National Institute for Health and Care Excellence

Pneumonia: diagnosis and management (update)

[A] Evidence reviews for the diagnostic accuracy of lung ultrasound compared to chest x-ray for diagnosing pneumonia

NICE guideline [number]
Evidence reviews underpinning recommendation 1.4.2 in the NICE guideline

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1.1 Review question

What is the diagnostic accuracy of lung ultrasound compared to chest x-ray for diagnosing community and hospital acquired pneumonia?

1.1.1 Introduction

Chest radiography is the primary imaging modality used for the evaluation of pneumonia, but lung ultrasound (LUS) may also be useful for diagnosing pneumonia and is a method that has been gaining popularity in recent years. It has a more favourable safety profile (because it doesn't expose patients to radiation), a lower cost than chest x-ray (CXR) and CT, and it can be used at the bedside to provide immediate results. However, the diagnostic accuracy of LUS for pneumonia remains uncertain.

This evidence review aims to determine the diagnostic accuracy of lung ultrasound compared to chest x-ray for diagnosing community acquired pneumonia (CAP) or hospital acquired pneumonia (HAP).

1.1.2 Summary of the protocol

Table 1: Summary of the protocol inclusion criteria

Population	Babies over 28 days (corrected gestational age), children, young people (age <18 years) and adults (≥18 years) with suspected pneumonia (community or hospital acquired) in secondary care settings
Test	Lung ultrasound
Reference standard	Chest imaging: x-ray or CT (with or without clinical diagnosis)
Outcomes	Sensitivity, specificity, LR+, LR-
Study type	Cross sectional studies, cohort studies and systematic reviews

CT: computed tomography; LR: likelihood ratio

For the full protocol see appendix A.

1.1.3 Methods and process

This evidence review was developed using the methods and process described in Developing NICE guidelines: the manual. Methods specific to this review question are described in the review protocol in appendix A and the methods document.

Declarations of interest were recorded according to NICE's conflicts of interest policy.

Searches for systematic reviews on all pneumonia topics identified 11 systematic reviews of lung ultrasound for babies, children and young people which matched the inclusion criteria for this review. Of these 11, one systematic review was both recent and a close match: Dong 2023. The systematic review searches also identified 13 systematic reviews of lung ultrasound for adults which matched the inclusion criteria for this review. Of these 13, one systematic review was both recent and a close match: Strom 2020.

The committee agreed that these reviews directly address the review question, were up to date and were thorough. For this reason, to repeat them would be a duplication of effort, so it was agreed that they would be used to answer the review question. However, they noted that both systematic reviews included studies from non-OECD countries, so they agreed that these studies should be excluded from the current review to restrict the evidence to studies from OECD countries only. The committee also noted that the searches were last run in July 2023 for Dong 2023 and May 2019 for Strom 2020, so it was possible that newer studies that might be eligible for inclusion could have been published since that time. They asked NICE to update the searches to identify any potential new studies that would affect the results. The selected studies from the systematic reviews were combined with the newly published studies for this review.

Protocol deviations

The protocol specified that sensitivity analyses would be conducted in any meta-analyses where some (but not all) of the data is from studies at high risk of bias, and where some (but not all) of the data is from indirect studies. In the evidence for babies, children and young people, no studies were rated as indirect and only 3 studies were at high risk of bias. These were small studies that together contributed under 5% of the weight in each of the meta-analyses they were included in. It was therefore agreed that results from sensitivity analyses would not significantly contribute to decision making and were therefore not required. For adults, although there was a larger number of studies rated as high risk of bias, it was agreed that the evidence base was sufficiently large and robust, so sensitivity analyses were not required.

The committee listed a number of subgroups of interest in the protocol and this did not initially include subgroup analyses by setting. However, they noted that data was available on the hospital setting in which the lung ultrasound had been performed (emergency department, paediatric or adult ward). They agreed that this would be useful information to inform decision making, so setting was added as a subgroup of interest via a protocol deviation.

