately?*

Probably yes

*4.7 Were relevant model performance measures evaluated appropriately?*

No information

*4.8 Were model overfitting and optimism in model performance accounted for? - Development studies*

Not applicable

*4.9 Do predictors and their assigned weights in the final model correspond to the results from the reported multivariable analysis? - Development studies*

Not applicable

*Overall risk of bias for analysis domain*

Low

**Overall Risk of bias and Applicability**

*Risk of bias*

Moderate

*Not all mothers had temperature recorded during labour so used temperature at admission. Highest antepartum temperature is one of the predictors in the neonatal sepsis calculator*

*Concerns for applicability*

Some concerns

*Study based in USA – differences in GBS screening policy to the UK and possibly differences in incidence rate of infection (background incidence rate is needed for the calculator)*

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3

## Sloane 2019

**Bibliographic Reference** Sloane A.J.; Coleman C.; Carola D.L.; Lafferty M.A.; Edwards C.; Greenspan J.; Aghai Z.H. ; Use of a Modified Early-Onset Sepsis Risk Calculator for Neonates Exposed to Chorioamnionitis; Journal of Pediatrics; 2019

### 4 Study Characteristics

<b>Study design</b>	Retrospective cohort study Follow-up from Carola 2018 following revision of neonatal sepsis calculator with a higher baseline incidence of risk of sepsis to 4/1000 live births (0.5/1000 used in Carola 2018)
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### 6 Study arms

#### Neonatal sepsis calculator (1) (N = 896)

Baseline incidence of infection set at 0.5/1000 live births (CDC national incidence)

#### Neonatal sepsis calculator (2) (N = 896)

Baseline incidence of infection set at 4/1000 live births. Based on the EOS incidence of 4.3/1000 live births in the population of infants exposed to chorioamnionitis in the NICU in the study

### 7 Risk of bias

#### Selection of participants

*1.1 Were appropriate data sources used, e.g. cohort, RCT or nested case-control study data?*

Yes

*1.2 Were all inclusions and exclusions of participants appropriate?*

Yes

*Overall risk of bias for selection of participants domain*

Low

*Concerns for applicability for selection of participants domain*

Low

**Predictors or their assessment**

*2.1 Were predictors defined and assessed in a similar way for all participants?*

Yes

*(EOS calculator )*

*2.2 Were predictor assessments made without knowledge of outcome data?*

No information

*(Unclear if assessors had knowledge of outcome. )*

*2.3 Are all predictors available at the time the model is intended to be used?*

Yes

*Overall risk of bias for predictors or their assessment domain*

Low

*Concerns for applicability for predictors or their assessment domain*

Low

**Outcome or its determination**

*3.1 Was the outcome determined appropriately?*

Yes

*3.2 Was a pre-specified or standard outcome definition used?*

Yes

*3.3 Were predictors excluded from the outcome definition?*

Yes

*3.4 Was the outcome defined and determined in a similar way for all participants?*

Yes

*3.5 Was the outcome determined without knowledge of predictor information?*

No information

*3.6 Was the time interval between predictor assessment and outcome determination appropriate?*

No information

*Overall risk of bias for outcome or its determination domain*

Low

*Concerns for applicability for outcome or its determination domain*

Low

**Analysis**

*4.1 Were there a reasonable number of participants with the outcome?*

No

*(N=5 culture-positive. )*

*4.2 Were continuous and categorical predictors handled appropriately?*

Yes

*4.3 Were all enrolled participants included in the analysis?*

Yes

*4.4 Were participants with missing data handled appropriately?*

No information

*4.5 Was selection of predictors based on univariable analysis avoided? - Development studies*

Not applicable

*4.6 Were complexities in the data (e.g. censoring, competing risks, sampling of control participants) accounted for appropriately?*

No information

*4.7 Were relevant model performance measures evaluated appropriately?*

Not applicable

*4.8 Were model overfitting and optimism in model performance accounted for? - Development studies*

Not applicable

*4.9 Do predictors and their assigned weights in the final model correspond to the results from the reported multivariable analysis? - Development studies*

Not applicable

*Overall risk of bias for analysis domain*

Low

**Overall Risk of bias and Applicability**

*Risk of bias*

Low

*Concerns for applicability*

Some concerns

*Study based in USA – differences in GBS screening policy to the UK and possibly differences in incidence rate of infection (background incidence rate is needed for the calculator)*

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**Bibliographic Reference** Strunk T.; Buchiboyina A.; Sharp M.; Nathan E.; Doherty D.; Patole S. ; Implementation of the Neonatal Sepsis Calculator in an Australian Tertiary Perinatal Centre; Neonatology; 2018; vol. 113 (no. 4); 379-382

## 1 Study Characteristics

<b>Study design</b>	Prospective cohort study
<b>Study details</b>	<p><b>Study location</b> Australia</p> <p><b>Study setting</b> Perinatal referral centre (King Edward Memorial Hospital for Women, Perth, WA)</p> <p><b>Study dates</b> Period 1 (pre-calculator): October 2014 - January 2015. Period 2 (post-calculator): July 2016 - December 2016</p> <p><b>Duration of follow-up</b> Birth to 1688 hours of life (separated into &lt;24 hours after birth and &gt;24 hours)</p>
<b>Inclusion criteria</b>	Neonates with gestational age $\geq 35$ weeks
<b>Exclusion criteria</b>	None reported
<b>Sample characteristics</b>	<p><b>Sample size</b> Pre-calculator: 1732; Post-calculator: 2502</p> <p><b>Female</b> Pre-calculator: 48.3%; Post-calculator: 48.4%</p> <p><b>Premature rupture of membranes &gt;24 hours</b> Pre-calculator: 0.6%; Post-calculator: 0.6%</p>
<b>Prognostic model</b>	Kaiser Permanente neonatal sepsis calculator

## 2 Study arms

### Baseline period (N = 1732)

Neonatal sepsis risk algorithm based on a local adaptation of the American Academy of Pediatrics guidelines

### Kaiser Permanente neonatal sepsis calculator (N = 2502)

Neonatal sepsis calculator with background incidence of early-onset infection set at 0.44/1000 live births (based on local 2005-2014 rate). Introduced following 2-month education period.

## 3 Risk of bias

### Selection of participants

*1.1 Were appropriate data sources used, e.g. cohort, RCT or nested case-control study data?*

Yes

*(Prospective cohort)*

*1.2 Were all inclusions and exclusions of participants appropriate?*

Yes

*Overall risk of bias for selection of participants domain*

Low

*Concerns for applicability for selection of participants domain*

Low

**Predictors or their assessment**

*2.1 Were predictors defined and assessed in a similar way for all participants?*

Yes

*2.2 Were predictor assessments made without knowledge of outcome data?*

No information

*2.3 Are all predictors available at the time the model is intended to be used?*

Yes

*Concerns for applicability for predictors or their assessment domain*

Low

**Outcome or its determination**

*3.1 Was the outcome determined appropriately?*

Yes

*3.2 Was a pre-specified or standard outcome definition used?*

Yes

*3.3 Were predictors excluded from the outcome definition?*

Yes

*3.4 Was the outcome defined and determined in a similar way for all participants?*

Yes

*3.5 Was the outcome determined without knowledge of predictor information?*

No information

*3.6 Was the time interval between predictor assessment and outcome determination appropriate?*

No information

*Overall risk of bias for outcome or its determination domain*

Low

*Concerns for applicability for outcome or its determination domain*

Low

## **Analysis**

*4.1 Were there a reasonable number of participants with the outcome?*

No

*4.2 Were continuous and categorical predictors handled appropriately?*

Yes

*4.3 Were all enrolled participants included in the analysis?*

Yes

*4.4 Were participants with missing data handled appropriately?*

No information

*4.5 Was selection of predictors based on univariable analysis avoided? - Development studies*

Not applicable

*4.6 Were complexities in the data (e.g. censoring, competing risks, sampling of control participants) accounted for appropriately?*

No information

*4.7 Were relevant model performance measures evaluated appropriately?*

Not applicable

*4.8 Were model overfitting and optimism in model performance accounted for? - Development studies*

Not applicable

*4.9 Do predictors and their assigned weights in the final model correspond to the results from the reported multivariable analysis? - Development studies*

Not applicable

*Overall risk of bias for analysis domain*

Low

## **Overall Risk of bias and Applicability**

*Risk of bias*

Low

*Concerns for applicability*

Some concerns

*Study based in USA – differences in GBS screening policy to the UK and possibly differences in incidence rate of infection (background incidence rate is needed for the calculator)*

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## D.2 Maternal and neonatal risk factors

### Dempsey, 2005

**Bibliographic Reference** Dempsey, E; Chen, M-F; Kokottis, T; Vallerand, D; Usher, R; Outcome of neonates less than 30 weeks gestation with histologic chorioamnionitis.; American journal of perinatology; 2005; vol. 22 (no. 3); 155-9

#### Study Characteristics

<b>Study design</b>	Retrospective cohort study
<b>Study details</b>	<p><b>Study location</b> Canada</p> <p><b>Study setting</b> Royal Victoria Hospital</p> <p><b>Study dates</b> 1989 - 1999</p> <p><b>Duration of follow-up</b> 72 hours</p> <p><b>Sources of funding</b> None reported</p>
<b>Inclusion criteria</b>	All singleton neonates delivered at <30 weeks gestational age
<b>Exclusion criteria</b>	None reported
<b>Sample characteristics</b>	<p><b>Sample size</b> 392</p> <p><b>Gestational age (weeks) (mean, SD)</b> Non-chorioamnionitis: 27.5 (1.9); Chorioamnionitis: 26.3 (2)</p> <p><b>Birth weight (g) (mean, SD)</b> Non-chorioamnionitis: 1030 (357); Chorioamnionitis: 920 (284)</p>
<b>Prognostic factors</b>	Chorioamnionitis Histological chorioamnionitis
<b>Reference Factor (s)</b>	Early onset infection

#### Study arms

##### Neonates less than 30 weeks' gestational age (N = 392)

Neonates born at <30 weeks' gestation with or without exposure to chorioamnionitis Chorioamnionitis: Histologic chorioamnionitis defined as the presence of abundant polymorphonuclear leukocytes in the chorion and amnion Early onset infection: A positive blood culture or positive cerebrospinal fluid culture in the

first 72 hours Multivariate analysis used to examine risk factors. Confounding variables adjusted for were: gestational age, antenatal steroid administration, and duration of membrane rupture

## **Risk of bias**

Study participation

### ***Summary Study participation***

Low risk of bias

Study Attrition

### ***Study Attrition Summary***

Low risk of bias

Prognostic factor measurement

### ***Prognostic factor Measurement Summary***

Low risk of bias

Outcome Measurement

### ***Outcome Measurement Summary***

Low risk of bias

(Retrospective analysis but outcomes were based on laboratory results rather than subjective outcomes)

Study Confounding

### ***Study Confounding Summary***

Low risk of bias

Statistical Analysis and Reporting

### ***Statistical Analysis and Presentation Summary***

Moderate risk of bias

(Limited information about multivariate analysis)

Overall risk of bias and directness

**Risk of Bias**

Moderate

(Limited information about multivariate analysis)

**Directness**

Directly applicable

**Dior, 2016**

**Bibliographic Reference** Dior, Uri P; Kogan, Liron; Eventov-Friedman, Smadar; Gil, Moran; Bahar, Raz; Ergaz, Zivanit; Porat, Shay; Calderon-Margalit, Ronit; Very High Intrapartum Fever in Term Pregnancies and Adverse Obstetric and Neonatal Outcomes.; Neonatology; 2016; vol. 109 (no. 1); 62-8

**Study Characteristics**

<b>Study design</b>	Retrospective cohort study
<b>Study details</b>	<p><b>Study location</b> Israel</p> <p><b>Study setting</b> 2 medical centres in Jerusalem</p> <p><b>Study dates</b> January 2003 - January 2011</p> <p><b>Duration of follow-up</b> 72 hours</p> <p><b>Sources of funding</b> None reported</p>
<b>Inclusion criteria</b>	<p>Women in labour who had a singleton live birth</p> <p>&lt;50 years old</p> <p>Had a term pregnancy (<math>\geq 37</math> weeks' gestation)</p> <p>Baby with a birth weight &lt;5000 g</p> <p>Spent &gt;1 hour in the delivery room</p>
<b>Exclusion criteria</b>	<p>Non-emergency cesarean deliveries</p> <p>Labour after a previous cesarean delivery</p> <p>use of prostaglandins during induction of labor</p> <p>Fetal malformations</p>

	Chromosomal abnormalities Unknown fever during labor
<b>Sample characteristics</b>	Sample size 43560 Gestational age (weeks) (%) Low febrile fever - 37-39 weeks: 39%, 40-41 weeks: 54%, >42 weeks: 6%; High febrile fever - 37-39 weeks: 37%, 40-41 weeks: 50%, >42 weeks: 11% Birth weight (%) Low febrile fever - <2500 g: 1%, 2500 - 3499 g: 59%, 3500 - 3999 g: 31%, >4000 g: 7%; High febrile fever - <2500 g: 0%, 2500 - 3499 g: 70%, 3500 - 3999 g: 21%, >4000 g: 8%
<b>Prognostic factors</b>	Intrapartum fever Low fever (38-38.9 degrees); High fever (>39 degrees)
<b>Reference Factor (s)</b>	Early onset infection Blood culture with or without a cerebrospinal fluid culture that was positive for a bacterial species and was obtained from an infant under 72 h of age

### Study arms

#### Babies born at term (N = 43560)

Babies born at term to mothers with a singleton pregnancy. Early onset infection: Blood culture with or without a cerebrospinal fluid culture that was positive for a bacterial species and was obtained from an infant under 72 h of age. Data regarding blood cultures was retrieved from the microbiology laboratory and verified by neonatology specialists Intrapartum fever: Based on maximal temperature measured during labor. Temperature <38 °C: normal fever, Temperature 38.0–38.9 °C: low febrile fever, Temperature ≥ 39 °C: high febrile fever Multivariate analysis used to examine association between intrapartum fever and neonatal infection. Model controlled for gestational age, birth weight (<2,500, 2,500–4,000, and >4,000 g), duration of labor and epidural analgesia

### Risk of bias

#### *Summary Study participation*

Low risk of bias

#### *Study Attrition Summary*

Low risk of bias

#### *Prognostic factor Measurement Summary*

Low risk of bias

(Retrospective study based on patient records but prognostic factors were based on test results rather than subjective outcomes)

### **Outcome Measurement Summary**

Low risk of bias

### **Study Confounding Summary**

Low risk of bias

### **Statistical Analysis and Presentation Summary**

Low risk of bias

### **Risk of Bias**

Moderate

*Limited information on how factors to be adjusted were selected*

### **Directness**

Directly applicable

## **Garcia-Munoz Rodrigo, 2014a**

**Bibliographic Reference** Garcia-Munoz Rodrigo, Fermin; Galan Henriquez, Gloria M; Ospina, Cristina Gomez; Morbidity and mortality among very-low-birth-weight infants born to mothers with clinical chorioamnionitis.; Pediatrics and neonatology; 2014; vol. 55 (no. 5); 381-6

### **Study Characteristics**

<b>Study design</b>	Prospective cohort study
<b>Study details</b>	<p><b>Study location</b> Spain</p> <p><b>Study setting</b> Neonatal Intensive Care Unit</p> <p><b>Study dates</b> January 2008 - December 2012</p> <p><b>Duration of follow-up</b> Until death or discharge (first 72 hours of life for early-onset infection)</p> <p><b>Sources of funding</b> None reported</p>
<b>Inclusion criteria</b>	Born in maternity unit or admitted to Neonatal Intensive Care Unit in the first 28 days of life

	Birth weight <1500 g or <30 weeks' gestational age
<b>Exclusion criteria</b>	None reported
<b>Sample characteristics</b>	<p>Sample size 451</p> <p>Female Mothers with chorioamnionitis: 52%, Mothers without chorioamnionitis: 46%</p> <p>Gestational age (weeks) (mean, SD) Mothers with chorioamnionitis: 27.9 (2.3), Mothers without chorioamnionitis: 29.6 (2.7)</p> <p>Birth weight (g) (mean, SD) Mothers with chorioamnionitis: 1029.7 (232.9), Mothers without chorioamnionitis: 1144.0 (253.7)</p>
<b>Prognostic factors</b>	Chorioamnionitis Defined according to adapted Gibbs criteria
<b>Reference Factor (s)</b>	Early onset infection Positive blood culture in the first 72 hours

### Study arms

#### Babies born <30 weeks' gestational age (N = 451)

Babies born at <30 weeks' gestational age to mothers with/without clinical chorioamnionitis Chorioamnionitis: Defined according to adapted Gibbs criteria as maternal fever >38 degrees at least on two occasions separated by 1 hour, plus as least two of the following: uterine tenderness defined as pain referred by the mother on abdomen palpation in the absence of uterine contractions, leucocytosis (>15,000 cells/mm<sup>3</sup>), maternal tachycardia >100 bpm), fetal tachycardia (>160 bpm), or foul smelling vaginal discharge Early onset infection: bacterial infection documented by a positive blood culture in the first 72 hours of life Multivariate analysis used to examine association between chorioamnionitis and infection. Adjusted for gestational age and body weight

#### Risk of bias

Study participation

##### *Summary Study participation*

Low risk of bias

Study Attrition

##### *Study Attrition Summary*

Low risk of bias

Prognostic factor measurement

### ***Prognostic factor Measurement Summary***

Low risk of bias

(Definition of chorioamnionitis was provided and appears appropriate.)

Outcome Measurement

### ***Outcome Measurement Summary***

Low risk of bias

Study Confounding

### ***Study Confounding Summary***

Low risk of bias

Statistical Analysis and Reporting

### ***Statistical Analysis and Presentation Summary***

Moderate risk of bias

(Insufficient details on the design of the multivariate model were reported, including how factors to be adjusted were selected)

Overall risk of bias and directness

### ***Risk of Bias***

Moderate

(Insufficient details on the design of the multivariate model were reported, including how factors to be adjusted were selected.)

### ***Directness***

Directly applicable

## **Garcia-Munoz Rodrigo, 2014b**

**Bibliographic Reference** Garcia-Munoz Rodrigo, Fermin; Galan Henriquez, Gloria; Figueras Aloy, Josep; Garcia-Alix Perez, Alfredo; Outcomes of very-low-birth-weight infants exposed to maternal clinical chorioamnionitis: a multicentre study.; Neonatology; 2014; vol. 106 (no. 3); 229-34

### Study Characteristics

<b>Study design</b>	Retrospective cohort study
<b>Study details</b>	<p><b>Study location</b> Spain</p> <p><b>Study setting</b> Multicentre: 53 neonatal intensive care units</p> <p><b>Study dates</b> 2008-2011</p> <p><b>Duration of follow-up</b> Not reported - likely to be duration of admission</p> <p><b>Sources of funding</b> Spanish society of neonatology</p>
<b>Inclusion criteria</b>	<p>Birthweight &lt;1500g</p> <p>Gestational age &lt;32 weeks</p> <p>Admitted to a neonatal unit</p>
<b>Exclusion criteria</b>	Incomplete data available from medical records
<b>Sample characteristics</b>	<p><b>Sample size</b> 8330</p> <p><b>Female</b> 47.9%</p> <p><b>Mean gestational age (weeks) (SD)</b> With chorioamnionitis: 27.1 (2.3) weeks Without chorioamnionitis: 28.8 (2.3) weeks</p> <p><b>Caesarian delivery (%)</b> 68.4% (calculated from table 1)</p> <p><b>Mean birthweight (SD)</b> With chorioamnionitis: 1016 (278.2) g Without chorioamnionitis: 1101.4 (267.5) g</p> <p><b>Multiple births (%)</b></p>
<b>Prognostic/diagnostic factors</b>	Maternal chorioamnionitis
<b>Reference Factor (s)</b>	<p><b>Early-onset neonatal sepsis</b> bacterial infection documented by a positive blood culture within 72 h of life, and with clinical symptoms: apnoea, temperature instability, feeding intolerance, worsening respiratory distress or hemodynamic instability.</p>

### Study arms

#### Very-low birthweight infants with gestational age <32 weeks (N = 8330)

Retrospective study. All neonates admitted to collaborating units with complete data who met inclusion criteria were included (83.1% of total eligible had complete data). Multivariate logistic regression was performed to assess the impact of maternal chorioamnionitis on late-onset sepsis with adjustment for

gestational age, birth weight, maternal hypertension, antenatal steroids, infant sex, multiplicity (2 or more fetuses), type of delivery, necessity of advanced cardiopulmonary resuscitation (CPR), and stability after admission based on the Clinical Risk Index for Babies 1 (CRIB 1) score.

## **Risk of bias**

Study participation

### ***Summary Study participation***

Low risk of bias

(Appropriate recruitment method and adequate description of sample.)

Study Attrition

### ***Study Attrition Summary***

Low risk of bias

(82.3% of eligible neonates had complete data sets and were included. Attrition unlikely to be important as data recorded during stay on neonatal unit,)

Prognostic factor measurement

### ***Prognostic factor Measurement Summary***

Low risk of bias

(Definition of maternal chorioamnionitis was reported and was unambiguous. )

Outcome Measurement

### ***Outcome Measurement Summary***

Low risk of bias

Study Confounding

### ***Study Confounding Summary***

Low risk of bias

(Adjustment for confounding factors was reported and appears adequate)

Statistical Analysis and Reporting

### ***Statistical Analysis and Presentation Summary***

Moderate risk of bias

(Strategy for model development and criteria for including confounding factors for adjustment was not reported.)

Overall risk of bias and directness

**Risk of Bias**

Moderate

(Strategy for model development and criteria for including confounding factors for adjustment was not reported)

**Directness**

Directly applicable

**Hakansson, 2006**

**Bibliographic Reference** Hakansson, S; Kallen, K; Impact and risk factors for early-onset group B streptococcal morbidity: analysis of a national, population-based cohort in Sweden 1997-2001.; BJOG : an international journal of obstetrics and gynaecology; 2006; vol. 113 (no. 12); 1452-8

**Study Characteristics**

<b>Study design</b>	Retrospective cohort study
<b>Study details</b>	<b>Study location</b> Sweden
	<b>Study setting</b> Medical Birth Register and the Hospital Discharge Register kept by the Epidemiological Centre of the Swedish National Board of Health and Welfare
	<b>Study dates</b> 1997-2001
	<b>Duration of follow-up</b> First 27 days of life
	<b>Sources of funding</b> Va'sterbotten County Council (S.H.) and by the Wallenberg Foundation (K.K.)
<b>Inclusion criteria</b>	Gestational age >21 weeks
<b>Exclusion criteria</b>	None reported Although stillbirths before 28 weeks' gestation not included because these are not included in the register

<b>Sample characteristics</b>	Sample size 319 (174 with positive blood culture)
<b>Prognostic factors</b>	Gestational age Twin/singleton births
<b>Reference Factor (s)</b>	Early onset infection Isolation of GBS from blood or cerebrospinal fluid

### Study arms

#### Babies with GBS (N = 319)

Babies with early onset neonatal infection. Verified early onset GBS: the isolation of GBS from blood or cerebrospinal fluid Multivariate analysis using multiple logistic regression models. Model adjusted for possible confounders: Year of birth, maternal age, maternal smoking status, parity

### Risk of bias

Study participation

#### **Summary Study participation**

Low risk of bias

Study Attrition

#### **Study Attrition Summary**

Low risk of bias

Prognostic factor measurement

#### **Prognostic factor Measurement Summary**

Low risk of bias

Outcome Measurement

#### **Outcome Measurement Summary**

Low risk of bias

(Retrospective analysis but based on test results rather than subjective diagnosis)

Study Confounding

#### **Study Confounding Summary**

Low risk of bias

Statistical Analysis and Reporting

***Statistical Analysis and Presentation Summary***

Low risk of bias

Overall risk of bias and directness

***Risk of Bias***

Moderate

(Limited information about choice of model factors for adjustment)

***Directness***

Directly applicable

**Hakansson, 2008**

**Bibliographic Reference** Hakansson, Stellan; Kallen, Karin; High maternal body mass index increases the risk of neonatal early onset group B streptococcal disease.; Acta paediatrica (Oslo, Norway : 1992); 2008; vol. 97 (no. 10); 1386-9

**Study Characteristics**

<b>Study design</b>	Retrospective cohort study
<b>Study details</b>	<b>Study location</b> Sweden
	<b>Study setting</b> Medical Birth Register and the Hospital Discharge Register of the Epidemiological Centre of the Swedish National Board of Health and Welfare
	<b>Study dates</b> 1997 - 2001
	<b>Duration of follow-up</b> First 27 days of life (within 6 days of life for early onset infection)
	<b>Sources of funding</b> The Evy and Gunnar Sandberg Foundation, and The Birgit and Sven Hakan Ohlsson Foundation
<b>Inclusion criteria</b>	Gestational age >22 weeks
	Vaginal birth or emergency cesarean section
<b>Exclusion criteria</b>	Deliveries that started with a cesarean section

	Included if started with vaginal birth but delivery was with cesarean section
<b>Sample characteristics</b>	<p>Sample size 344,127 mothers</p> <p>Maternal BMI (%) &lt;18.5: 2.6%; 18.5-24.9: 63.9%; 25-29.9: 24.2%; &gt;30: 9.3%</p>
<b>Prognostic factors</b>	<p>Maternal BMI BMI classes categorized according to the definition of the World Health Organisation</p>
<b>Reference Factor (s)</b>	<p>Early onset infection Verified with a positive blood culture</p>

### Study arms

#### Babies born at >22 weeks' gestation (N = 344,127)

Babies born at >22 weeks' gestation to mothers. Early onset infection: verified with a positive blood culture  
 Maternal BMI: categorized according to the definition of the World Health Organisation (underweight <18.5, normal 18.5–24.9, overweight 25–29.9 and obese ≥30). BMI 18.5-24.9 used as reference value for analysis  
 Multiple logistic regression analysis used to examine association between BMI and early onset infection.  
 Model adjusted for possible confounders: year of birth, maternal age, parity, smoking, standard deviation weight scores, small for gestational age, large for gestational age, gestational age, birth weight and gestational diabetes

### Risk of bias

Study participation

#### *Summary Study participation*

Low risk of bias

Study Attrition

#### *Study Attrition Summary*

Low risk of bias

Prognostic factor measurement

#### *Prognostic factor Measurement Summary*

Low risk of bias

Outcome Measurement

#### *Outcome Measurement Summary*

Low risk of bias

## Study Confounding

### **Study Confounding Summary**

Low risk of bias

## Statistical Analysis and Reporting

### **Statistical Analysis and Presentation Summary**

Low risk of bias

Overall risk of bias and directness

### **Risk of Bias**

Low

### **Directness**

Partially applicable

*BMI categories do not match those used to classify obesity in clinical practice*

## Klinger, 2009

**Bibliographic Reference** Klinger, Gil; Levy, Itzhak; Sirota, Lea; Boyko, Valentina; Reichman, Brian; Lerner-Geva, Liat; Israel Neonatal, Network; Epidemiology and risk factors for early onset sepsis among very-low-birthweight infants.; American journal of obstetrics and gynecology; 2009; vol. 201 (no. 1); 38e1-6

### Study Characteristics

<b>Study design</b>	Retrospective cohort study
<b>Study details</b>	<b>Study location</b> Israel
	<b>Study setting</b> 28 neonatal departments
	<b>Study dates</b> 1995 - 2005
	<b>Duration of follow-up</b> Unclear. States early-onset infection but does not define time of infection
	<b>Sources of funding</b> Israel Center for Disease Control and the Israel Ministry of Health

<b>Inclusion criteria</b>	Infants whose data was collected by the Israel Neonatal Network on very low birth weight newborn infants (BW <1500 g)
<b>Exclusion criteria</b>	Babies who died in the delivery room Babies with lethal malformations
<b>Sample characteristics</b>	<p>Sample size 15839 (383 with EOS)</p> <p>Female With early onset infection: 47%; Without early onset infection: 50%</p> <p>Maternal age (mean, SD) With early onset infection: 29.8 years (6.1); Without early onset infection: 29.4 years (5.9)</p> <p>Gestational age at delivery With early onset infection: 27.7 (2.6); Without early onset infection: 29.1 (3.0)</p> <p>Birth weight (mean, SD) With early onset infection: 1005 g (287); Without early onset infection: 1102 g (283)</p>
<b>Prognostic factors</b>	<p>Chorioamnionitis maternal fever ( 37.8°C orally or 38.0°C rectally) recorded twice in 1 hour, during membrane rupture or within 6 hours after delivery providing no other cause for fever was found</p> <p>Single/multiple birth</p> <p>Gestational age</p>
<b>Reference Factor (s)</b>	<p>Early onset sepsis Positive blood culture within first 72 hours of life</p>

### Study arms

#### Very low birth weight infants (N = 15839)

Included effects of single/multiple births, amnionitis and gestational age on risk of early onset infection (culture confirmed within 72 hours of life). Multivariate analysis used to account for other risk factors (does not state what factors were adjusted for in the model)

### Risk of bias

Study participation

#### **Summary Study participation**

Low risk of bias

Study Attrition

#### **Study Attrition Summary**

Low risk of bias

Prognostic factor measurement

***Prognostic factor Measurement Summary***

Low risk of bias

Outcome Measurement

***Outcome Measurement Summary***

Low risk of bias

Study Confounding

***Study Confounding Summary***

Low risk of bias

Statistical Analysis and Reporting

***Statistical Analysis and Presentation Summary***

Moderate risk of bias

(Unclear what factors were adjusted for in multivariate model)

Overall risk of bias and directness

***Risk of Bias***

Moderate

(Unclear what factors were adjusted for in multivariate model)

***Directness***

Directly applicable

**Mularoni, 2014**

**Bibliographic Reference** Mularoni, Alessandra; Madrid, Marisela; Azpeitia, Agueda; Valls i Soler, Adolf; The role of coagulase-negative staphylococci in early onset sepsis in a large European cohort of very low birth weight infants.; The Pediatric infectious disease journal; 2014; vol. 33 (no. 5); e121-5

**Study Characteristics**

<b>Study design</b>	Prospective cohort study
<b>Study details</b>	<p><b>Study location</b> Europe (Austria, Czech Republic, Finland, France, Germany, Greece, Italy, Poland, Russia, Spain, Sweden, Switzerland, UK)</p> <p><b>Study setting</b> European centers participating in EuroNeoNet</p> <p><b>Study dates</b> January 2006 - December 2009</p> <p><b>Duration of follow-up</b> 72 hours</p> <p><b>Sources of funding</b> Directorate-General for Health and Consumers (DG SANCO) and the Italian Society of Tropical and Infectious Diseases (SIMIT)</p>
<b>Inclusion criteria</b>	<p>Babies weighing 401 - 1500 g</p> <p>Babies with a positive blood culture and clinical signs of sepsis during the first 72 hours of life</p>
<b>Exclusion criteria</b>	<p>Babies that died in the delivery room</p> <p>Units that classified &gt;20% of pathogens as 'other' (nonspecified organism)</p>
<b>Sample characteristics</b>	<p><b>Sample size</b> 14719</p>
<b>Prognostic factors</b>	Twin/singleton births
<b>Reference Factor (s)</b>	<p>Early onset infection</p> <p>Presence of clinical symptoms and a positive blood culture drawn within 72 hours of birth</p>

### Study arms

#### Very low birth weight neonates (N = 14719)

Very low birth weight infants with early onset neonatal infection. Early onset infection: the presence of clinical symptoms and a positive blood culture drawn within 72 hours of birth. Multivariate logistic regression model used to examine association between risk factors and early onset infection. Potential confounders were those whose p value in univariate analysis were <0.1 (birth weight, gestational age, gender, antenatal steroids, single pregnancy, delivery room resuscitation, apgar score at 5 minutes, vaginal delivery)

### Risk of bias

Study participation

#### *Summary Study participation*

Low risk of bias

Study Attrition

***Study Attrition Summary***

Low risk of bias

Prognostic factor measurement

***Prognostic factor Measurement Summary***

Low risk of bias

Outcome Measurement

***Outcome Measurement Summary***

Low risk of bias

Study Confounding

***Study Confounding Summary***

Low risk of bias

Statistical Analysis and Reporting

***Statistical Analysis and Presentation Summary***

Moderate risk of bias

(Only prognostic factors with significant results in univariate analysis were included in the multivariate model)

Overall risk of bias and directness

***Risk of Bias***

Moderate

Only prognostic factors with significant results in univariate analysis were included in the multivariate model

***Directness***

Directly applicable

**Ofman, 2016**

**Bibliographic Reference** Ofman, Gaston; Vasco, Natalia; Cantey, Joseph B; Risk of Early-Onset Sepsis following Preterm, Prolonged Rupture of Membranes with or without Chorioamnionitis.; American journal of perinatology; 2016; vol. 33 (no. 4); 339-42

### Study Characteristics

<b>Study design</b>	Retrospective cohort study
<b>Study details</b>	<p><b>Study location</b> USA</p> <p><b>Study setting</b> Parkland Memorial Hospital level IIIC neonatal intensive care unit</p> <p><b>Study dates</b> September 2005 - September 2014</p> <p><b>Duration of follow-up</b> 72 hours</p> <p><b>Sources of funding</b> None reported</p>
<b>Inclusion criteria</b>	Moderately preterm infants 30-34 weeks' gestational age
<b>Exclusion criteria</b>	<p>Infants with a major congenital anomaly</p> <p>Infants born before 30 weeks</p>
<b>Sample characteristics</b>	<p><b>Sample size</b> 2192 infants</p> <p><b>Female</b> No PPROM or chorioamnionitis: 48%; PPROM but no chorioamnionitis: 48%; Chorioamnionitis: 46%</p> <p><b>Birth weight (median, IQR)</b> No PPROM or chorioamnionitis: 1,960g (1,618–2,250); PPROM but no chorioamnionitis: 2,045g (1,710–2,240); Chorioamnionitis: 1,985g (1,720–2,195)</p> <p><b>Proven or suspected EOS</b> No PPROM or chorioamnionitis: 5.4%; PPROM but no chorioamnionitis: 5.5%; Chorioamnionitis: 24.6%</p>
<b>Prognostic factors</b>	<p><b>Chorioamnionitis</b> defined as maternal temperature <math>\geq 38^{\circ}\text{C}</math> during labor, the presence of two or more clinical findings (maternal tachycardia, uterine tenderness, leukocytosis, malodorous amniotic fluid, or fetal tachycardia), and notation of chorioamnionitis by the obstetrician.</p>
<b>Reference Factor (s)</b>	<p>Early onset sepsis</p> <p>Proven or suspected</p>

### Study arms

#### Moderately preterm neonates born to mothers with chorioamnionitis (N = 2192)

Clinical chorioamnionitis: maternal temperature  $> 38^{\circ}\text{C}$  during labor, the presence of two or more clinical findings (maternal tachycardia, uterine tenderness, leukocytosis, malodorous amniotic fluid, or fetal

tachycardia), and notation of chorioamnionitis by the obstetrician. Histological chorioamnionitis not recorded  
Early onset sepsis: Proven (isolation of a pathogen from blood or cerebrospinal fluid culture samples drawn within 72 hours of delivery) or clinically suspected. Babies with clinically suspected infection had: (1) sterile cultures; (2) with at least one clinical sign of infection, including tachypnea, temperature instability, lethargy, or feeding intolerance; and (3) antibiotic therapy for >5 days Multivariate model used for analysis. Factors adjusted for in the model not stated

## **Risk of bias**

Study participation

### ***Summary Study participation***

Low risk of bias

Study Attrition

### ***Study Attrition Summary***

Low risk of bias

Prognostic factor measurement

### ***Prognostic factor Measurement Summary***

Moderate risk of bias

(Retrospective study so diagnosis of chorioamnionitis and early onset infection based on medical record)

Outcome Measurement

### ***Outcome Measurement Summary***

Moderate risk of bias

(Diagnosis of suspected infection based on clinician's decision rather than objective test results)

Study Confounding

### ***Study Confounding Summary***

Low risk of bias

Statistical Analysis and Reporting

### ***Statistical Analysis and Presentation Summary***

Moderate risk of bias

(Unclear what factors were adjusted for in multivariate model)

Overall risk of bias and directness

**Risk of Bias**

High

(Retrospective study so diagnosis of chorioamnionitis based on medical record and diagnosis of suspected infection based on clinician's decision rather than objective test results. Unclear what factors were adjusted for in multivariate model)

**Directness**

Directly applicable

**Ronnestad, 2005**

**Bibliographic Reference** Ronnestad, Arild; Abrahamsen, Tore G; Medbo, Sverre; Reigstad, Hallvard; Lossius, Kristin; Kaaresen, Per I; Engelund, Inger E; Irgens, Lorentz M; Markestad, Trond; Septicemia in the first week of life in a Norwegian national cohort of extremely premature infants.; Pediatrics; 2005; vol. 115 (no. 3); e262-8

**Study Characteristics**

<b>Study design</b>	Prospective cohort study
<b>Study details</b>	Study location Norway
	Study setting 21 Norwegian neonatal units
	Study dates Not reported
	Duration of follow-up First week of life
	Sources of funding Research Council of Norway and the Norwegian Foundation for Health and Rehabilitation
<b>Inclusion criteria</b>	Birth weight <1000 g or gestational age 22+0 - 27+6 weeks (extremely premature infants)
<b>Exclusion criteria</b>	None reported
<b>Sample characteristics</b>	Sample size 462
	Birth weight (g) (median, IQR)

	<p>Very early onset sepsis: 780 (675-855); Early onset sepsis: 720 (630-841)</p> <p><b>Gestational age (weeks) (median, IQR)</b>          Very early onset sepsis: 25 (25-27); Early onset sepsis: 27 (26-28)</p> <p><b>Maternal age (years) (median, IQR)</b>          Very early onset sepsis: 35 (30-37); Early onset sepsis: 28 (24-35)</p>
<b>Prognostic factors</b>	<p>Chorioamnionitis</p> <p>Gestational age  <math>\leq 25</math> vs <math>\geq 26</math> weeks</p>
<b>Reference Factor (s)</b>	<p>Early onset infection          The growth of bacteria or fungi in blood cultures in conjunction with clinical signs of systemic infection</p>

### Study arms

#### Extremely premature infants (N = 462)

Extremely premature infants with/without neonatal infection. Neonatal infection - Very early onset: septicemia diagnosed within 24 hours after delivery. Early onset: septicemia diagnosed between 2 and 7 days of age (septicemia = growth of bacteria or fungi in blood cultures in conjunction with clinical signs of systemic infection) Multivariate logistic regression model used to examine association between risk factors and early onset infection. Model adjusted for potential confounders (gestational age)

### Risk of bias

Study participation

#### **Summary Study participation**

Low risk of bias

Study Attrition

#### **Study Attrition Summary**

Low risk of bias

Prognostic factor measurement

#### **Prognostic factor Measurement Summary**

Moderate risk of bias

(Prognostic factors not clearly defined)

Outcome Measurement

#### **Outcome Measurement Summary**

Low risk of bias

Study Confounding

***Study Confounding Summary***

Low risk of bias

Statistical Analysis and Reporting

***Statistical Analysis and Presentation Summary***

Low risk of bias

Overall risk of bias and directness

***Risk of Bias***

Moderate

(Prognostic factors not clearly defined. Included a model designed to reduce the number of variables included in multivariate analysis)

***Directness***

Directly applicable

**Soraisham, 2009**

**Bibliographic Reference** Soraisham, Amuchou S; Singhal, Nalini; McMillan, Douglas D; Sauve, Reg S; Lee, Shoo K; Canadian Neonatal, Network; A multicenter study on the clinical outcome of chorioamnionitis in preterm infants.; American journal of obstetrics and gynecology; 2009; vol. 200 (no. 4); 372e1-6

**Study Characteristics**

<b>Study design</b>	Retrospective cohort study
<b>Study details</b>	Study location Canada
	Study setting 24 tertiary neonatal intensive care units
	Study dates January 2005 - December 2006
	Duration of follow-up First 48 hours after birth for early onset infection

	Sources of funding None reported
<b>Inclusion criteria</b>	All singleton infants with birth gestational age <33 weeks No congenital anomalies
<b>Exclusion criteria</b>	None reported
<b>Sample characteristics</b>	Sample size 3094  Female Chorioamnionitis: 51%; No chorioamnionitis: 46%  Gestational age (weeks) (mean, SD) Chorioamnionitis: 27.7 (2.7); No chorioamnionitis: 29.1 (2.4)  Birth weight (g) (mean, SD) Chorioamnionitis: 1174 (439); No chorioamnionitis: 1347 (460)
<b>Prognostic factors</b>	Chorioamnionitis Inflammation of amnion and chorion
<b>Reference Factor (s)</b>	Early onset infection Positive single-organism cultures from blood or cerebrospinal fluid that were obtained from an infant with signs or risk factors for sepsis during the first 48 hours after birth

### Study arms

#### Singleton babies with gestational age <33 weeks (N = 3094)

Singleton babies with gestational age <33 weeks with or without neonatal infection. Early onset neonatal infection: positive single-organism cultures from blood or cerebrospinal fluid that were obtained from an infant with signs or risk factors for sepsis during the first 48 hours after birth. Chorioamnionitis: Inflammation of amnion and chorion. The diagnosis of chorioamnionitis was made by the attending obstetrician, based on the presence of accepted clinical signs which included foul-smelling amniotic fluid, maternal fever during labor, uterine tenderness (without another cause), fetal tachycardia, and maternal leukocytosis. Multivariate logistic analysis used to examine association between chorioamnionitis and neonatal infection. Model adjusted for gestational age, birthweight, vaginal delivery, antenatal steroid and maternal hypertension, Apgar score at 5 minutes and illness severity.

### Risk of bias

Study participation

**Summary Study participation**

Low risk of bias

Study Attrition

**Study Attrition Summary**

Low risk of bias

Prognostic factor measurement

***Prognostic factor Measurement Summary***

Moderate risk of bias

(Retrospective study so chorioamnionitis based on clinical judgement which could be subjective)

Outcome Measurement

***Outcome Measurement Summary***

Low risk of bias

Study Confounding

***Study Confounding Summary***

Low risk of bias

Statistical Analysis and Reporting

***Statistical Analysis and Presentation Summary***

Low risk of bias

Overall risk of bias and directness

***Risk of Bias***

Moderate

(Retrospective study so chorioamnionitis based on clinical judgement which could be subjective)

***Directness***

Directly applicable

## D.3 Additional studies

Studies that did not meet the inclusion criteria but were considered by the committee

**Pettinger, 2019**

**Bibliographic Reference** Pettinger, K.J.; Mayers, K; McKechnie, L; Phillips, B; Sensitivity of the Kaiser Permanente early-onset sepsis calculator: A systematic review and meta-analysis.; EClinicalMedicine; 2019

#### Study Characteristics

<b>Study design</b>	Systematic review
<b>Summary</b>	A systematic review of various studies evaluating the accuracy of the neonatal sepsis calculator. Compared the number of babies with early-onset infection who were not picked up by the calculator but would have been identified by the 2012 NICE guidelines.
<b>Outcomes</b>	Proportion of the missed cases of early-onset infection from the neonatal sepsis calculator compared to the NICE guidelines: <ul style="list-style-type: none"> <li>• Best case scenario (babies where confirmed diagnosis of neonatal infection was unclear are treated as if they were not missed by the calculator)</li> <li>• Worst case scenario (babies where confirmed diagnosis of neonatal infection was unclear are treated as if they were missed by the calculator)</li> </ul>
<b>Results</b> Proportion (95% CI)	<ul style="list-style-type: none"> <li>• Best case: 0.19 (0.11 – 0.29)</li> <li>• Worst case: 0.31 (0.17 – 0.49)</li> </ul>
<b>Reason for exclusion from the review</b>	<ul style="list-style-type: none"> <li>• Insufficient information provided to calculate the sensitivity and specificity of the tools</li> </ul>

### Morris, 2020

**Bibliographic Reference** Morris, R.; Jones, S; Banerjee, S; et al.; Comparison of the management recommendations of the Kaiser Permanente neonatal early-onset sepsis risk calculator (SRC) with NICE guideline CG149 in infants ≥34 weeks' gestation who developed early-onset sepsis; Arch Dis Child Fetal Neonatal Ed; 2020

#### Study Characteristics

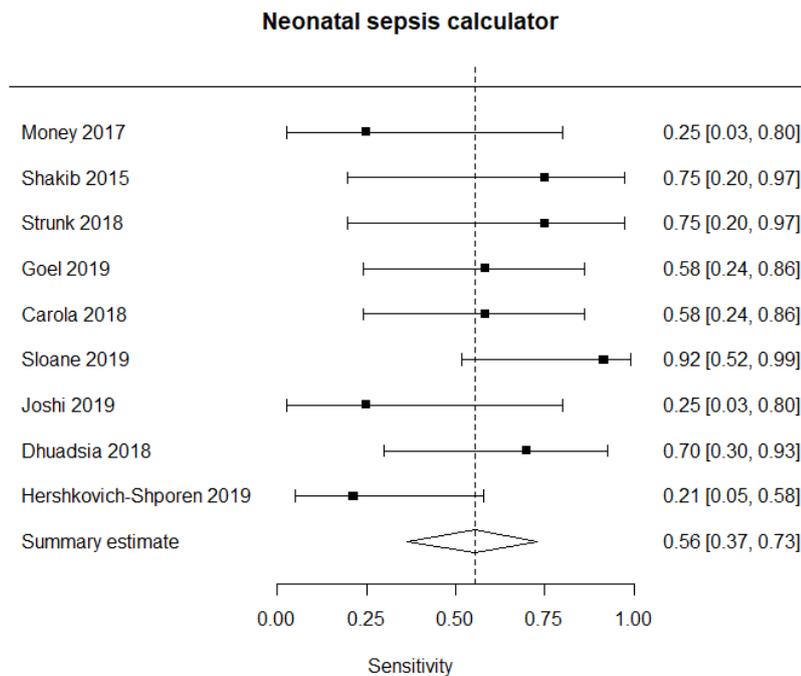
<b>Study design</b>	Retrospective cohort study
<b>Summary</b>	A review of clinical notes from 5 hospital sites in England and Wales between 2008-2017. The neonatal sepsis calculator and 2012 NICE guideline recommendations were retrospectively applied to babies in all sites based on information in clinical notes taken 4 hours after birth.
<b>Outcomes</b>	<ul style="list-style-type: none"> <li>• Number of babies recommended antibiotic treatment by the NICE guidelines but not by the neonatal sepsis calculator</li> <li>• Number of babies recommended antibiotic treatment by the neonatal sepsis calculator but not by the NICE guidelines</li> <li>• Sensitivity</li> </ul>
<b>Results</b>	<ul style="list-style-type: none"> <li>• Number of babies recommended antibiotic treatment by the NICE guidelines but not by the neonatal sepsis calculator: 12</li> </ul>

	<ul style="list-style-type: none"><li>• Number of babies recommended antibiotic treatment by the neonatal sepsis calculator but not by the NICE guidelines: 0</li><li>• Sensitivity: NICE guidelines – 54%; Neonatal sepsis calculator – 37.5%</li></ul>
<b>Reason for exclusion from the review</b>	<ul style="list-style-type: none"><li>• Insufficient information provided to calculate the specificity of the tools</li><li>• Only included babies with culture-confirmed infection</li></ul>

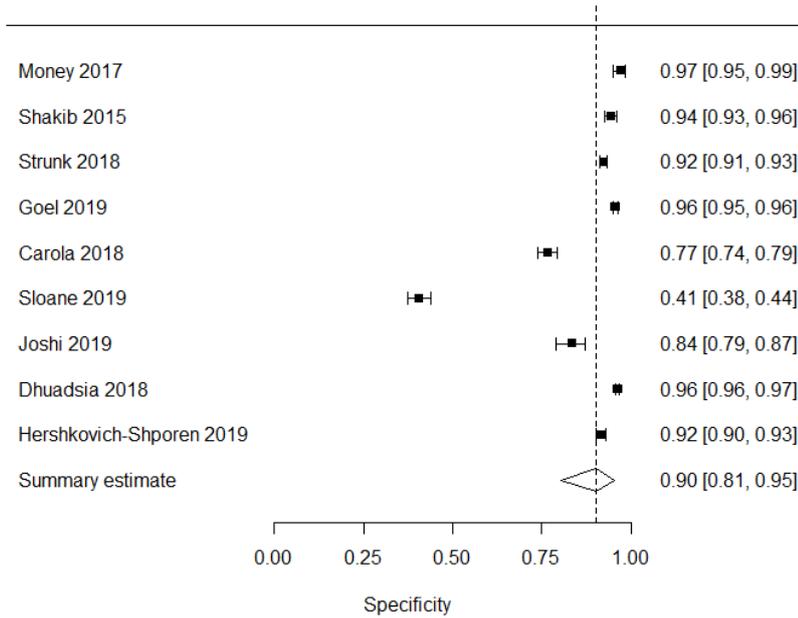
## Appendix E – Forest plots

### Kaiser Permanente early-onset neonatal sepsis calculator: number of babies recommended antibiotic treatment and blood culture

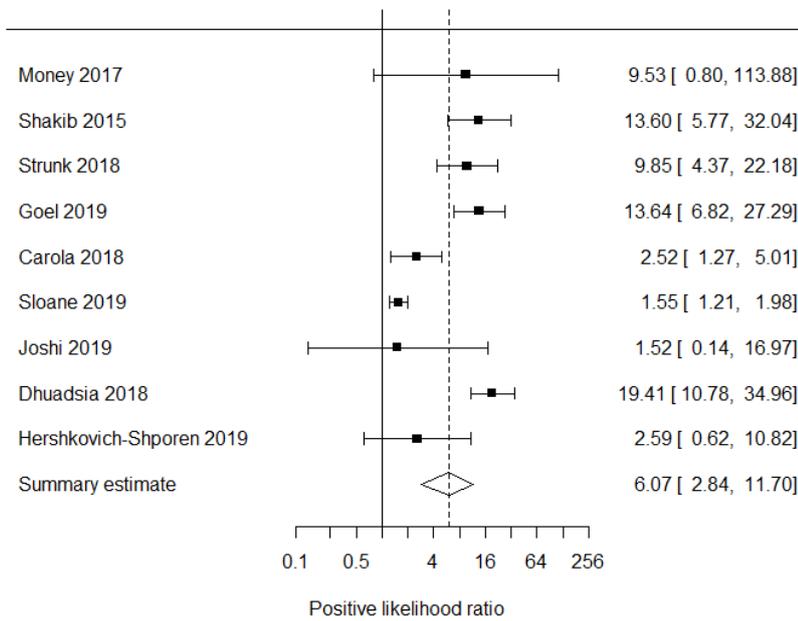
#### Overall analysis (all studies)



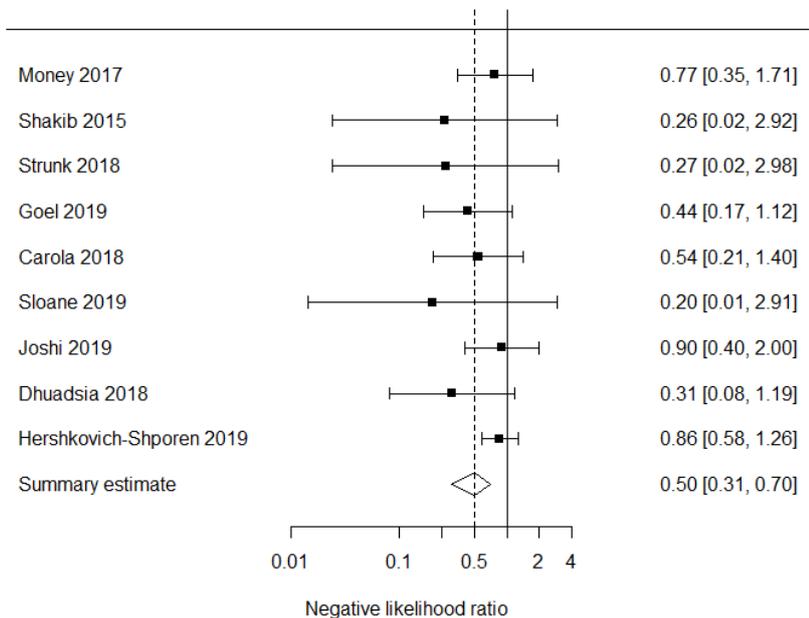
**Neonatal sepsis calculator**



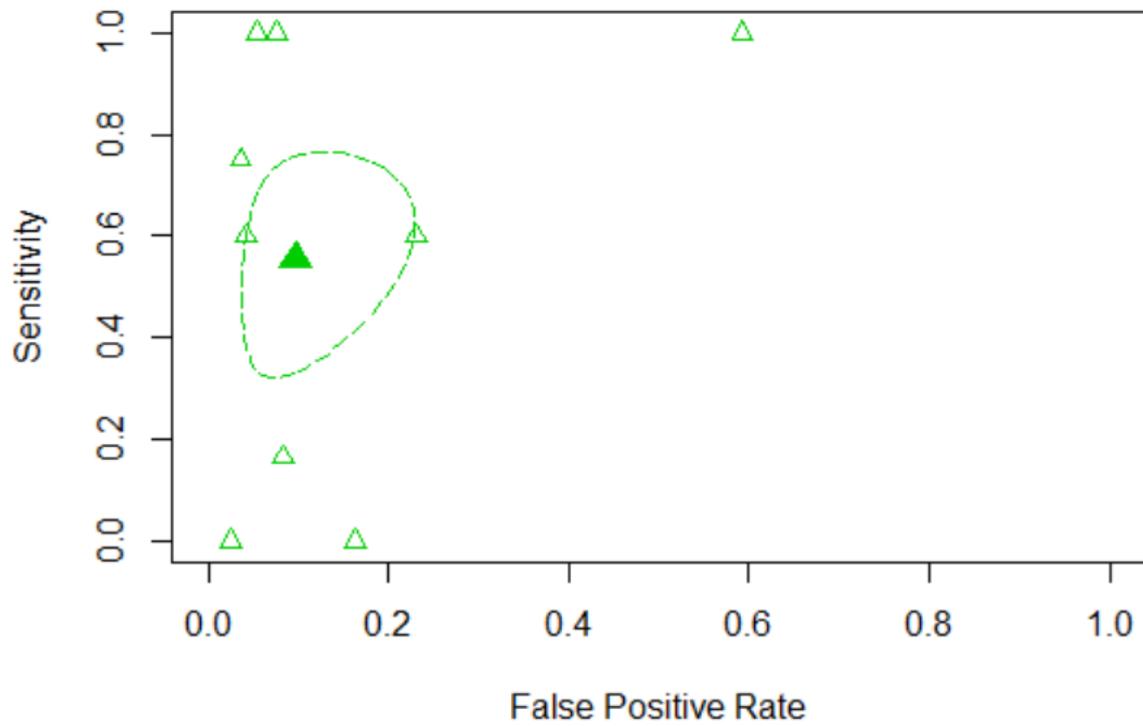
**Neonatal sepsis calculator**



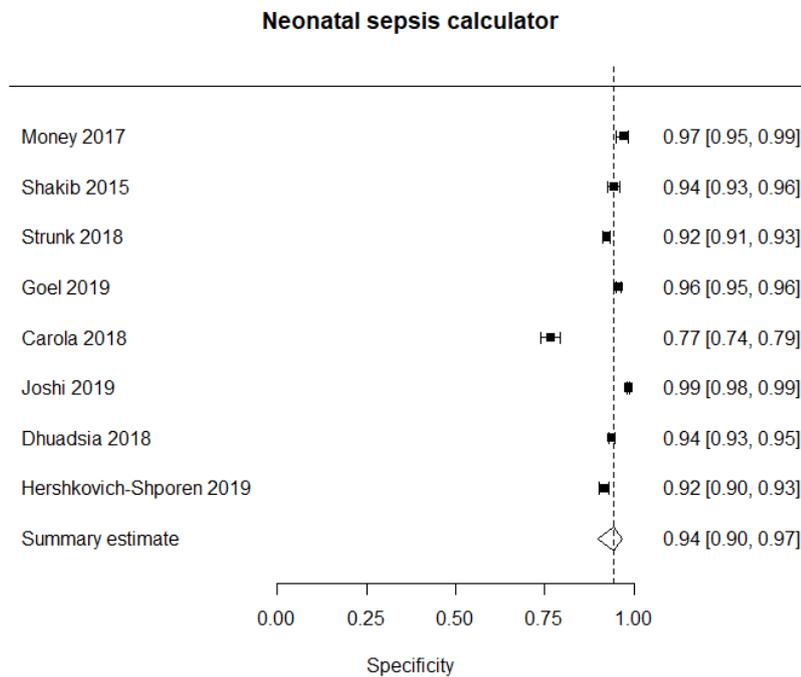
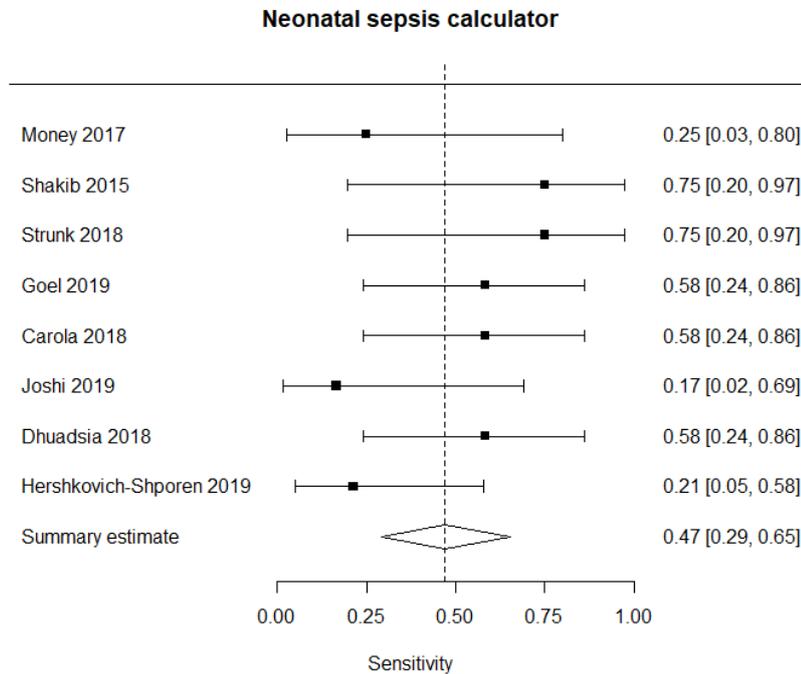
Neonatal sepsis calculator

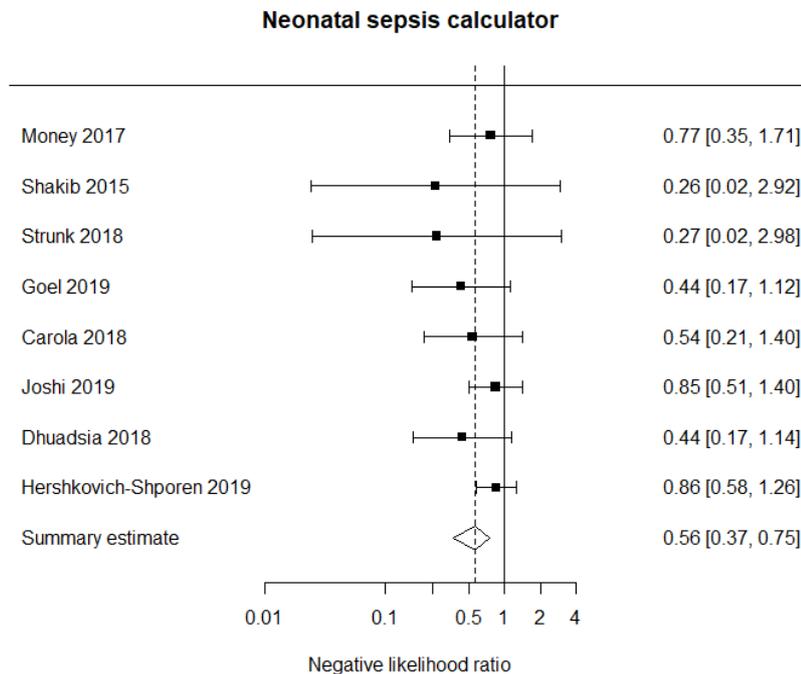
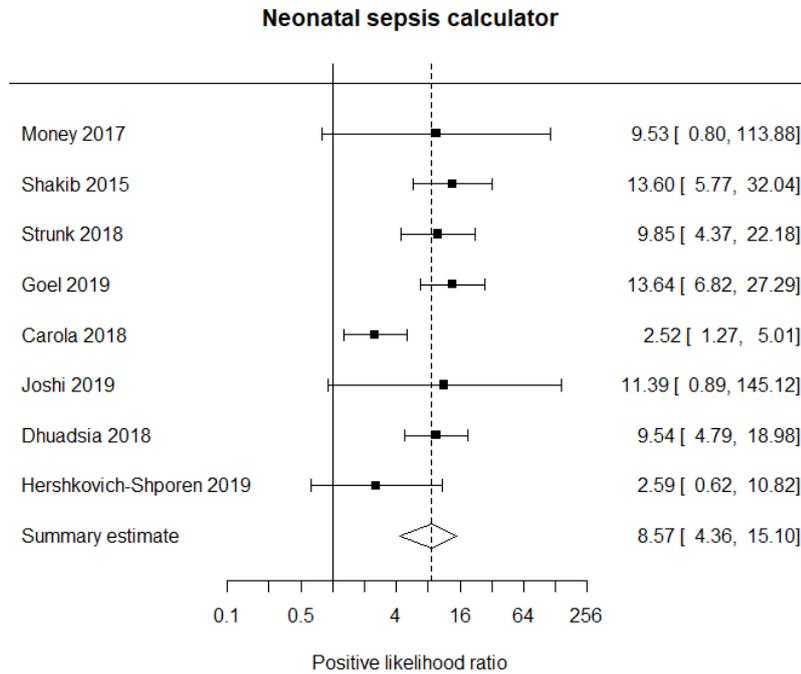


### Neonatal sepsis Calculator



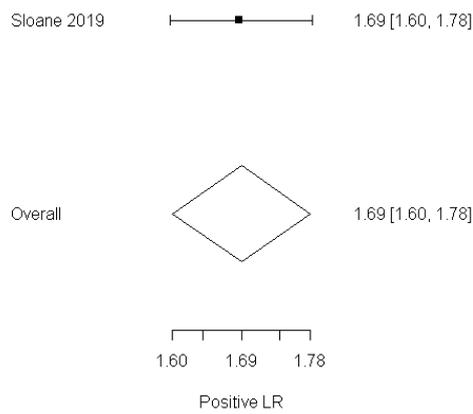
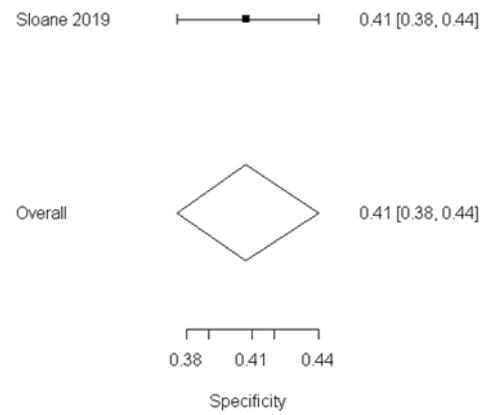
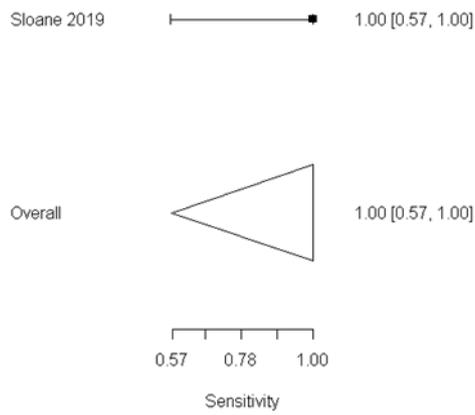
**Subgroup analysis: lower baseline incidence of sepsis (0.44-0.6/1000 live births)**



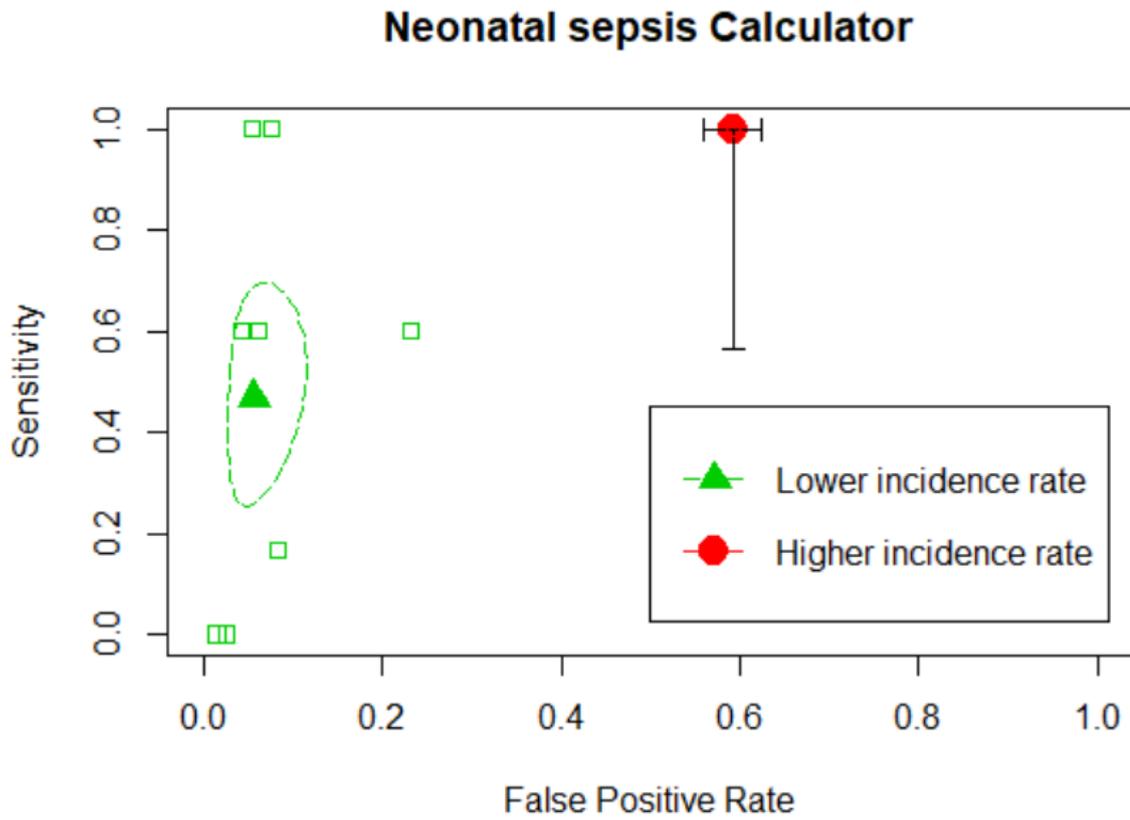


**Subgroup analysis: higher baseline incidence of sepsis (4.0/1000 live births)**

**Neonatal sepsis calculator**

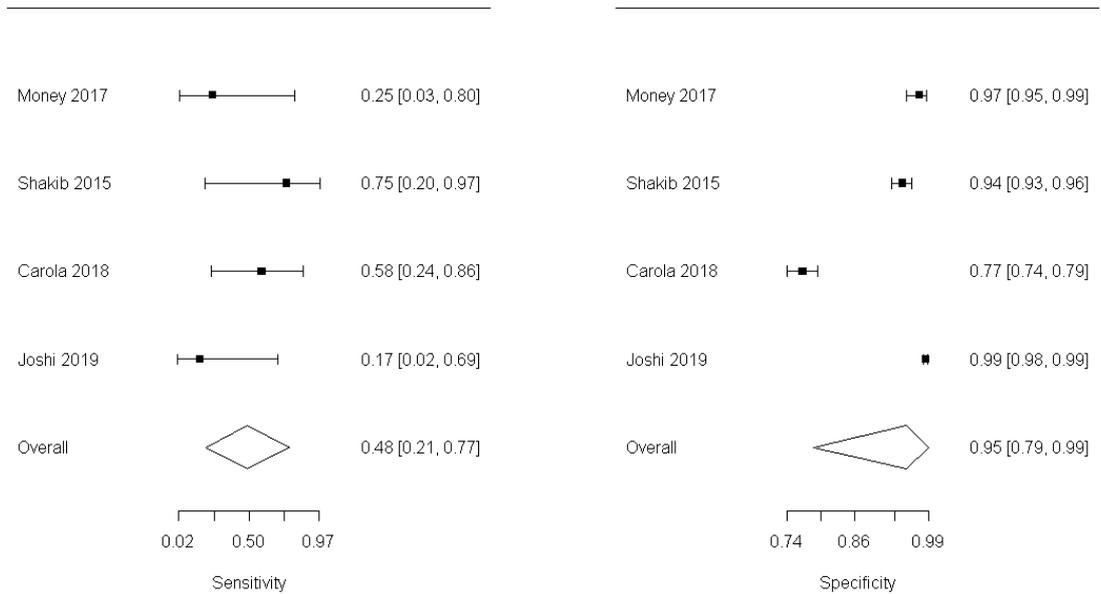


Negative LR not calculable

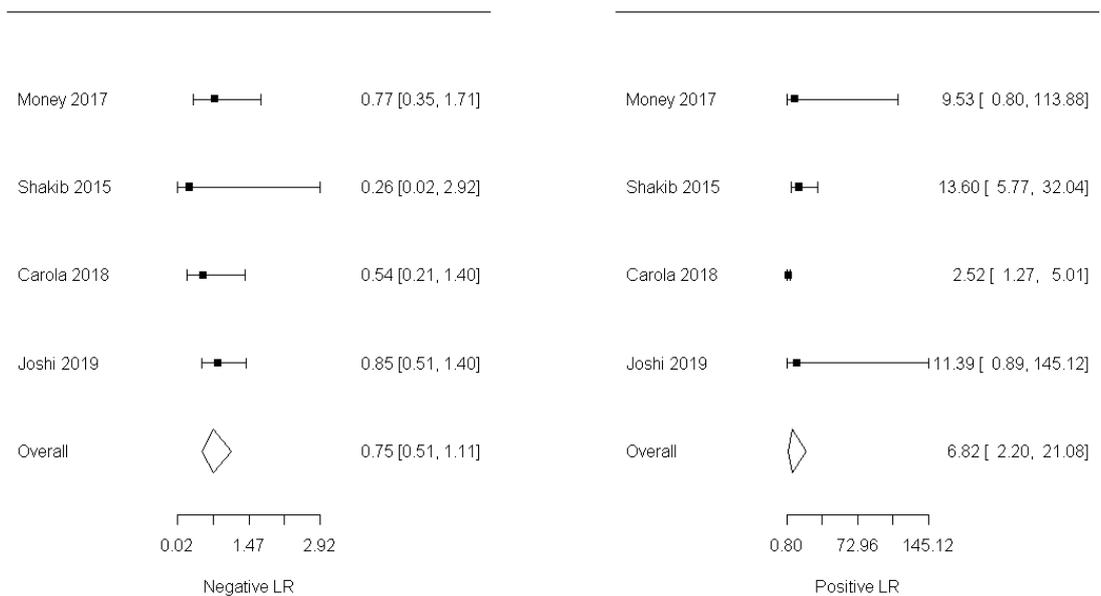


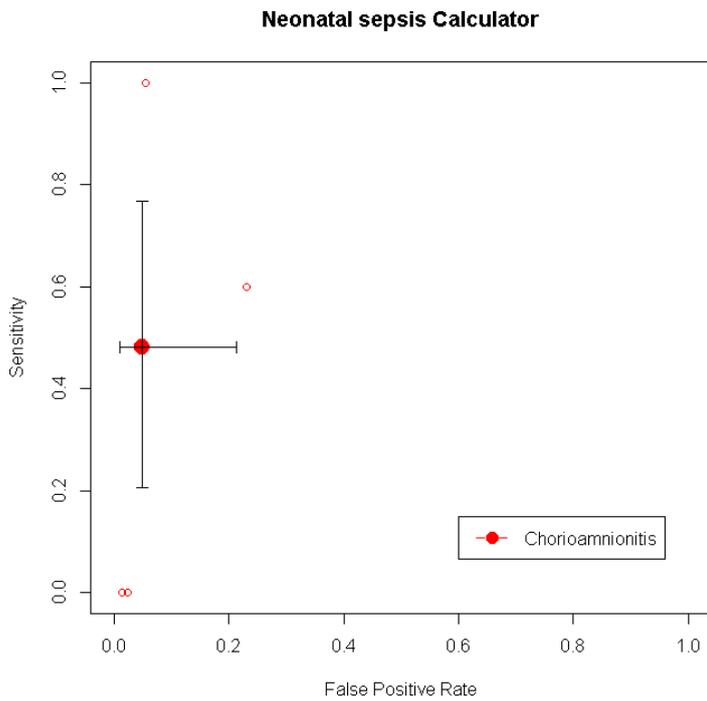
**Subgroup analysis: babies born to mothers with chorioamnionitis**

**Neonatal sepsis calculator**

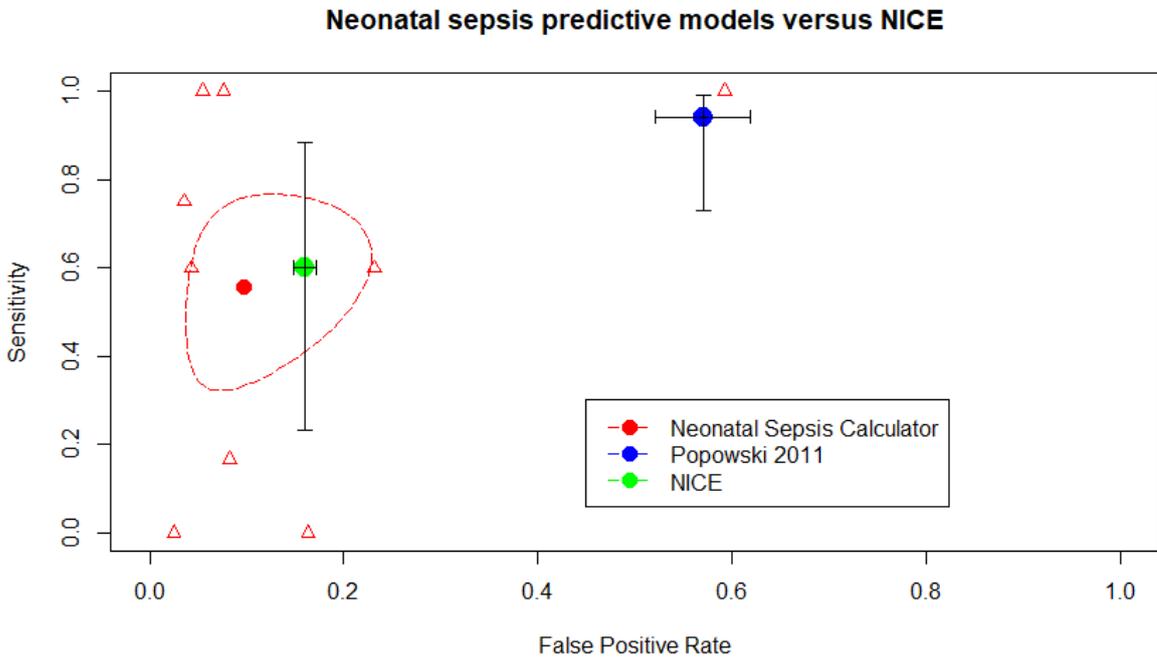


**Neonatal sepsis calculator**



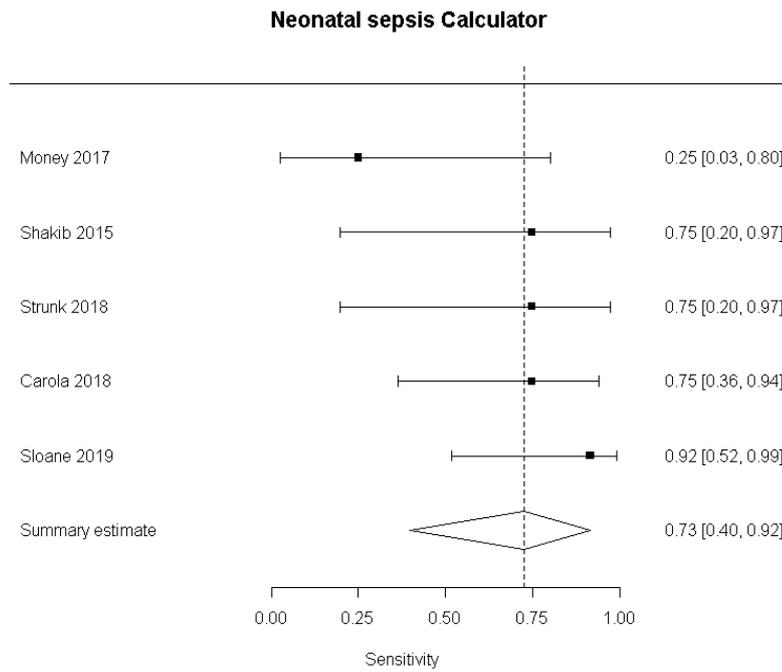


### Comparison to standard care

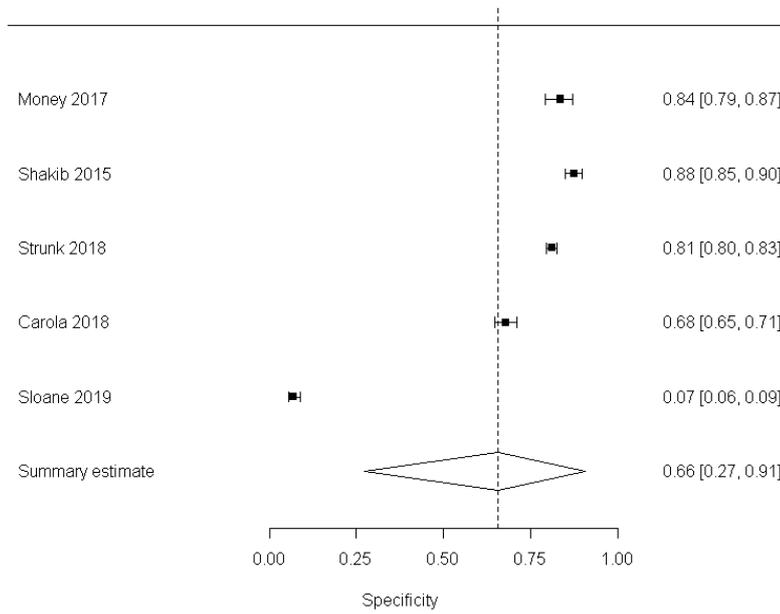


**Kaiser Permanente early-onset neonatal sepsis calculator: number of babies recommended either antibiotic treatment and blood culture or blood culture and vital sign monitoring every 4 hours**

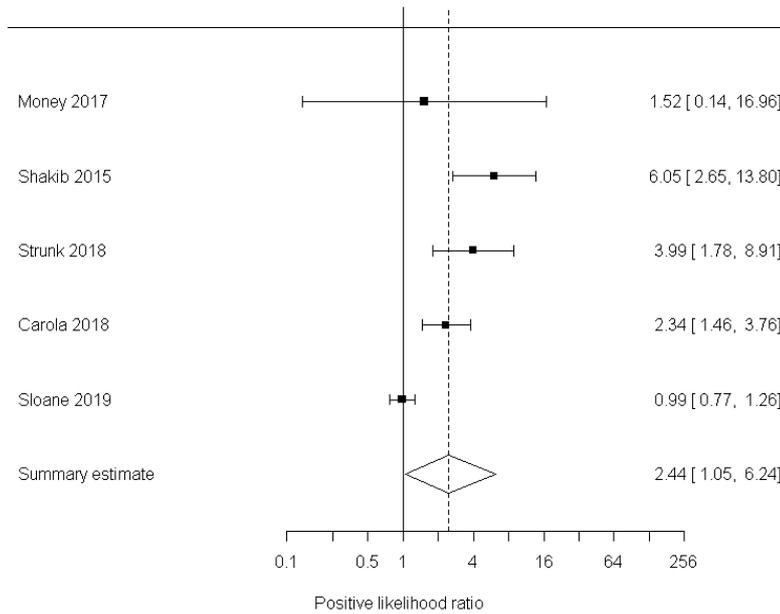
**Overall analysis (all studies)**



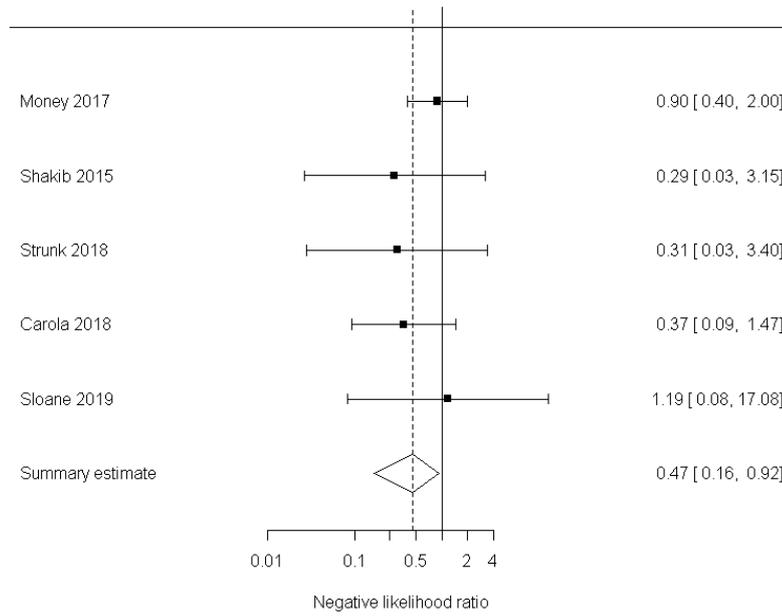
**Neonatal sepsis Calculator**



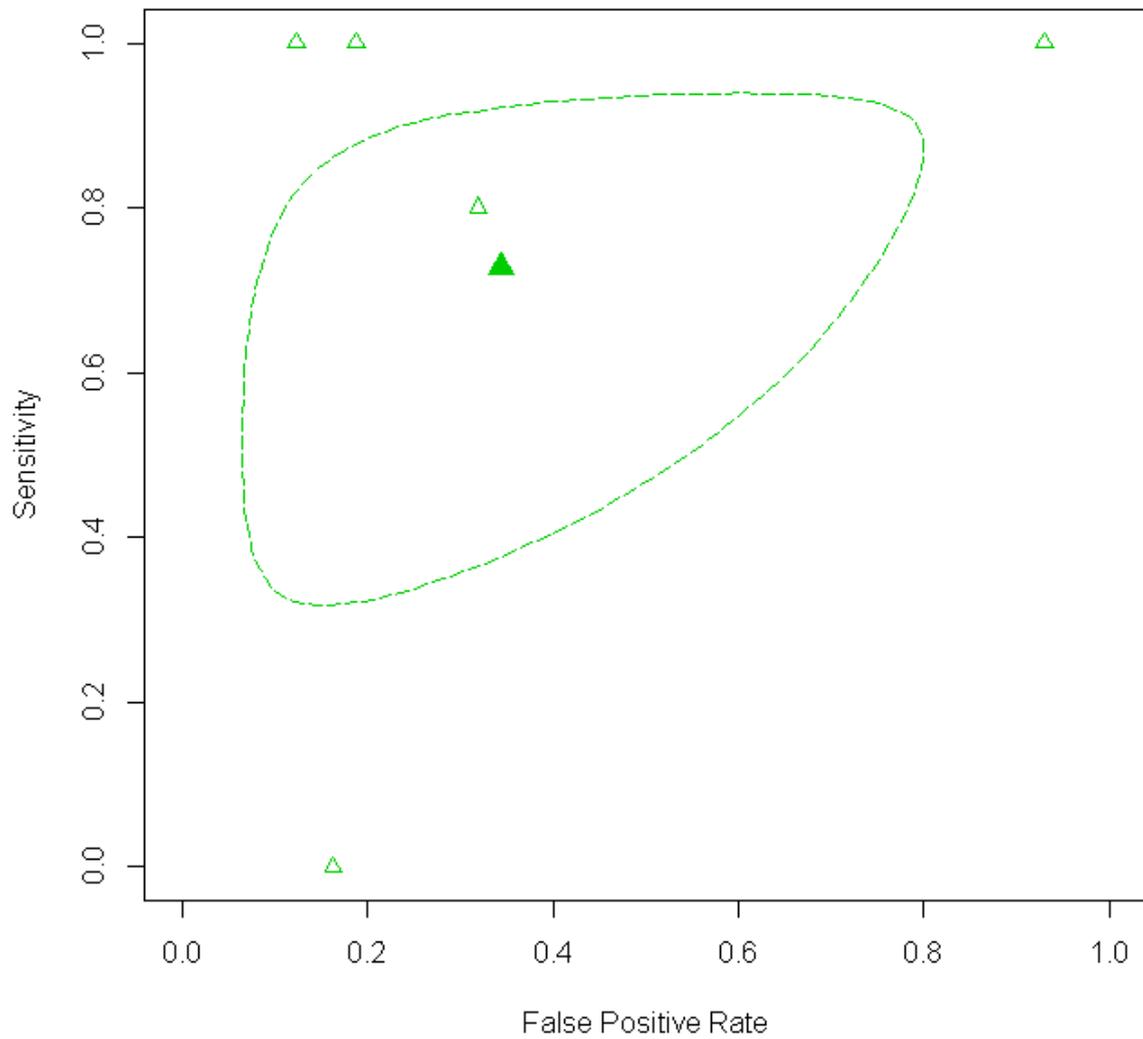
**Neonatal sepsis Calculator**



**Neonatal sepsis Calculator**

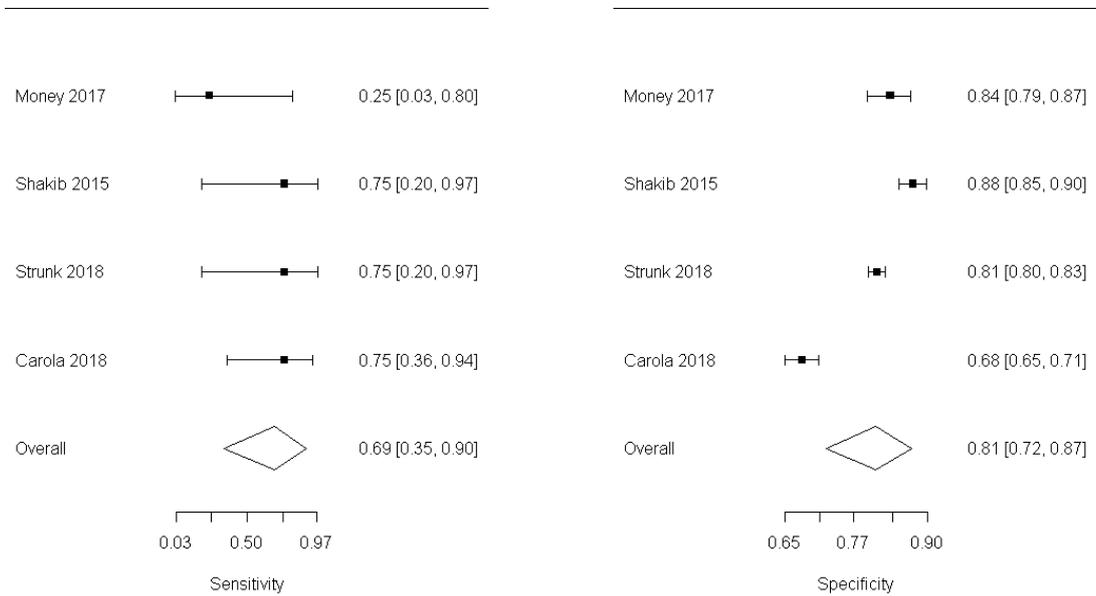


### Neonatal sepsis Calculator

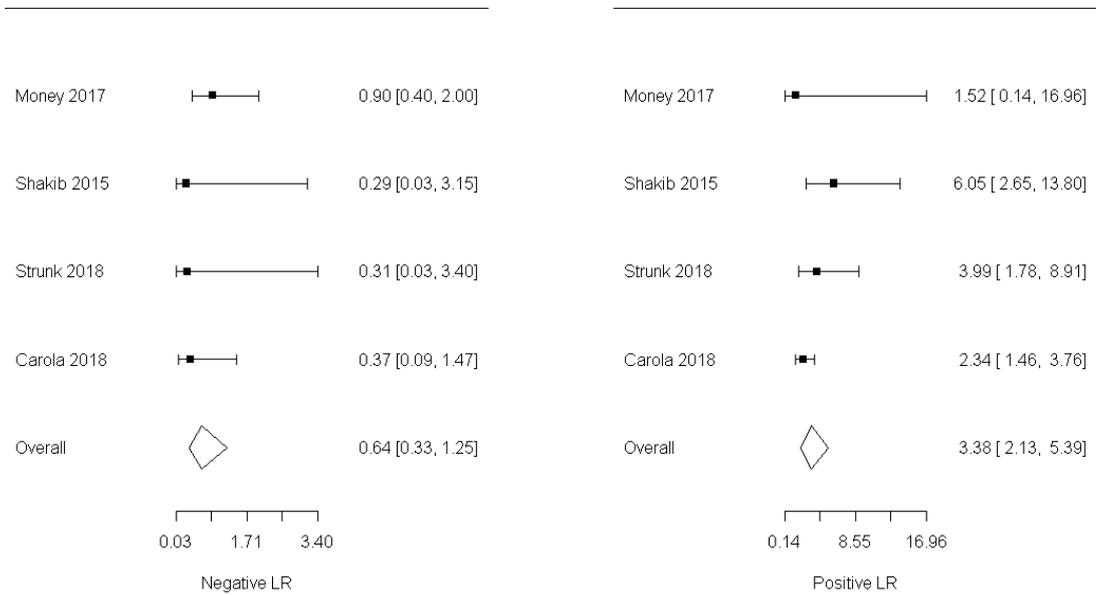


**Subgroup analysis: lower baseline incidence of sepsis (0.44-0.5/1000 live births)**

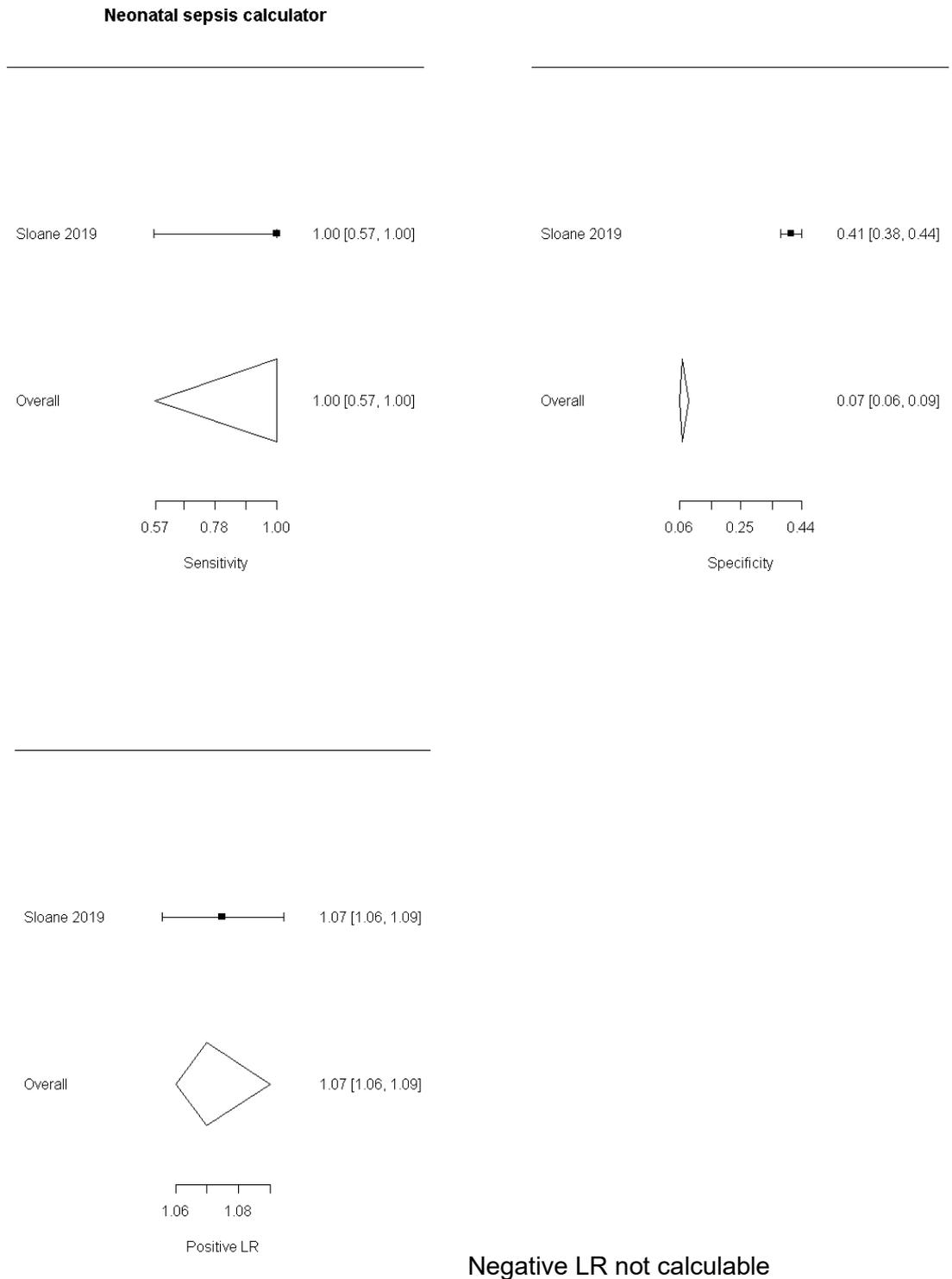
**Neonatal sepsis calculator**



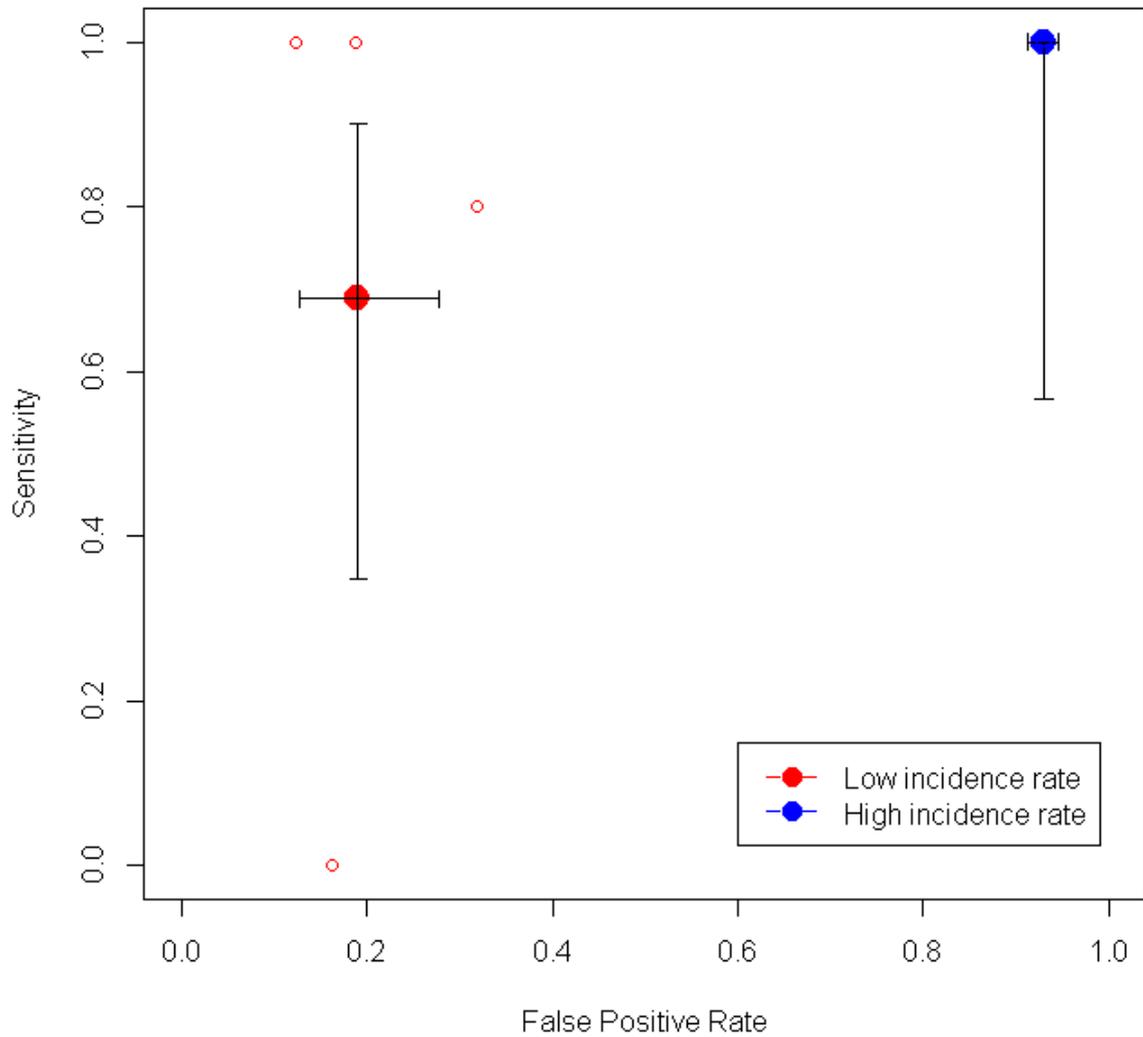
**Neonatal sepsis calculator**



**Subgroup analysis: higher baseline incidence of sepsis (4/1000 live births)**

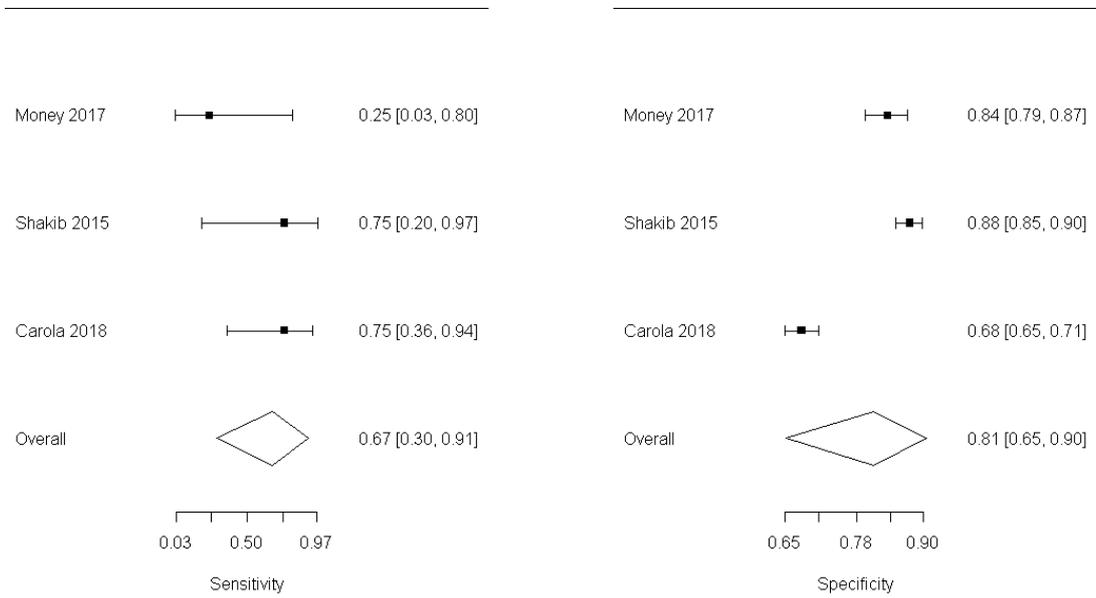


### Neonatal sepsis Calculator

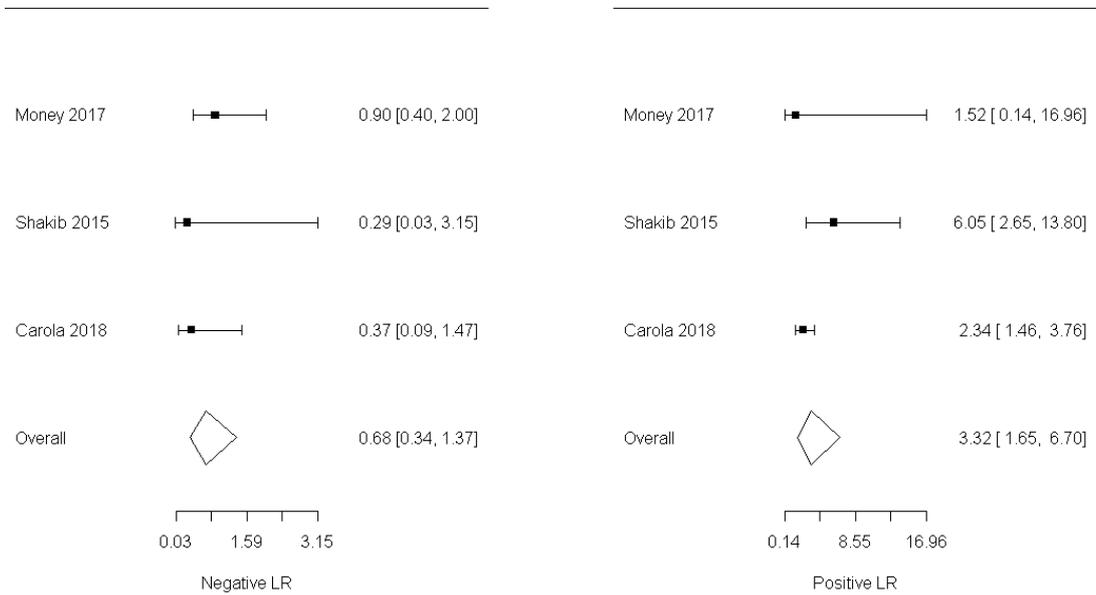


**Subgroup analysis: babies born to mothers with chorioamnionitis**

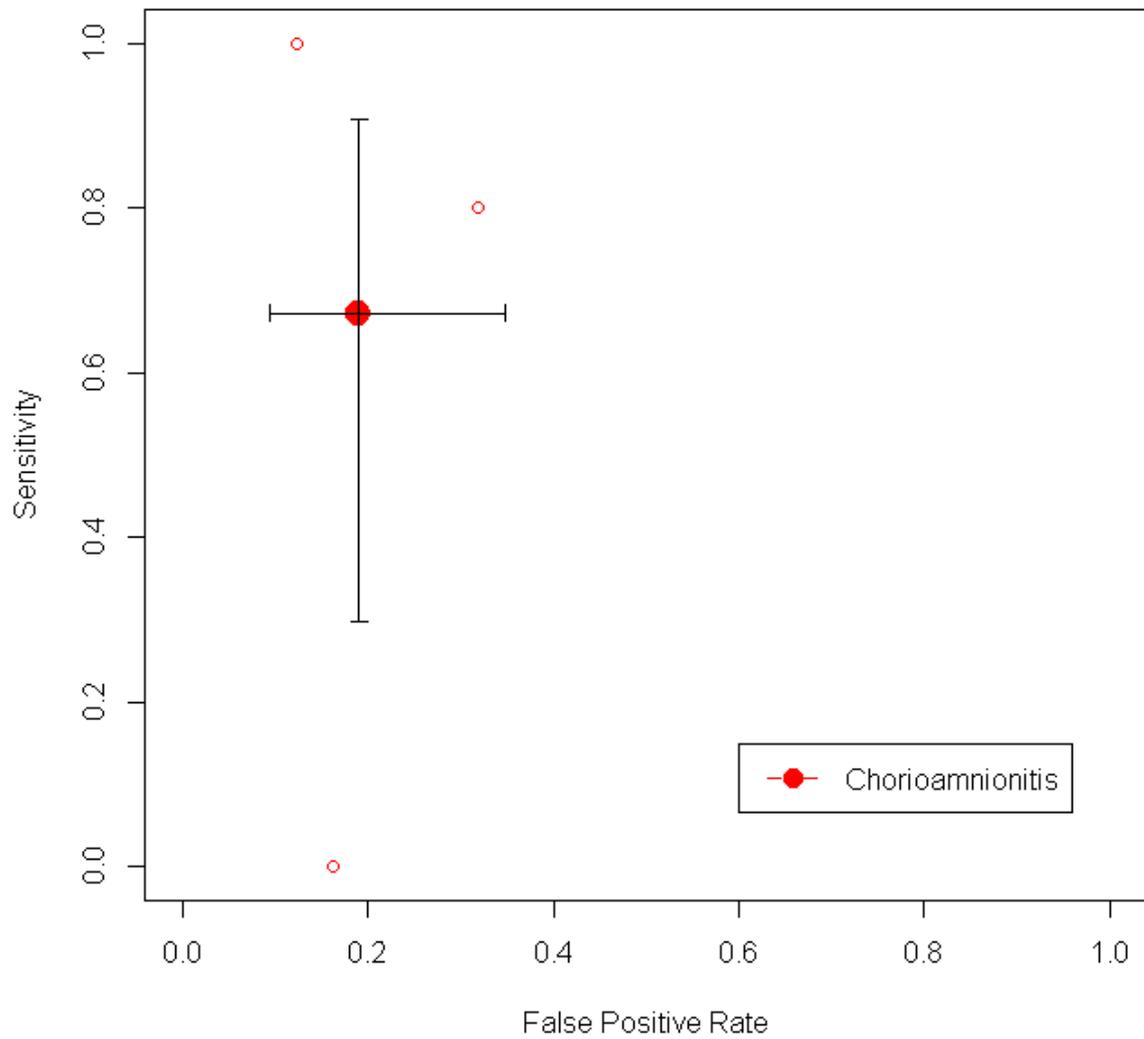
**Neonatal sepsis calculator**



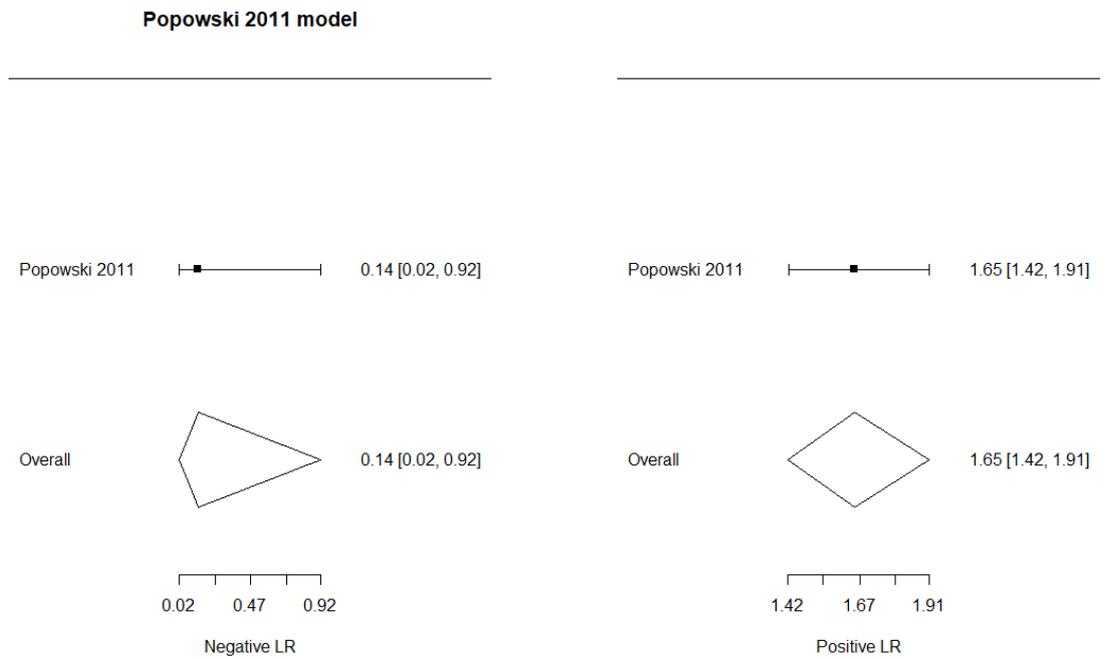
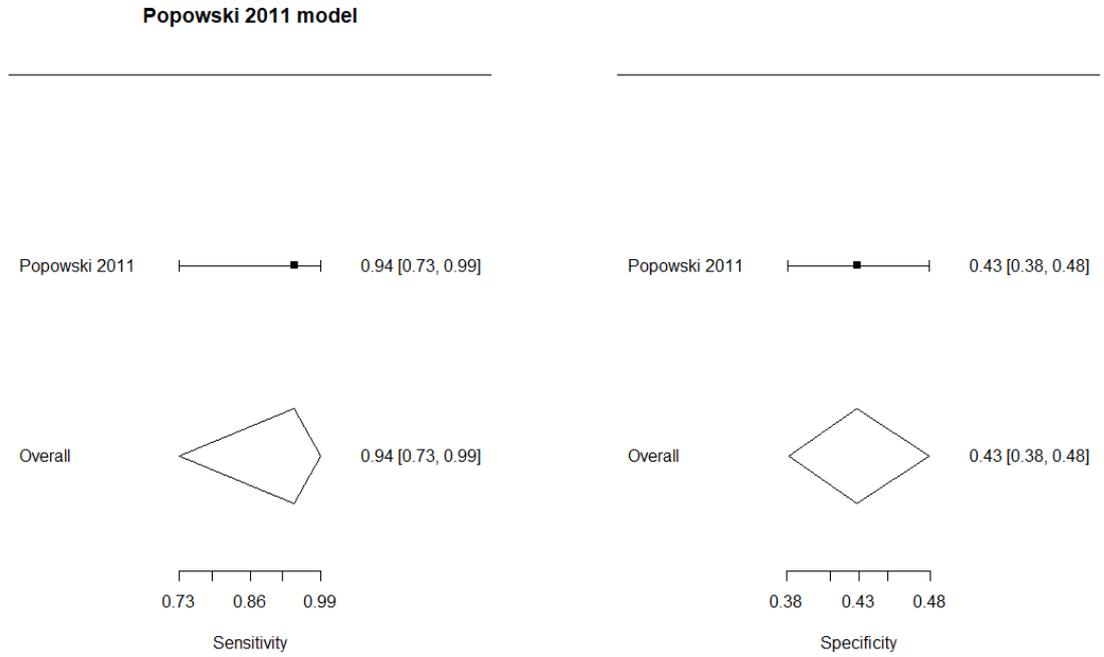
**Neonatal sepsis calculator**

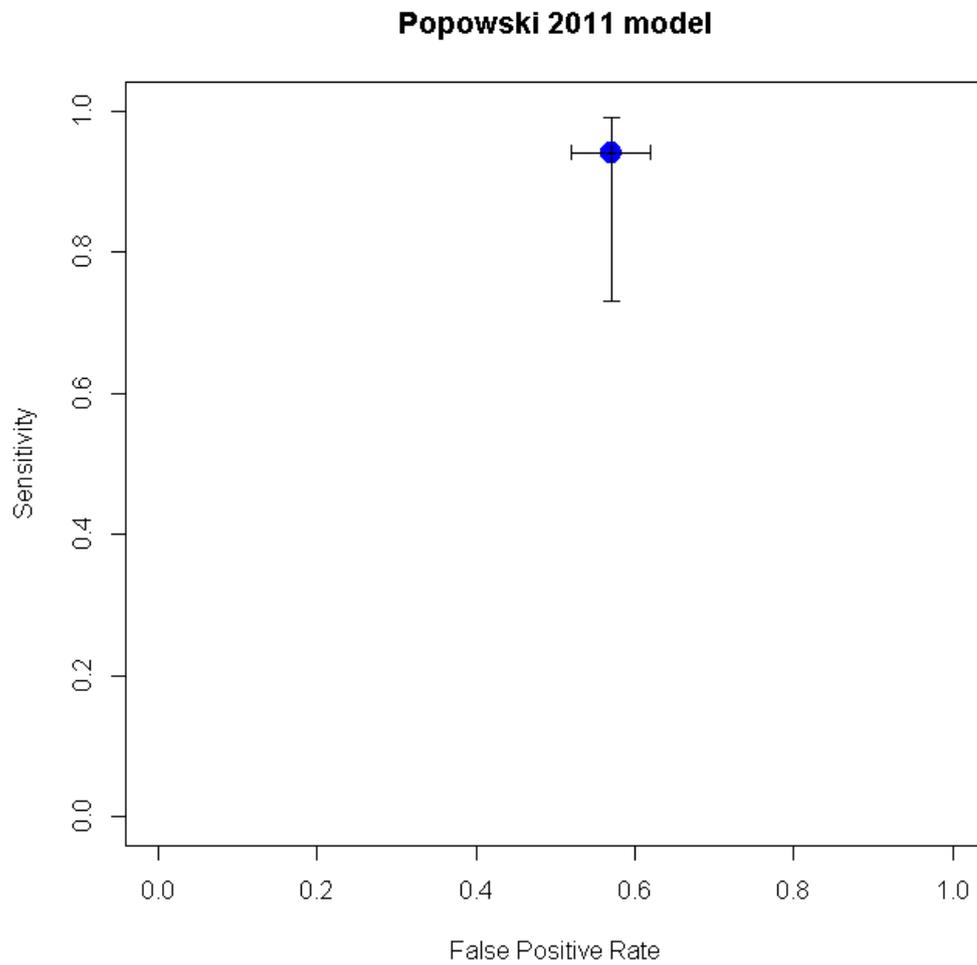


### Neonatal sepsis Calculator



**Popowski 2011 model – mothers with premature rupture of membranes (based on C-reactive protein and white blood cell count)**





## Appendix F – GRADE tables

### F.1 Clinical prediction models

Kaiser Permanente early-onset neonatal sepsis calculator: number of babies recommended antibiotic treatment and blood culture

#### Sensitivity, specificity and likelihood ratios

No. of studies	Study design	Sample size	Sensitivity (95%CI)	Specificity (95%CI)	Effect size (95%CI)	Risk of bias	Indirectness	Inconsistency	Imprecision	Quality
Overall analysis (all studies)										
9	Cohort studies (5 prospective, 4 retrospective)	16697	0.56 (0.37, 0.73)	0.90 (0.81, 0.95)	LR+ 6.07 (2.84, 11.70)	Serious <sup>7</sup>	Serious <sup>8</sup>	Very serious <sup>1</sup>	Not serious	Very low
					LR- 0.50 (0.31, 0.70)	Serious <sup>7</sup>	Serious <sup>8</sup>	Not serious	Serious <sup>3</sup>	Very low
Subgroup analysis: lower baseline incidence of sepsis (0.44-0.6/1000 live births)										
8	Cohort studies (5 prospective, 3 retrospective)	16583	0.47 (0.29, 0.65)	0.94 (0.90, 0.97)	LR+ 8.57 (4.36, 15.10)	Serious <sup>7</sup>	Serious <sup>8</sup>	Very serious <sup>1</sup>	Not serious	Very low
					LR- 0.56 (0.37, 0.75)	Serious <sup>7</sup>	Serious <sup>8</sup>	Not serious	Serious <sup>3</sup>	Very low
Subgroup analysis: higher baseline incidence of sepsis (4.0/1000 live births)										
1 (Sloane 2019)	Retrospective cohort study	896	1.00 (0.57, 1.00)	0.41 (0.38, 0.44)	LR+ 1.69 (1.60, 1.78)	Not serious	Serious <sup>8</sup>	N/A <sup>2</sup>	Not serious	Moderate
					LR- not calculable <sup>6</sup>	N/A <sup>5</sup>	N/A <sup>5</sup>	N/A <sup>2</sup>	N/A <sup>5</sup>	N/A <sup>5</sup>

No. of studies	Study design	Sample size	Sensitivity (95%CI)	Specificity (95%CI)	Effect size (95%CI)	Risk of bias	Indirectness	Inconsistency	Imprecision	Quality
Subgroup analysis: Babies born to mothers with chorioamnionitis										
4	Cohort studies (1 prospective, 3 retrospective)	5552	0.48 (0.21, 0.77)	0.95 (0.79, 0.99)	LR+ 6.82 (2.20, 21.08)	Serious <sup>7</sup>	Serious <sup>8</sup>	Very serious <sup>1</sup>	Not serious	Very low
					LR- 0.75 (0.51, 1.11)	Serious <sup>7</sup>	Serious <sup>8</sup>	Not serious	Very serious <sup>4</sup>	Very low

1.  $I^2 > 66.7\%$ . Quality downgraded 2 levels
2. Single study. Inconsistency not applicable
3. Negative likelihood ratio crossed 1 end of the defined MIDs (0.5 or 1). Quality downgraded 1 level
4. Negative likelihood ratio crossed both ends of the defined MIDs (0.5 and 1). Quality downgraded 2 levels
5. Negative likelihood ratio not calculable and so quality assessment of outcome is not applicable
6. All babies testing positive for infection were identified by the model. Negative likelihood ratio therefore not calculable
7.  $>33.3\%$  weight of meta-analysis at moderate risk of bias. Quality downgraded 1 level
8.  $>33.3\%$  weight of meta-analysis from partially applicable studies. Quality downgraded 1 level

**Kaiser Permanente early-onset neonatal sepsis calculator: number of babies recommended either antibiotic treatment and blood culture or blood culture and vital sign monitoring every 4 hours**

**Sensitivity, specificity and likelihood ratios**

No. of studies	Study design	Sample size	Sensitivity (95%CI)	Specificity (95%CI)	Effect size (95%CI)	Risk of bias	Indirectness	Inconsistency	Imprecision	Quality
Overall analysis (all studies)										
5	Cohort studies (1 prospective, 4 retrospective)	5354	0.73 (0.40, 0.92)	0.66 (0.27, 0.91)	LR+ 2.44 (1.05, 6.24)	Serious <sup>6</sup>	Serious <sup>10</sup>	Very serious <sup>1</sup>	Serious <sup>4</sup>	Very low
					LR- 0.47 (0.16, 0.92)					
Subgroup analysis: lower baseline incidence of sepsis (0.44-0.5/1000 live births)										
4	Cohort studies (1 prospective, 3 retrospective)	4458	0.69 (0.35, 0.90)	0.81 (0.72, 0.87)	LR+ 3.38 (2.13, 5.39)	Serious <sup>6</sup>	Serious <sup>10</sup>	Not serious	Not serious	Low
					LR- 0.64 (0.33, 1.25)					
Subgroup analysis: higher baseline incidence of sepsis (4.0/1000 live births)										
1 (Sloane 2019)	Retrospective cohort study	896	1.00 (0.57, 1.00)	0.07 (0.06, 0.09)	LR+ 1.07 (1.06, 1.09)	Not serious	Serious <sup>10</sup>	N/A <sup>3</sup>	Not serious	Moderate
					LR- <i>not calculable</i> <sup>7</sup>					
Subgroup analysis: Babies born to mothers with chorioamnionitis										
3		1956	0.67 (0.30, 0.91)	0.81 (0.65, 0.91)	LR+ 3.32 (1.65, 6.70)	Serious <sup>6</sup>	Serious <sup>10</sup>	Serious <sup>2</sup>	Serious <sup>4</sup>	Very low

No. of studies	Study design	Sample size	Sensitivity (95%CI)	Specificity (95%CI)	Effect size (95%CI)	Risk of bias	Indirectness	Inconsistency	Imprecision	Quality
	Retrospective cohort studies				LR- 0.68 (0.34, 1.37)	Serious <sup>6</sup>	Serious <sup>10</sup>	Not serious	Very serious <sup>5</sup>	Very low

1.  $I^2 > 66.7\%$ . Quality downgraded 2 levels
2.  $I^2$  between 33.3% and 66.7%. Quality downgraded 1 level
3. Single study. Inconsistency not applicable
4. Positive likelihood ratio crossed 1 end of the defined MIDs (1 or 2). Quality downgraded 1 level
5. Negative likelihood ratio crossed both ends of the defined MIDs (0.5 and 1). Quality downgraded 2 levels
6.  $>33.3\%$  weight of meta-analysis at moderate risk of bias. Quality downgraded 1 level
7. All babies testing positive for infection were identified by the model. Negative likelihood ratio therefore not calculable
8. Negative likelihood ratio crossed one end of the defined MIDs (0.5 or 1). Quality downgraded 1 level
9. Negative likelihood ratio not calculable and so quality assessment of outcome is not applicable
10.  $>33.3\%$  weight of meta-analysis from partially applicable studies. Quality downgraded 1 level

**Unnamed model – mothers with premature rupture of membranes (based on C-reactive protein and white blood cell count)**

**Sensitivity, specificity and likelihood ratios**

No. of studies	Study design	Sample size	Sensitivity (95%CI)	Specificity (95%CI)	Effect size (95%CI)	Risk of bias	Indirectness	Inconsistency	Imprecision	Quality
Overall analysis										
1 (Popowski 2011)	Prospective cohort study	399	0.94 (0.73, 0.99)	0.43 (0.38, 0.48)	LR+ 1.65 (1.42, 1.91)	Not serious	Not serious	N/A <sup>1</sup>	Not serious	High
					LR- 0.14 (0.02, 0.92)	Not serious	Not serious	N/A <sup>1</sup>	Serious <sup>2</sup>	Moderate

1. Single study. Inconsistency not applicable
2. Negative likelihood ratio crossed 1 end of the defined MIDs (0.5 or 1). Quality downgraded 1 level

**c-statistics**

No. of studies	Study design	Sample size	Effect size (95% CI)	Risk of bias	Inconsistency	Indirectness	Imprecision	Quality
1 (Popowski 2011)	Prospective cohort study	399	0.82 (0.72, 0.92)	Not serious	N/A	Not serious	Serious <sup>1</sup>	Moderate

1. 95% confidence intervals crossed 2 categories of test classification accuracy, ranging from good to outstanding accuracy (0.8 - <0.9 and 0.9 - <1.0). Quality downgraded 1 level

## Current NICE guidelines

### Sensitivity, specificity and likelihood ratios

No. of studies	Study design	Sample size	Sensitivity (95%CI)	Specificity (95%CI)	Effect size (95%CI)	Risk of bias	Indirectness	Inconsistency	Imprecision	Quality
NICE										
1 (Goel 2020)	Cohort study	3588	0.60 (0.23, 0.88)	0.84 (0.83, 0.85)	LR+ 3.8 (1.8, 7.7)	Not serious	Not serious	N/A <sup>1</sup>	Serious <sup>1</sup>	Moderate
					LR- 0.48 (0.16, 1.39)	Not serious	Not serious	N/A <sup>1</sup>	Very serious <sup>2</sup>	Low

1. Positive likelihood ratio crossed one end of the defined MIDs (1 or 2). Quality downgraded 1 level
2. Negative likelihood ratio crossed both ends of the defined MIDs (0.5 and 1). Quality downgraded 2 levels

## F.2 Maternal risk factors

### Risk factors

No. of studies	Study design	Sample size	Effect size (95%CI)	Risk of bias	Indirectness	Inconsistency	Imprecision	Quality
<b>Chorioamnionitis:</b> Histological chorioamnionitis in babies born <30 weeks' gestational age (OR >1 indicates greater risk of infection for babies born to mothers with chorioamnionitis)								
1 (Dempsey 2005)	Retrospective cohort study	392	Adjusted OR 6.9 (2.2, 20.0)	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Not serious	Moderate
<b>Chorioamnionitis:</b> Clinical chorioamnionitis in very low birth weight babies (OR/RR >1 indicates greater risk of infection for babies born to mothers with chorioamnionitis)								
1 (Garcia-Munoz 2014a)	Prospective cohort study	451	Adjusted RR 6.13 (1.67, 22.58)	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Not serious	Moderate
1 (Garcia-Munoz 2014b)	Retrospective cohort study	8330	Adjusted OR 3.10 (2.31-4.17)	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Not serious	Moderate
<b>Chorioamnionitis:</b> Clinical chorioamnionitis in preterm babies (OR >1 indicates greater risk of infection for babies born to mothers with chorioamnionitis)								
1 (Soraisham 2009)	Retrospective cohort study	3094	Adjusted OR 5.54 (2.87-10.69)	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Not serious	Moderate
<b>Chorioamnionitis:</b> Clinical chorioamnionitis in moderately preterm babies (OR >1 indicates greater risk of infection for babies born to mothers with chorioamnionitis)								
1 (Ofman 2016)	Retrospective cohort study	2192	Adjusted OR 4.1 (2.83-5.30)	Very serious <sup>4</sup>	Not serious	N/A <sup>1</sup>	Not serious	Low
<b>Chorioamnionitis:</b> Clinical chorioamnionitis in extremely preterm babies (OR >1 indicates greater risk of infection for babies born to mothers with chorioamnionitis)								

No. of studies	Study design	Sample size	Effect size (95%CI)	Risk of bias	Indirectness	Inconsistency	Imprecision	Quality
1 (Ronnestad 2005)	Prospective cohort study	451	Adjusted OR 10.5 (3.3-33.4)	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Not serious	Moderate
<b>Intrapartum fever:</b> Low febrile fever (38.0-38.9°C) in mothers of babies born at term in a singleton pregnancy (OR >1 indicates greater risk of infection for babies born to mothers with low febrile fever)								
1 (Dior 2016)	Retrospective cohort study	43,560	Adjusted OR 7.44 (3.29, 16.85)	Not serious	Not serious	N/A <sup>1</sup>	Not serious	Moderate
<b>Intrapartum fever:</b> High febrile fever (>39°C) in mothers of babies born at term in a singleton pregnancy (OR >1 indicates greater risk of infection for babies born to mothers with high febrile fever)								
1 (Dior 2016)	Retrospective cohort study	43,560	Adjusted OR 16.08 (2.15, 120.3)	Not serious	Not serious	N/A <sup>1</sup>	Not serious	Moderate
<b>Maternal obesity:</b> Overweight mothers (BMI 25-29.9) of babies born at >22 weeks' gestational age (OR >1 indicates greater risk of infection for babies born to overweight mothers)								
1 (Hakansson 2008)	Retrospective cohort study	344,127	Adjusted OR 1.3 (0.9, 2.0)	Not serious	Serious <sup>5</sup>	N/A <sup>1</sup>	Serious <sup>2</sup>	Low
<b>Maternal obesity:</b> Obese mothers (BMI 30.0) of babies born at >22 weeks' gestational age (OR >1 indicates greater risk of infection for babies born to obese mothers)								
1 (Hakansson 2008)	Retrospective cohort study	344,127	Adjusted OR 1.8 (1.1, 3.0)	Not serious	Serious <sup>5</sup>	N/A <sup>1</sup>	Not serious	Moderate
<b>Single birth:</b> Very low birth weight babies (OR >1 indicates greater risk of infection for single births)								
1 (Mularoni 2014)	Prospective cohort study	14,719	Adjusted OR 1.4 (1.1, 1.8)	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Not serious	Moderate
1 (Klinger 2009)	Prospective cohort study	15,839	Adjusted OR 1.4	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Not serious	Moderate

No. of studies	Study design	Sample size	Effect size (95%CI)	Risk of bias	Indirectness	Inconsistency	Imprecision	Quality
			(1.1, 1.8)					
<b>Single birth:</b> Babies born $\geq 22$ weeks' gestational age (OR >1 indicates greater risk of infection for single births)								
1 (Hakansson 2006)	Retrospective cohort study	319	Adjusted OR 1.1 (0.6, 2.0)	Not serious	Not serious	N/A <sup>1</sup>	Serious <sup>2</sup>	Moderate

1. Single study. Inconsistency not applicable
2. Single study where CIs cross the line of no effect. Quality downgraded 1 level
3. Single study at moderate risk of bias. Quality downgraded 1 level
4. Single study at high risk of bias. Quality downgraded 2 levels
5. Single study which is partially applicable. Quality downgraded 1 level

## F.3 Neonatal risk factors

### Risk factors

No. of studies	Study design	Sample size	Effect size (95%CI)	Risk of bias	Indirectness	Inconsistency	Imprecision	Quality
<b>Gestational age:</b> Very early onset infection (up to 2 days). Extremely premature babies ( $\leq 25$ weeks vs $\geq 26$ weeks) (OR >1 indicates greater risk of infection for extremely premature babies)								
1 (Ronnestad 2005)	Prospective cohort study	462	Adjusted OR 1.1 (0.4, 3.6)	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Serious <sup>2</sup>	Low
<b>Gestational age:</b> Early onset infection (2-7 days days). Extremely premature babies ( $\leq 25$ weeks vs $\geq 26$ weeks) (OR >1 indicates greater risk of infection for extremely premature babies)								
1 (Ronnestad 2005)	Prospective cohort study	462	Adjusted OR 3.0 (0.6, 14.9)	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Serious <sup>2</sup>	Low

No. of studies	Study design	Sample size	Effect size (95%CI)	Risk of bias	Indirectness	Inconsistency	Imprecision	Quality
<b>Gestational age:</b> Very low birthweight babies (comparisons between 1-week increases in gestational age) (OR >1 indicates greater risk of infection for babies of lower gestational age)								
1 (Klinger 2009)	Prospective cohort study	15,839	Adjusted OR 0.98 (0.94, 1.03)	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Serious <sup>2</sup>	Low
<b>Gestational age:</b> Babies born ≥22 weeks' gestational age (<28 weeks vs 40 weeks) (OR >1 indicates greater risk of infection for babies of lower gestational age)								
1 (Hakansson 2006)	Retrospective cohort study	319	Adjusted OR 22.1 (8.5, 57.4)	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Not serious	Moderate
<b>Gestational age:</b> Babies born ≥22 weeks' gestational age (28-31 weeks vs 40 weeks) (OR >1 indicates greater risk of infection for babies of lower gestational age)								
1 (Hakansson 2006)	Retrospective cohort study	319	Adjusted OR 34.1 (18.6, 62.7)	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Not serious	Moderate
<b>Gestational age:</b> Babies born ≥22 weeks' gestational age (32-34 weeks vs 40 weeks) (OR >1 indicates greater risk of infection for babies of lower gestational age)								
1 (Hakansson 2006)	Retrospective cohort study	319	Adjusted OR 11.2 (6.0, 21.0)	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Not serious	Moderate
<b>Gestational age:</b> Babies born ≥22 weeks' gestational age (35-36 weeks vs 40 weeks) (OR >1 indicates greater risk of infection for babies of lower gestational age)								
1 (Hakansson 2006)	Retrospective cohort study	319	Adjusted OR 4.7 (2.5, 8.9)	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Not serious	Moderate
<b>Gestational age:</b> Babies born ≥22 weeks' gestational age (37 weeks vs 40 weeks) (OR >1 indicates greater risk of infection for babies of lower gestational age)								
1 (Hakansson 2006)	Retrospective cohort study	319	Adjusted OR 3.5	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Not serious	Moderate

No. of studies	Study design	Sample size	Effect size (95%CI)	Risk of bias	Indirectness	Inconsistency	Imprecision	Quality
			(1.8, 6.5)					
<b>Gestational age:</b> Babies born $\geq 22$ weeks' gestational age ( $\geq 42$ weeks vs 40 weeks) (OR $>1$ indicates greater risk of infection for babies of lower gestational age)								
1 (Hakansson 2006)	Retrospective cohort study	319	Adjusted OR 1.9 (0.9, 3.7)	Serious <sup>3</sup>	Not serious	N/A <sup>1</sup>	Serious <sup>2</sup>	Low

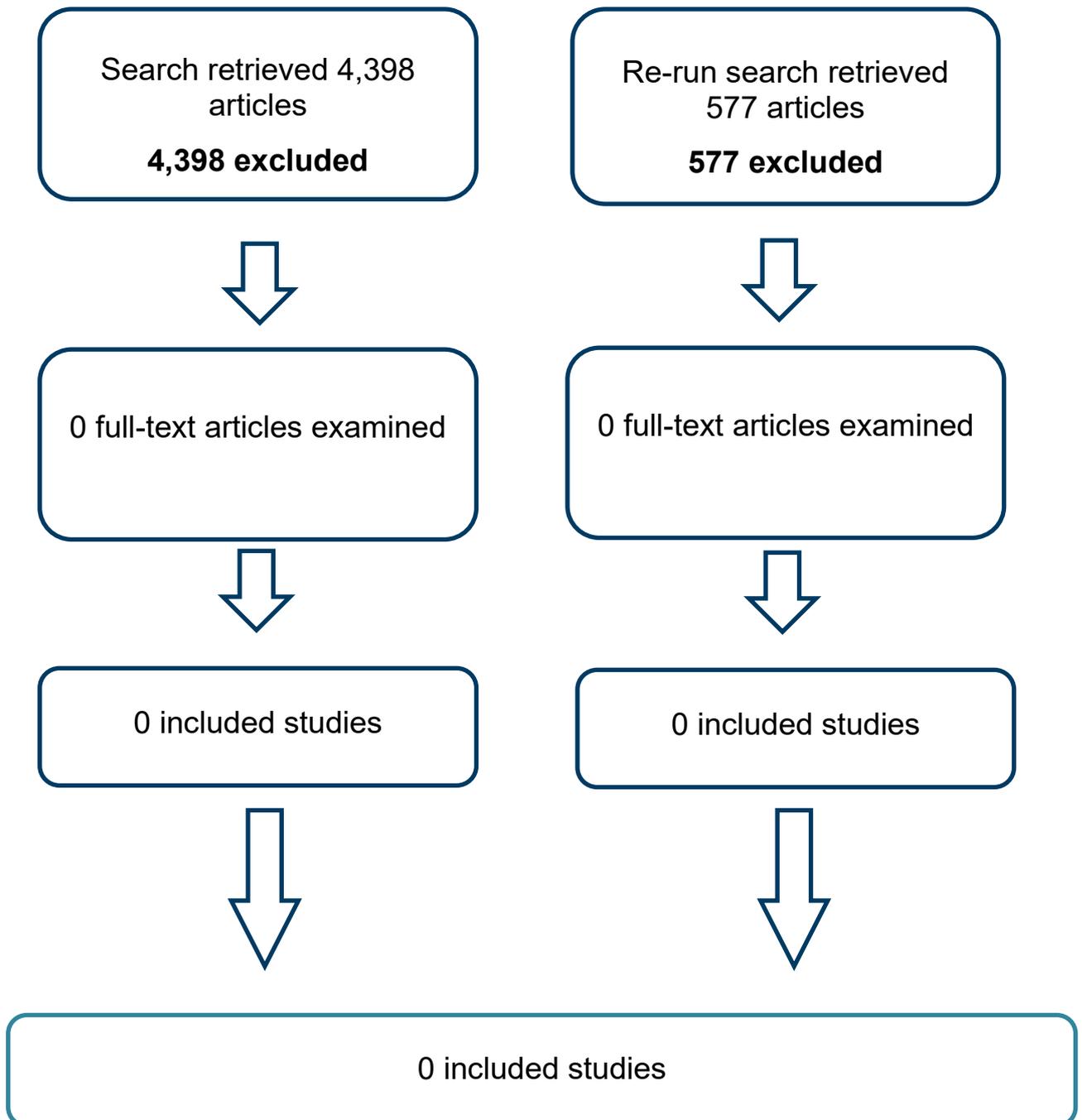
1. Single study. Inconsistency not applicable
2. Single study where CIs cross the line of no effect. Quality downgraded 1 level
3. Single study at moderate risk of bias. Quality downgraded 1 level

## Signs and symptoms

No. of studies	Study design	Sample size	Effect size (95%CI)	Risk of bias	Indirectness	Inconsistency	Imprecision	Quality
<b>Respiratory distress syndrome:</b> Moderately preterm babies (OR $>1$ indicates greater risk of infection for babies with respiratory distress syndrome)								
1 (Ofman 2016)	Retrospective cohort study	2192	Adjusted OR 2.05 (1.62-3.14)	Very serious <sup>2</sup>	Not serious	N/A <sup>1</sup>	Not serious	Low

1. Single study. Inconsistency not applicable
2. Single study at high risk of bias. Quality downgraded 2 levels

## Appendix G – Economic evidence study selection



## **Appendix H – Economic evidence tables**

No economic evidence is available as none of the studies in the economic search results were found to be relevant.

## **Appendix I – Health economic model**

This question was not prioritised for original economic analysis.

## Appendix J – Excluded studies

### J.1 Clinical prediction models

#### Clinical studies

Study	Reason for exclusion
Achten N.B., Zonneveld R., Tromp E. et al. (2017) Association between sepsis calculator and infection parameters for newborns with suspected early onset sepsis. <i>Journal of Clinical Neonatology</i> 6(3): 159-162	- Does not contain outcomes of interest
Achten, Niek B, Dorigo-Zetsma, J Wendelien, van der Linden, Paul D et al. (2018) Sepsis calculator implementation reduces empiric antibiotics for suspected early-onset sepsis.. <i>European journal of pediatrics</i> 177(5): 741-746	- Not possible to calculate a 2x2 table from the data specified in the protocol
Achten, N.B., Klingenberg, C., Benitz, W.E. et al. (2019) Association of Use of the Neonatal Early-Onset Sepsis Calculator with Reduction in Antibiotic Therapy and Safety: A Systematic Review and Meta-analysis. <i>JAMA Pediatrics</i> 173(11): 1032-1040	- Systematic review. Reference list checked for possible includes
Achten, N.B., Visser, D.H., Tromp, E. et al. (2020) Early onset sepsis calculator implementation is associated with reduced healthcare utilization and financial costs in late preterm and term newborns. <i>European Journal of Pediatrics</i> 179(5): 727-734	- Outcome to be predicted does not match that specified in the protocol <i>Health economics analysis</i>
Achten, Niek B, Dorigo-Zetsma, J Wendelien, van Rossum, Annemarie M C et al. (2020) Risk-based maternal group B streptococcus screening strategy is compatible with neonatal early onset sepsis calculator implementation. <i>Clinical and experimental pediatrics</i>	- End point does not match that specified in the protocol <i>Effects of known vs unknown maternal GBS status</i>
Aghai, Zubair H (2018) Is early-onset sepsis risk calculator safe for the management of neonates born to mothers with chorioamnionitis?.. <i>Journal of perinatology : official journal of the California Perinatal Association</i> 38(6): 769-770	- Article correspondence
Akangire, G., Simpson, E., Weiner, J. et al. (2020) Implementation of the Neonatal Sepsis Calculator in Early-Onset Sepsis and Maternal Chorioamnionitis. <i>Advances in neonatal care : official journal of the National Association of Neonatal Nurses</i> 20(1): 25-32	- Outcome to be predicted do not match that specified in the protocol <i>Comparison between clinician and calculator outcomes</i>
Anonymous (1999) Conclusions from the WHO multicenter study of serious infections in young infants. The WHO Young Infants Study Group.. <i>The Pediatric infectious disease journal</i> 18(10suppl): 32-4	- End point does not match that specified in the protocol
Anonymous (1999) Clinical prediction of serious bacterial infections in young infants in developing countries. The WHO Young Infants Study Group.. <i>The Pediatric infectious disease journal</i> 18(10suppl): 23-31	- Outcome to be predicted does not match that specified in the protocol [Bacterial infection in infants aged up to 90 days. Results for

	<b>neonates not presented separately]</b>
Bachur, R G and Harper, M B (2001) Predictive model for serious bacterial infections among infants younger than 3 months of age.. Pediatrics 108(2): 311-6	<b>- Outcome to be predicted does not match that specified in the protocol [Bacterial infection in infants less than 3 months. Data for neonates not presented separately]</b>
Baizat, Melinda, Zaharie, Gabriela, Iancu, Mihaela et al. (2019) Potential Clinical Predictors of Suspected Early and Late Onset Sepsis (EOS and LOS) in Preterm Newborns: a Single Tertiary Center Retrospective Study. Clinical laboratory 65(7)	<b>- Non-OECD country</b>
Barbadoro, Pamela, Marigliano, Anne, D'Errico, Marcello Mario et al. (2011) Gestational age as a single predictor of health care-associated bloodstream infections in neonatal intensive care unit patients.. American journal of infection control 39(2): 159-62	<b>- Assessment tool do not match that specified in the protocol [Suggests single predictor for neonatal infection]</b>
Benaim, E.H.; Upadhyay, K.; Talati, A.J. (2020) Comparison of institutional guidelines with established early onset sepsis risk calculator in reducing antibiotic use in an inner-city NICU in US. Journal of Global Antimicrobial Resistance 21: 124-129	<b>- End point do not match that specified in the protocol</b>
Berger, R M, Berger, M Y, van Steensel-Moll, H A et al. (1996) A predictive model to estimate the risk of serious bacterial infections in febrile infants.. European journal of pediatrics 155(6): 468-73	<b>- Study does not contain the population of interest [Excluded babies with gestational age &lt;37 weeks. Included children aged 2 weeks - 1 year but results not separated by age]</b>
Bressan, Silvia, Gomez, Borja, Mintegi, Santiago et al. (2012) Diagnostic performance of the lab-score in predicting severe and invasive bacterial infections in well-appearing young febrile infants.. The Pediatric infectious disease journal 31(12): 1239-44	<b>- Outcome to be predicted does not match that specified in the protocol [Bacterial infection in infants up to 1 year. Results for neonates not presented separately]</b>
Bridges M., Pesek E., McRae M. et al. (2019) Use of an Early Onset-Sepsis Calculator to Decrease Unnecessary NICU Admissions and Increase Exclusive Breastfeeding. Journal of obstetric, gynecologic, and neonatal nursing : JOGNN 48(3): 372-382	<b>- Does not contain outcomes of interest</b>
Cabaret B., Laurans C., Launay E. et al. (2013) Diagnostic value of a new procalcitonin cord sample-guided algorithm to manage newborns suspected of early-onset infection. Archives de Pediatrie 20(9): 954-962	<b>- Study not reported in English</b>
Celik, I H, Demirel, G, Sukhachev, D et al. (2013) Neutrophil volume, conductivity and scatter parameters with effective modeling of molecular activity statistical program gives better results in neonatal sepsis.. International journal of laboratory hematology 35(1): 82-7	<b>- Late-onset neonatal infection</b>
Chen, Chun-Jen, Lo, Yu-Fang, Huang, Miao-Chiu et al. (2009) A model for predicting risk of serious bacterial infection in	<b>- Study does not contain the population of interest</b>

febrile infants younger than 3 months of age.. Journal of the Chinese Medical Association : JCMA 72(10): 521-6	<b>[Excludes babies &lt;36 weeks gestation. Includes infants up to 3 months but results not separated by age]</b>
Chiu, C H and Lin, T Y (1998) Application of the Rochester Criteria in febrile neonates.. The Pediatric infectious disease journal 17(3): 267-9	<b>- Article type correspondence</b>
Degraeuwe, Pieter (2018) Applying the neonatal Early-Onset Sepsis calculator in cases of clinical chorioamnionitis at or after 34 weeks of gestation.. The Journal of pediatrics 203: 463-464	<b>- Article type correspondence</b>
Deshmukh, Mangesh; Mehta, Shailender; Patole, Sanjay (2019) Sepsis calculator for neonatal early onset sepsis - a systematic review and meta-analysis.. The journal of maternal-fetal & neonatal medicine : the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians: 1-9	<b>- Systematic review. Reference list was checked for additional articles</b>
Despins, Laurel A (2017) Automated Detection of Sepsis Using Electronic Medical Record Data: A Systematic Review.. Journal for healthcare quality : official publication of the National Association for Healthcare Quality 39(6): 322-333	<b>- Systematic review. Reference list was checked for additional articles</b>
Eason, J., Ward, H., Danko, O. et al. (2019) Early-onset sepsis: Can we screen fewer babies safely?. Archives of Disease in Childhood	<b>- End point do not match that specified in the protocol</b>
Escobar, Gabriel J, Puopolo, Karen M, Wi, Soora et al. (2014) Stratification of risk of early-onset sepsis in newborns >= 34 weeks' gestation.. Pediatrics 133(1): 30-6	<b>- Not possible to calculate a contingency table from the data specified in the protocol</b>
Fairchild, Karen D, Lake, Douglas E, Kattwinkel, John et al. (2017) Vital signs and their cross-correlation in sepsis and NEC: a study of 1,065 very-low-birth-weight infants in two NICUs.. Pediatric research 81(2): 315-321	<b>- Outcome to be predicted does not match that specified in the protocol</b> <b>[Sepsis in neonates, results not separated by early- and late-onset]</b>
Fowler, Nyles T; Garcia, Michael; Hankins, Cynthia (2019) Impact of Integrating a Neonatal Early-Onset Sepsis Risk Calculator into the Electronic Health Record. Pediatric quality & safety 4(6): e235	<b>- Outcome to be predicted do not match that specified in the protocol</b> <b>Only reports true positives</b>
Fowlie, P W, Gould, C R, Parry, G J et al. (1996) CRIB (clinical risk index for babies) in relation to nosocomial bacteraemia in very low birthweight or preterm infants.. Archives of disease in childhood. Fetal and neonatal edition 75(1): f49-52	<b>- Study does not contain any relevant index tests</b>
Franz, Axel R, Bauer, Karl, Schalk, Andreas et al. (2004) Measurement of interleukin 8 in combination with C-reactive protein reduced unnecessary antibiotic therapy in newborn infants: a multicenter, randomized, controlled trial.. Pediatrics 114(1): 1-8	<b>- Assessment tool do not match that specified in the protocol</b> <b>[Individual predictors of infection, not a model]</b>

Garra, Gregory; Cunningham, Sandra J; Crain, Ellen F (2005) Reappraisal of criteria used to predict serious bacterial illness in febrile infants less than 8 weeks of age.. Academic emergency medicine : official journal of the Society for Academic Emergency Medicine 12(10): 921-5	- Study does not contain the population of interest [Infants. Results for neonates not reported separately]
Gievers L.L., Sedler J., Phillipi C.A. et al. (2018) Implementation of the sepsis risk score for chorioamnionitis-exposed newborns. Journal of Perinatology 38(11): 1581-1587	- Study design does not match protocol
Good, Pamela I and Hooven, Thomas A (2019) Evaluating Newborns at Risk for Early-Onset Sepsis.. Pediatric clinics of North America 66(2): 321-331	- Review article but not a systematic review
Griffin, M Pamela, O'Shea, T Michael, Bissonette, Eric A et al. (2003) Abnormal heart rate characteristics preceding neonatal sepsis and sepsis-like illness.. Pediatric research 53(6): 920-6	- Late-onset neonatal infection
Griffin, M Pamela; Lake, Douglas E; Moorman, J Randall (2005) Heart rate characteristics and laboratory tests in neonatal sepsis.. Pediatrics 115(4): 937-41	- Assessment tool do not match that specified in the protocol
Gupta, R; Sachdev, H P; Shah, D (2000) Evaluation of the WHO/UNICEF algorithm for integrated management of childhood illness between the ages of one week to two months.. Indian pediatrics 37(4): 383-90	- End point do not match that specified in the protocol [No information about the model and primarily predicting hospitalisation]
Gur, Ilan, Markel, Gal, Nave, Yaron et al. (2014) A mathematical algorithm for detection of late-onset sepsis in very-low birth weight infants: a preliminary diagnostic test evaluation.. Indian pediatrics 51(8): 647-50	- Late-onset neonatal infection
Gur, Ilan, Riskin, Arieh, Markel, Gal et al. (2015) Pilot study of a new mathematical algorithm for early detection of late-onset sepsis in very low-birth-weight infants.. American journal of perinatology 32(4): 321-30	- Late-onset neonatal infection
Harrell, F E Jr, Margolis, P A, Gove, S et al. (1998) Development of a clinical prediction model for an ordinal outcome: the World Health Organization Multicentre Study of Clinical Signs and Etiological agents of Pneumonia, Sepsis and Meningitis in Young Infants. WHO/ARI Young Infant Multicentre Study Group.. Statistics in medicine 17(8): 909-44	- Study does not contain the population of interest [Sepsis in infants but not specifically neonatal sepsis]
He, Yi, Chen, Jie, Liu, Zhenqiu et al. (2019) Efficacy and safety of applying a neonatal early-onset sepsis risk calculator in China.. Journal of paediatrics and child health	- Set in non-OECD country
Helmbrecht A.R.; Marfurt S.; Chaaban H. (2019) Systematic Review of the Effectiveness of the Neonatal Early-Onset Sepsis Calculator. The Journal of perinatal & neonatal nursing 33(1): 82-88	- Systematic review. Reference list was checked for additional articles
Huang, Yuejun, Yu, Xiaochan, Li, Weidong et al. (2020) Development and validation of a nomogram for predicting late-onset sepsis in preterm infants on the basis of thyroid function and other risk factors: Mixed retrospective and prospective cohort study. Journal of advanced research 24: 43-51	- Non-OECD country
Ji H., Bridges M., Pesek E. et al. (2019) Acute Funisitis Correlates With the Risk of Early-Onset Sepsis in Term	- End point do not match that specified in the protocol

Newborns Assessed Using the Kaiser Sepsis Calculator. Pediatric and Developmental Pathology	
Kerste, Marleen, Corver, Jellina, Sonneveld, Martine C et al. (2016) Application of sepsis calculator in newborns with suspected infection.. The journal of maternal-fetal & neonatal medicine : the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians 29(23): 3860-5	- Not possible to calculate a contingency table from the data specified in the protocol
Klingenberg C. (2018) Early-onset sepsis risk calculator reduces empiric antibiotic use. Journal of Pediatrics 192: 266-269	- Conference abstract
Kordek, Agnieszka; Halasa, Maciej; Podraza, Wojciech (2008) Early detection of an early onset infection in the neonate based on measurements of procalcitonin and C-reactive protein concentrations in cord blood.. Clinical chemistry and laboratory medicine 46(8): 1143-8	- Not possible to calculate a contingency table from the data specified in the protocol
Kuzniewicz, Michael W, Puopolo, Karen M, Fischer, Allen et al. (2017) A Quantitative, Risk-Based Approach to the Management of Neonatal Early-Onset Sepsis.. JAMA pediatrics 171(4): 365-371	- Not possible to calculate a contingency table from the data specified in the protocol
Kuzniewicz, Michael W, Walsh, Eileen M, Li, Sherian et al. (2016) Development and Implementation of an Early-Onset Sepsis Calculator to Guide Antibiotic Management in Late Preterm and Term Neonates.. Joint Commission journal on quality and patient safety 42(5): 232-9	- Prediction model tutorial paper
Labenne, Marc, Lizard, Gerard, Ferdynus, Cyril et al. (2011) A clinic-biological score for diagnosing early-onset neonatal infection in critically ill preterm infants.. Pediatric critical care medicine : a journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies 12(2): 203-9	- Study design does not match protocol
Lake, Douglas E; Fairchild, Karen D; Moorman, J Randall (2014) Complex signals bioinformatics: evaluation of heart rate characteristics monitoring as a novel risk marker for neonatal sepsis.. Journal of clinical monitoring and computing 28(4): 329-39	- Assessment tool do not match that specified in the protocol
Lawder, Richard, Whyte, Bruce, Wood, Rachael et al. (2019) Impact of maternal smoking on early childhood health: a retrospective cohort linked dataset analysis of 697 003 children born in Scotland 1997-2009. BMJ open 9(3): e023213	- Outcome to be predicted does not match that specified in the protocol
Leonardi, Bianca M, Binder, Margaret, Griswold, Katherine J et al. (2019) Utilization of a Neonatal Early-Onset Sepsis Calculator to Guide Initial Newborn Management. Pediatric quality & safety 4(5): e214	- Outcome to be predicted does not match that specified in the protocol
Loughlin, L., Knowles, S., Twomey, A. et al. (2020) The Neonatal Early Onset Sepsis Calculator; in Clinical Practice. Irish medical journal 113(4): 57	- Outcome to be predicted does not match that specified in the protocol

Mahieu LM, De Dooy JJ, Cossey VR et al. (2002) Internal and external validation of the NOSEP prediction score for nosocomial sepsis in neonates.. Critical care medicine 30(7): 1459-1466	- Late-onset neonatal infection
Mahieu LM, De Muynck AO, De Dooy JJ et al. (2000) Prediction of nosocomial sepsis in neonates by means of a computer-weighted bedside scoring system (NOSEP score). Critical care medicine 28(6): 2026-2033	- Late-onset neonatal infection
Mani, Subramani, Ozdas, Asli, Aliferis, Constantin et al. (2014) Medical decision support using machine learning for early detection of late-onset neonatal sepsis.. Journal of the American Medical Informatics Association : JAMIA 21(2): 326-36	- Late-onset neonatal infection
Mithal, Leena Bhattacharya, Yogev, Ram, Palac, Hannah et al. (2016) Computerized vital signs analysis and late onset infections in extremely low gestational age infants.. Journal of perinatal medicine 44(5): 491-7	- Late-onset neonatal infection
Modi, N, Dore, C J, Saraswatula, A et al. (2009) A case definition for national and international neonatal bloodstream infection surveillance.. Archives of disease in childhood. Fetal and neonatal edition 94(1): f8-12	- End point do not match that specified in the protocol [Used to produce definition of infection rather than a model for wider use]
Moorman, J Randall, Delos, John B, Flower, Abigail A et al. (2011) Cardiovascular oscillations at the bedside: early diagnosis of neonatal sepsis using heart rate characteristics monitoring.. Physiological measurement 32(11): 1821-32	- Assessment tool do not match that specified in the protocol
Morris, R., Jones, S., Banerjee, S. et al. (2020) Comparison of the management recommendations of the Kaiser Permanente neonatal early-onset sepsis risk calculator (SRC) with NICE guideline CG149 in infants >=34 weeks' gestation who developed early-onset sepsis. Archives of Disease in Childhood: Fetal and Neonatal Edition: 2019317165	- Outcome to be predicted does not match that specified in the protocol  <i>All babies have confirmed infection - not possible to calculate specificity</i>
Okascharoen, C, Hui, C, Cairnie, J et al. (2007) External validation of bedside prediction score for diagnosis of late-onset neonatal sepsis.. Journal of perinatology : official journal of the California Perinatal Association 27(8): 496-501	- Set in non-OECD country
Okascharoen, Chusak, Sirinavin, Sayomporn, Thakkinstian, Ammarin et al. (2005) A bedside prediction-scoring model for late-onset neonatal sepsis.. Journal of perinatology : official journal of the California Perinatal Association 25(12): 778-83	- Set in non-OECD country
Puopolo, Karen M and Escobar, Gabriel J (2013) Early-onset sepsis: a predictive model based on maternal risk factors.. Current opinion in pediatrics 25(2): 161-6	- Review article but not a systematic review
Rosenberg, Rebecca E, Ahmed, A S M Nawshad U, Saha, Samir K et al. (2010) Nosocomial sepsis risk score for preterm infants in low-resource settings.. Journal of tropical pediatrics 56(2): 82-9	- Set in non-OECD country

Singh SA; Dutta S; Narang A (2003) Predictive clinical scores for diagnosis of late onset neonatal septicemia.. Journal of tropical pediatrics 49(4): 235-239	<b>- Assessment tool do not match that specified in the protocol [Individual factors rather than combined predictor model]</b>
Stipelman, Carole H, Smith, Elizabeth R, Diaz-Ochu, Margarita et al. (2019) Early-Onset Sepsis Risk Calculator Integration Into an Electronic Health Record in the Nursery. Pediatrics 144(2)	<b>- Outcome to be predicted do not match that specified in the protocol</b> <i>Frequency of calculator use</i>
Strunk, Tobias, Campbell, Catherine, Burgner, David et al. (2019) Histological chorioamnionitis and developmental outcomes in very preterm infants. Journal of perinatology : official journal of the California Perinatal Association 39(2): 321-330	<b>- Outcome to be predicted does not match that specified in the protocol</b>
Thakur J.; Pahuja S.K.; Pahuja R. (2019) Performance comparison of prediction models for neonatal sepsis using logistic regression, multiple discriminant analysis and artificial neural network. Biomedical Physics and Engineering Express 5(3): 035013	<b>- Outcome to be predicted does not match that specified in the protocol</b> <b>[Overall neonatal sepsis risk. Results not separated by early- and late-onset neonatal infection]</b>
Thakur J.; Pahuja S.K.; Pahuja R. (2019) Non-invasive prediction model for developing countries to predict sepsis in neonates. Biomedical Engineering - Applications, Basis and Communications 31(1): 1950001	<b>- Outcome to be predicted does not match that specified in the protocol</b> <b>[Overall neonatal sepsis risk. Results not separated by early- and late-onset neonatal infection]</b>
Tziiala, Chryssoula, Manzoni, Paolo, Achille, Cristian et al. (2018) New Diagnostic Possibilities for Neonatal Sepsis.. American journal of perinatology 35(6): 575-577	<b>- Review article but not a systematic review</b>
van der Ham, David P, van Kuijk, Sander, Opmeer, Brent C et al. (2014) Can neonatal sepsis be predicted in late preterm premature rupture of membranes? Development of a prediction model.. European journal of obstetrics, gynecology, and reproductive biology 176: 90-5	<b>- Study design does not match protocol</b>
Verstraete, Evelien Hilde, Blot, Koen, Mahieu, Ludo et al. (2015) Prediction models for neonatal health care-associated sepsis: a meta-analysis.. Pediatrics 135(4): e1002-14	<b>- Systematic review used as source of primary studies</b>
Villamor-Martinez, E., Lubach, G.A., Rahim, O.M. et al. (2020) Association of histological and clinical chorioamnionitis with neonatal sepsis among preterm infants: A systematic review, meta-analysis, and meta-regression. Frontiers in Immunology 11: e972	<b>- Systematic review. Reference list checked for possible includes</b>
Vujevic, Matea; Benzon, Benjamin; Markic, Josko (2017) New prediction model for diagnosis of bacterial infection in febrile infants younger than 90 days.. The Turkish journal of pediatrics 59(3): 261-268	<b>- Study does not contain the population of interest</b> <b>[Excludes babies &lt;37 weeks gestation. Includes infants age</b>

	<b>0-90 days but results not separated by age]</b>
Walker, Sandra A N, Cormier, Melanie, Elligsen, Marion et al. (2019) Development, evaluation and validation of a screening tool for late onset bacteremia in neonates - a pilot study.. BMC pediatrics 19(1): 253	<b>- Study design does not match protocol</b>
Warren, S; Garcia, M; Hankins, C (2017) Impact of neonatal early-onset sepsis calculator on antibiotic use within two tertiary healthcare centers.. Journal of perinatology : official journal of the California Perinatal Association 37(4): 394-397	<b>- Study design does not match protocol</b>
Young, Paul C (2014) A data-based approach to evaluation and empiric treatment of newborn sepsis.. The Journal of pediatrics 165(3): 640-1	<b>- Conference abstract</b>
Xiao, Yuping, Griffin, M Pamela, Lake, Douglas E et al. (2010) Nearest-neighbor and logistic regression analyses of clinical and heart rate characteristics in the early diagnosis of neonatal sepsis.. Medical decision making : an international journal of the Society for Medical Decision Making 30(2): 258-66	<b>- Late-onset neonatal infection</b>

## J.2 Maternal and neonatal risk factors

### Clinical studies

<b>Study</b>	<b>Reason for exclusion</b>
Berardi, Alberto, Lugli, Licia, Rossi, Cecilia et al. (2011) Intrapartum antibiotic prophylaxis failure and group-B streptococcus early-onset disease. The journal of maternal-fetal & neonatal medicine : the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians 24(10): 1221-4	- Statistical outcomes do not match those specified in the protocol <i>[Does not include multivariate model]</i>
Bobitt, J.R.; Damato, J.D.; Sakakini Jr., J. (1985) Perinatal complications in group B streptococcal carriers: A longitudinal study of prenatal patients. American Journal of Obstetrics and Gynecology 151(6): 711-717	- Reference standard in study does not match that specified in protocol
Cakir, Ufuk; Tayman, Cuneyt; Buyuktiryaki, Mehmet (2019) An Unknown Risk Factor for Sepsis in Very Low Birth Weight Preterms: ABO Blood Groups (BGaPS Study). American journal of perinatology	- Predictive factors do not match the protocol <i>[Blood type]</i>
Capanna, Federica, Emonet, Stephane P, Cherkaoui, Abdessalam et al. (2013) Antibiotic resistance patterns among group B Streptococcus isolates: implications for antibiotic prophylaxis for early-onset neonatal sepsis. Swiss medical weekly 143: w13778	- Outcome to be predicted do not match that specified in the protocol
Chan, Grace J, Lee, Anne C C, Baqui, Abdullah H et al. (2013) Risk of early-onset neonatal infection with maternal infection or colonization: a global systematic review and meta-analysis. PLoS medicine 10(8): e1001502	- Systematic review. References checked for possible includes

	<i>[2 studies added for review of full text articles]</i>
Chen, Katherine T, Ringer, Steven, Cohen, Amy P et al. (2002) The role of intrapartum fever in identifying asymptomatic term neonates with early-onset neonatal sepsis. Journal of perinatology : official journal of the California Perinatal Association 22(8): 653-7	- Statistical outcomes do not match those specified in the protocol
Dutta, Sourabh, Reddy, Rajeshwar, Sheikh, Samir et al. (2010) Intrapartum antibiotics and risk factors for early onset sepsis. Archives of disease in childhood. Fetal and neonatal edition 95(2): f99-103	- Based in non-OECD country
Egarter C, Leitich H, Karas H, Wieser F, Husslein P, Kaider A, Schemper M (1996) Antibiotic treatment in preterm premature rupture of membranes and neonatal morbidity: a metaanalysis. American Journal of Obstetrics and Gynecology 174(2): 589-597	- Systematic review. References checked for possible includes
Evers, Annemieke C C, Nijhuis, Lotte, Koster, Maria P H et al. (2012) Intrapartum fever at term: diagnostic markers to individualize the risk of fetal infection: a review. Obstetrical & gynecological survey 67(3): 187-200	- Systematic review. References checked for possible includes
Geethanath, R.M., Ahmed, I., Abu-Harb, M. et al. (2019) Intrapartum antibiotics for prolonged rupture of membranes at term to prevent Group B Streptococcal sepsis. Journal of Obstetrics and Gynaecology 39(5): 619-622	- Study design does not match the protocol
Grimwood, K, Darlow, B A, Gosling, I A et al. (2002) Early-onset neonatal group B streptococcal infections in New Zealand 1998-1999. Journal of paediatrics and child health 38(3): 272-7	- Statistical outcomes do not match those specified in the protocol
Hafed, B M, Bilikova, E, Kovacicova, G et al. (2003) Prognostic factors for 246 neonates with infections. Clinical infectious diseases : an official publication of the Infectious Diseases Society of America 36(9): 1203-5	- Not a peer-reviewed publication <i>[Article correspondence]</i>
Hofer, Nora; Muller, Wilhelm; Resch, Bernhard (2012) Neonates presenting with temperature symptoms: role in the diagnosis of early onset sepsis. Pediatrics international : official journal of the Japan Pediatric Society 54(4): 486-90	- Reference standard in study does not match that specified in protocol <i>[Positive blood, CSF or tracheal aspirate culture]</i>
Jeong, Heejeong, Han, Su-jin, Yoo, Ha-Na et al. (2015) Comparison of changes in etiologic microorganisms causing early-onset neonatal sepsis between preterm labor and preterm premature rupture of membranes. The journal of maternal-fetal & neonatal medicine : the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians 28(16): 1923-8	- Outcome to be predicted do not match that specified in the protocol <i>[Criteria for infection not defined]</i>

Langley, S. (2000) Group B streptococci and early onset neonatal infection. Nursing times 96(25): 36-37	- Not a peer-reviewed publication
Lawder, Richard, Whyte, Bruce, Wood, Rachael et al. (2019) Impact of maternal smoking on early childhood health: a retrospective cohort linked dataset analysis of 697 003 children born in Scotland 1997-2009. BMJ open 9(3): e023213	- Outcome to be predicted do not match that specified in the protocol
Lorthe, E., Ancel, P.-Y., Torchin, H. et al. (2017) Impact of Latency Duration on the Prognosis of Preterm Infants after Preterm Premature Rupture of Membranes at 24 to 32 Weeks' Gestation: A National Population-Based Cohort Study. Journal of Pediatrics 182: 47	- Predictive factors do not match the protocol <i>[Factors reported for multivariate analysis do not match the protocol]</i>
Moore, M.R.; Schrag, S.J.; Schuchat, A. (2003) Effects of intrapartum antimicrobial prophylaxis for prevention of group-B-streptococcal disease on the incidence and ecology of early-onset neonatal sepsis. Lancet Infectious Diseases 3(4): 201-213	- Review article but not a systematic review
Parente, V., Clark, R.H., Ku, L. et al. (2017) Risk factors for group B streptococcal disease in neonates of mothers with negative antenatal testing. Journal of Perinatology 37(2): 157-161	- Reference standard in study does not match that specified in protocol <i>[Positive blood, urine or CSF culture]</i>
Petrova, A, Demissie, K, Rhoads, G G et al. (2001) Association of maternal fever during labor with neonatal and infant morbidity and mortality. Obstetrics and gynecology 98(1): 20-7	- Outcome to be predicted do not match that specified in the protocol <i>[Neonatal and infant mortality]</i>
Ramesh Bhat, Y. and Baby, L.P. (2012) Early onset of neonatal sepsis: Analysis of the risk factors and the bacterial isolates by using the BacT alert system. Journal of Clinical and Diagnostic Research 5(7): 1385-1388	- Statistical outcomes do not match those specified in the protocol
Saccone, Gabriele and Berghella, Vincenzo (2015) Antibiotic prophylaxis for term or near-term premature rupture of membranes: metaanalysis of randomized trials. American journal of obstetrics and gynecology 212(5): 627e1-9	- Systematic review. References checked for possible includes
Salem, Shimrit Yaniv, Sheiner, Eyal, Zmora, Ehud et al. (2006) Risk factors for early neonatal sepsis. Archives of gynecology and obstetrics 274(4): 198-202	- Study design does not match the protocol <i>[Case-control study]</i>
Schrag, Stephanie J, Cutland, Clare L, Zell, Elizabeth R et al. (2012) Risk factors for neonatal sepsis and perinatal death	- Predictive factors do not match the protocol

among infants enrolled in the prevention of perinatal sepsis trial, Soweto, South Africa. The Pediatric infectious disease journal 31(8): 821-6	<i>[Factors reported for multivariate analysis do not match the protocol]</i>
Strunk, Tobias, Campbell, Catherine, Burgner, David et al. (2019) Histological chorioamnionitis and developmental outcomes in very preterm infants. Journal of perinatology : official journal of the California Perinatal Association 39(2): 321-330	- Outcome to be predicted do not match that specified in the protocol
Tsai, M.-L., Hsu, C.-H., Chang, J.-H. et al. (2004) Group B streptococcal sepsis and meningitis in neonates: An 11-year survey. Clinical Neonatology 11(2): 62-66	- Full text paper not available
Turrentine, M.A., Greisinger, A.J., Brown, K.S. et al. (2013) Duration of intrapartum antibiotics for group B streptococcus on the diagnosis of clinical neonatal sepsis. Infectious Diseases in Obstetrics and Gynecology 2013: 525878	- Reference standard in study does not match that specified in protocol  <i>[Includes suspected infection but does not include treatment with antibiotics in the criteria]</i>
Veleminsky, Milos and Tosner, Jindrich (2008) Relationship of vaginal microflora to PROM, pPROM and the risk of early-onset neonatal sepsis. Neuro endocrinology letters 29(2): 205-21	- Statistical outcomes do not match those specified in the protocol
Strunk, Tobias, Campbell, Catherine, Burgner, David et al. (2019) Histological chorioamnionitis and developmental outcomes in very preterm infants. Journal of perinatology : official journal of the California Perinatal Association 39(2): 321-330	- Outcome to be predicted do not match that specified in the protocol
Wassen, M M L H, Winkens, B, Dorssers, E M I et al. (2014) Neonatal sepsis is mediated by maternal fever in labour epidural analgesia. Journal of obstetrics and gynaecology : the journal of the Institute of Obstetrics and Gynaecology 34(8): 679-83	- Study design does not match the protocol  <i>[Case control study]</i>
Wojcieszek Aleena M, Stock Owen M, Flenady Vicki (2014) Antibiotics for prelabour rupture of membranes at or near term. Cochrane Database of Systematic Reviews: Reviews issue10	- Systematic review. References checked for possible includes
Wojkowska-Mach, Jadwiga, Borszewska-Kornacka, Maria, Domanska, Joanna et al. (2012) Early-onset infections of very-low-birth-weight infants in Polish neonatal intensive care units. The Pediatric infectious disease journal 31(7): 691-5	- Statistical outcomes do not match those specified in the protocol

Wortham, Jonathan M, Hansen, Nellie I, Schrag, Stephanie J et al. (2016) Chorioamnionitis and Culture-Confirmed, Early-Onset Neonatal Infections. Pediatrics 137(1)	- Statistical outcomes do not match those specified in the protocol
Yoon, B.H., Yang, S.H., Jun, J.K. et al. (1996) Maternal blood C-reactive protein, white blood cell count, and temperature in preterm labor: A comparison with amniotic fluid white blood cell count. Obstetrics and Gynecology 87(2i): 231-237	- Outcome to be predicted do not match that specified in the protocol <i>[Criteria for neonatal sepsis not defined]</i>
Auriti, C, Maccallini, A, Di Liso, G et al. (2003) Risk factors for nosocomial infections in a neonatal intensive-care unit. The Journal of hospital infection 53(1): 25-30	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Babazono, Akira, Kitajima, Hiroyuki, Nishimaki, Shigeru et al. (2008) Risk factors for nosocomial infection in the neonatal intensive care unit by the Japanese Nosocomial Infection Surveillance (JANIS). Acta medica Okayama 62(4): 261-8	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Bekhof, Jolita, Reitsma, Johannes B, Kok, Joke H et al. (2013) Clinical signs to identify late-onset sepsis in preterm infants. European journal of pediatrics 172(4): 501-8	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Boghossian, Nansi S, Page, Grier P, Bell, Edward F et al. (2013) Late-onset sepsis in very low birth weight infants from singleton and multiple-gestation births. The Journal of pediatrics 162(6): 1120-1124e1	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Dempsey, E, Chen, M-F, Kokottis, T et al. (2005) Outcome of neonates less than 30 weeks gestation with histologic chorioamnionitis. American journal of perinatology 22(3): 155-9	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Dior, Uri P, Kogan, Liron, Eventov-Friedman, Smadar et al. (2016) Very High Intrapartum Fever in Term Pregnancies and Adverse Obstetric and Neonatal Outcomes. Neonatology 109(1): 62-8	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Garcia-Munoz Rodrigo, Fermin; Galan Henriquez, Gloria M; Ospina, Cristina Gomez (2014) Morbidity and mortality among very-low-birth-weight infants born to mothers with clinical chorioamnionitis. Pediatrics and neonatology 55(5): 381-6	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Garcia-Munoz Rodrigo, Fermin, Galan Henriquez, Gloria, Figueras Aloy, Josep et al. (2014) Outcomes of very-low-birth-weight infants exposed to maternal clinical chorioamnionitis: a multicentre study. Neonatology 106(3): 229-34	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Garland, J S, Kanneberg, S, Mayr, K A et al. (2017) Risk of morbidity following catheter removal among neonates with	- Study does not examine early-onset infection

<p>catheter associated bloodstream infection. Journal of neonatal-perinatal medicine 10(3): 291-299</p>	<p>[Examines late-onset infection]</p>
<p>Hakansson, S and Kallen, K (2006) Impact and risk factors for early-onset group B streptococcal morbidity: analysis of a national, population-based cohort in Sweden 1997-2001. BJOG : an international journal of obstetrics and gynaecology 113(12): 1452-8</p>	<p>- Study does not examine early-onset infection [Examines late-onset infection]</p>
<p>Hakansson, Stellan and Kallen, Karin (2008) High maternal body mass index increases the risk of neonatal early onset group B streptococcal disease. Acta paediatrica (Oslo, Norway : 1992) 97(10): 1386-9</p>	<p>- Study does not examine early-onset infection [Examines late-onset infection]</p>
<p>Kilic, A., Okulu, E., Kocabas, B.A. et al. (2019) Health care-associated infection surveillance: A prospective study of a tertiary neonatal intensive care unit. Journal of Infection in Developing Countries 13(3): 181-187</p>	<p>- Study does not examine early-onset infection [Examines late-onset infection]</p>
<p>Kim, J.K., Chang, Y.S., Sung, S. et al. (2018) Trends in the incidence and associated factors of late-onset sepsis associated with improved survival in extremely preterm infants born at 23-26 weeks' gestation: A retrospective study. BMC Pediatrics 18(1): 172</p>	<p>- Study does not examine early-onset infection [Examines late-onset infection]</p>
<p>Leal, Yelda A, Alvarez-Nemegyei, Jose, Velazquez, Juan R et al. (2012) Risk factors and prognosis for neonatal sepsis in southeastern Mexico: analysis of a four-year historic cohort follow-up. BMC pregnancy and childbirth 12: 48</p>	<p>- Study does not examine early-onset infection [Examines late-onset infection]</p>
<p>Makhoul, Imad R, Yacoub, Afeefi, Smolkin, Tatiana et al. (2006) Values of C-reactive protein, procalcitonin, and Staphylococcus-specific PCR in neonatal late-onset sepsis. Acta paediatrica (Oslo, Norway : 1992) 95(10): 1218-23</p>	<p>- Study does not examine early-onset infection [Examines late-onset infection]</p>
<p>Mularoni, Alessandra, Madrid, Marisela, Azpeitia, Agueda et al. (2014) The role of coagulase-negative staphylococci in early onset sepsis in a large European cohort of very low birth weight infants. The Pediatric infectious disease journal 33(5): e121-5</p>	<p>- Study does not examine early-onset infection [Examines late-onset infection]</p>
<p>Nayeri, Unzila Ali, Buhimschi, Catalin S, Zhao, Guomao et al. (2018) Components of the antepartum, intrapartum, and postpartum exposome impact on distinct short-term adverse neonatal outcomes of premature infants: A prospective cohort study. PloS one 13(12): e0207298</p>	<p>- Study does not examine early-onset infection [Examines late-onset infection]</p>
<p>Olivier, F, Bertelle, V, Shah, P S et al. (2016) Association between birth route and late-onset sepsis in very preterm neonates. Journal of perinatology : official journal of the California Perinatal Association 36(12): 1083-1087</p>	<p>- Study does not examine early-onset infection [Examines late-onset infection]</p>
<p>Padula, Michael A, Dewan, Maya L, Shah, Samir S et al. (2014) Risk factors associated with laboratory-confirmed bloodstream infections in a tertiary neonatal intensive care unit. The Pediatric infectious disease journal 33(10): 1027-32</p>	<p>- Study does not examine early-onset infection [Examines late-onset infection]</p>

Rastogi, Shantanu, Rojas, Mary, Rastogi, Deepa et al. (2015) Neonatal morbidities among full-term infants born to obese mothers. The journal of maternal-fetal & neonatal medicine : the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians 28(7): 829-35	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Rønnestad, Arild, Abrahamsen, Tore G, Medbo, Sverre et al. (2005) Septicemia in the first week of life in a Norwegian national cohort of extremely premature infants. Pediatrics 115(3): e262-8	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Sanderson, E, Yeo, K T, Wang, A Y et al. (2017) Dwell time and risk of central-line-associated bloodstream infection in neonates. The Journal of hospital infection 97(3): 267-274	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Shah, P, Nathan, E, Doherty, D et al. (2013) Prolonged exposure to antibiotics and its associations in extremely preterm neonates--the Western Australian experience. The journal of maternal-fetal & neonatal medicine : the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians 26(17): 1710-4	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Smith, P Brian, Benjamin, Daniel K Jr, Cotten, C Michael et al. (2008) Is an increased dwell time of a peripherally inserted catheter associated with an increased risk of bloodstream infection in infants?. Infection control and hospital epidemiology 29(8): 749-53	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Soraisham, Amuchou S, Singhal, Nalini, McMillan, Douglas D et al. (2009) A multicenter study on the clinical outcome of chorioamnionitis in preterm infants. American journal of obstetrics and gynecology 200(4): 372e1-6	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Stoll, B J, Gordon, T, Korones, S B et al. (1996) Late-onset sepsis in very low birth weight neonates: a report from the National Institute of Child Health and Human Development Neonatal Research Network. The Journal of pediatrics 129(1): 63-71	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Troger, Birte, Gopel, Wolfgang, Faust, Kirstin et al. (2014) Risk for late-onset blood-culture proven sepsis in very-low-birth weight infants born small for gestational age: a large multicenter study from the German Neonatal Network. The Pediatric infectious disease journal 33(3): 238-43	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>
Yapicioglu, H., Ozcan, K., Sertdemir, Y. et al. (2011) Healthcare-associated infections in a Neonatal Intensive Care Unit in Turkey in 2008: Incidence and risk factors, a prospective study. Journal of Tropical Pediatrics 57(3): 157-164	- Study does not examine early-onset infection <i>[Examines late-onset infection]</i>



## Appendix K – Research recommendations – full details

### K.1.1 Research recommendation

What is the accuracy of clinical prediction models for early-onset neonatal infection in the UK and what is their effectiveness in guiding management in the baby?

### K.1.2 Why this is important

Nine observational studies were identified evaluating the accuracy of clinical prediction models for early-onset neonatal infection. These primarily evaluated the use of the Kaiser Permanente neonatal sepsis calculator. However, most of the evidence has validated the use of this tool in the USA, with only one study examining its use in the UK. In addition, the neonatal sepsis calculator is designed for use with babies at or over 34 weeks' gestational age. There is currently no evidence for the use of clinical prediction models for babies born at a gestational age of less than 34 weeks.

Further research is needed using a robust study design such as prospective cohort studies, parallel RCTs or cluster RCTs to either examine the effectiveness of existing clinical prediction models for early-onset neonatal infection, or to develop new clinical prediction models designed for use in UK clinical practice. Research in this area is essential to help develop accurate methods of identifying newborn babies most at risk of developing early-onset neonatal infection whilst avoiding over-prescribing of antibiotics.

### K.1.3 Rationale for research recommendation

Importance to 'patients' or the population	<p>Neonatal infection can have serious consequences if left untreated but can be difficult to diagnose. There is currently only one prognostic tool, with limited validation in the UK, to predict which babies are at high risk of early-onset neonatal infection. Consequently, many babies are being given antibiotic treatment while waiting for a culture result, and treatment is stopped if the culture result is negative. This results in many babies who do not have early-onset neonatal infection being given unnecessary antibiotic treatment.</p> <p>The development of a tool that can predict a babies' risk of early-onset neonatal infection will mean that decisions about whether a baby needs treatment can be made more quickly than waiting for a blood culture. This will ensure that those who need antibiotics will receive them quickly while reducing the number of babies who receive unnecessary antibiotics.</p>
Relevance to NICE guidance	The committee were able to make recommendations based on the Kaiser Permanente neonatal sepsis calculator and

	individual risk factors. However, they could not recommend solely using the neonatal sepsis risk calculator, or other prediction tools, until they were validated for use in the UK. Future research will help to develop validated risk prediction tools suitable for use in the UK.
Relevance to the NHS	The outcome would help to identify any prognostic models that can accurately predict a baby's risk of developing early-onset infection. This would help to ensure that babies who need antibiotic treatment receive this as quickly as possible, reducing potential side effects as well as reducing additional treatment costs that result from late diagnosis of neonatal infection. Babies at low risk of infection would also be less likely to receive unnecessary treatment, again reducing additional costs to the NHS.
National priorities	Medium
Current evidence base	This review identified 9 studies reporting data on 2 different prognostic models to predict early-onset neonatal infection. Only one model (Kaiser Permanente neonatal sepsis calculator) has been externally validated. There is currently no evidence for prognostic models designed for use in babies born at less than 34 weeks' gestational age.
Equality considerations	No specific equality concerns are relevant to this research recommendation

#### K.1.4 Modified PICO table (Part A – prognostic accuracy)

<b>PICO</b>	<p><b>Population:</b> Unborn or newborn babies under 72 hours Pregnant women</p> <p><b>Risk tool:</b> Any validated risk tool using multiple predictors to predict the risk of development or the presence of early-onset neonatal infection</p> <p><b>Reference standard:</b> Culture-proven infection from a sample taken within 72 hours of birth where available or within the study-defined period for early onset neonatal infection</p> <p><b>Outcomes:</b> Predictive accuracy measures, for example:  <ul style="list-style-type: none"> <li>• Model fit, including discrimination (C statistic, area under ROC curve) and calibration (r squared)</li> <li>• Sensitivity, specificity, positive and negative predictive values</li> </ul> </p>
<b>Current evidence base</b>	9 observational studies

<b>Study design</b>	Prospective cohort studies
<b>Other comments</b>	Study should be adequately powered, could link with local audits, and should collect data on resource-use and cost

### K.1.5 Modified PICO table (Part B – clinical effectiveness)

<b>PICO</b>	<p><b>Population:</b> Unborn or newborn babies under 72 hours Pregnant women</p> <p><b>Intervention:</b> Any validated risk tool for early-onset neonatal infection that meets the criteria for Part A of the protocol</p> <p><b>Comparator:</b></p> <ul style="list-style-type: none"> <li>• Standard care: treatment based on clinician experience or existing clinical protocols (for example, existing NICE guidance)</li> <li>• Comparisons between risk tools</li> </ul> <p><b>Outcomes:</b> Neonatal outcomes:</p> <ul style="list-style-type: none"> <li>• Culture-proven infection from sample taken within 72 hours of birth</li> <li>• Antibiotics for suspected bloodstream infection within 72 hours of birth</li> <li>• Mortality</li> <li>• Respiratory distress within 72 hours of birth</li> <li>• Health-related quality of life, measured using a validated tool</li> <li>• Hospital length of stay</li> </ul>
<b>Current evidence base</b>	No evidence
<b>Study design</b>	Test and treat RCTs
<b>Other comments</b>	Study should be adequately powered

### K.2.1 Research recommendation

What is the risk of early-onset neonatal infection with maternal obesity and how does this change with increasing BMI?

### K.2.2 Why this is important

One retrospective cohort study (Hakansson 2008) was identified evaluating the association between maternal obesity and early-onset neonatal infection. This defined maternal obesity using the World Health Organisation definition based on BMI (underweight <18.5, normal 18.5–24.9, overweight 25–29.9 and obese ≥30). However, this definition does not reflect the definition that is used in current practice, where mothers with a BMI greater than 35 are now classified as obese. The differences in BMI classifications between this study and clinical practice mean that there is currently no evidence that can be directly applied to clinical practice in the UK. In addition, with only one study currently available it is difficult to assess any associations between BMI and the risk of neonatal infection.

Further research is needed using a robust study design such as prospective cohort studies, to determine the association between maternal obesity and the risk of babies developing early-onset neonatal infection. Research in this area is important to help provide clinicians with a more detailed understanding of the risk factors associated with early-onset infection, thereby helping to identify which babies are most at risk of infection within the first 72 hours of life. Such research is relevant to the NHS due the potential resource impact. Infections are both costly to treat and may result in severe adverse health outcomes. As such, research that helps clinicians identify which babies are most at risk, is likely to result in cost-savings at the population level and also improve health outcomes.

### K.2.3 Rationale for research recommendation

<p>Importance to 'patients' or the population</p>	<p>Neonatal infection can have serious consequences if left untreated but there is currently limited information about the risks of maternal obesity on a baby's chance of developing early-onset neonatal infection. An increased understanding of the association between maternal BMI and early-onset infection will help clinicians understand whether a baby is at greater risk of developing infection if they are born to an obese mother.</p> <p>If there is found to be an association between maternal obesity and early-onset neonatal infection, then clinicians will be aware that they may need to monitor the baby more closely for signs of infection. This may lead to quicker decisions about whether a baby needs treatment. A greater understanding the association between maternal obesity and early-onset infection will also ensure help provide more detailed information to mothers about the potential risks of infection.</p>
<p>Relevance to NICE guidance</p>	<p>The committee were unable to make recommendations for risk factors for early-onset infection onset in relation to maternal obesity. However, they felt that not including maternal obesity within the list of risk factors should not result in an increased risk of a baby being missed for treatment for neonatal infection. Future research will help to develop more detailed guidance on the risk factors for early-onset neonatal infection suitable for use in the UK.</p>
<p>Relevance to the NHS</p>	<p>The outcome would help to identify whether maternal obesity is a risk factor for babies to develop early-onset neonatal infection. This information will help to determine whether babies born to mothers who are obese should be considered at higher risk of developing</p>

	infection. This will also help to provide mothers with more detailed information during pregnancy.
National priorities	Medium
Current evidence base	This review identified 1 study reporting data on the association between maternal obesity and early-onset neonatal infection. However, the BMI categories that were used to classify maternal obesity were not relevant to current practice. In UK practice, a mother with a BMI greater than 35 is classified as obese, whereas a BMI of 30 was used to represent maternal obesity in the study. The committee advised that more research is needed to be confident whether maternal obesity is a risk factor for early-onset infection.
Equality considerations	No specific equality concerns are relevant to this research recommendation

#### K.2.4 Modified PICO table

<b>PICO</b>	<p><b>Population:</b> Unborn or newborn babies under 72 hours Pregnant women</p> <p><b>Risk factors:</b> Maternal obesity (based on BMI definitions used in clinical practice in the UK)</p> <p><b>Reference standard:</b> Culture-proven infection from a sample taken within 72 hours of birth where available or within the study-defined period for early onset neonatal infection</p> <p><b>Outcomes:</b> Association measures, for example:  <ul style="list-style-type: none"> <li>• Odds ratios/hazard ratios</li> <li>• Sensitivity, specificity, positive and negative predictive values</li> </ul> </p>
<b>Current evidence base</b>	1 observational study
<b>Study design</b>	Prospective cohort studies
<b>Other comments</b>	Study should be adequately powered, could link with local audits, and should collect data on resource-use and cost