The subgroup analysis for operator experience was based on the information available in the study information. There were 3 subgroups:

- Trained operator: Studies where the ultrasound operator had received training on lung ultrasound as part of the study but had little or no prior experience.
- Standard operator: Studies where the ultrasound operator had experience of lung ultrasound as part of a wider clinical role (e.g. paediatrician) but was not an imaging specialist.
- Specialist operator: Studies where the ultrasound operator was a professional sonographer or radiographer.

1.1.3.1 Search methods

Each evidence review for this guideline had a search conducted in three parts. Part 1 was a single search for all systematic reviews relating to pneumonia published since 2014 that was screened for relevance to all the review questions. Part 2 was tailored to each evidence review. Part 3 covered the cost effectiveness elements of all review questions in a single search.

The searches for systematic reviews on all pneumonia topics were run on 20 November 2023 and re-run on 15 October 2024 in Cochrane Database of Systematic Reviews (CDSR) (Wiley) and Epistemonikos (https://www.epistemonikos.org).

The searches for diagnostic evidence were run on 19 April 2024 and re-run on 7 August 2024. The following databases were searched: Cochrane Central Register of Controlled Trials (CENTRAL) (Wiley); Embase (Ovid); and MEDLINE ALL (Ovid). Limits were applied to remove animal studies, case reports, conference abstracts, editorials, empty registry entries, letters, news items and references not published in the English language. Study filters were used to limit to diagnostic test accuracy studies in MEDLINE and Embase.

The database searches were supplemented with additional search methods. Reference list checking and forward citation searching were conducted on Web of Science Core Collection on 18 April 2024 using seed references identified from the search for systematic reviews.

The searches for cost effectiveness evidence were run on 20 November 2023 and re-run on 14 October 2024 for papers published since 2014. The following databases were searched: Econlit (Ovid); Embase (Ovid); International HTA Database (https://database.inahta.org); MEDLINE ALL (Ovid); and NHS Economic Evaluation Database (NHS EED) (CRD). The same limits as in the effectiveness search were used. The validated NICE Cost Utility Filter was used on MEDLINE and Embase. Validated NICE filters were used in MEDLINE and Embase to remove references exclusively set in countries that are not OECD members.

A NICE senior information specialist (SIS) conducted the searches. The MEDLINE strategy was quality assured by another NICE SIS and all translated search strategies were peer reviewed to ensure their accuracy. Both procedures were adapted from the 2015 PRESS Guideline Statement.

Explanatory notes and full search strategies for each database are provided in appendix B.

1.1.4 Diagnostic evidence

1.1.4.1 Included studies

A systematic search carried out to identify potentially relevant studies found 2,354 references (see appendix B for the literature search strategy).

These 2,354 references were screened at title and abstract level against the review protocol, with 2,234 excluded at this level. The full texts of 139 were ordered for closer inspection. 24 of these were systematic reviews; 11 were for babies, children and young people, and 13 were for adults. The most recent, comprehensive and well conducted systematic review for each of the 2 populations was selected (Dong 2023 and Strom 2020). The remaining reviews were used to identify primary studies suitable for inclusion only. For babies, children and young people, 64 full texts were examined and 4 of these studies met the criteria specified in the review protocol (appendix A), alongside 17 studies identified from the Dong 2023 review. For adults, 51 full texts were examined and 6 of these studies met the inclusion criteria, alongside 10 studies identified from the Strom 2020 review. For a summary of the 37 included studies see table 2.

The clinical evidence study selection is presented as PRISMA diagrams in appendix C.

See section 1.1.14 References – included studies for the full references of the included studies.

1.1.4.2 Excluded studies

Details of studies excluded at full text, along with reasons for exclusion are given in appendix J.

1.1.5 Summary of studies included in the diagnostic evidence

Table 2: Summary of systematic reviews included in the diagnostic evidence

Study details	Population	Test	Reference standard	Outcomes	Risk of bias
Babies, children and young people < 18 years					
Dong (2023) Systematic review and meta-analysis 26 studies, of which 17 are relevant	Total N = 4436 N from relevant studies = 2288 • 2866 with pneumonia, 1570 without pneumonia. • 54.1% male, 45.9% female • Samples from OECD countries selected	Lung ultrasound	Clinical diagnoses, laboratory and chest imaging examinations	Sensitivity and specificity	Low risk of bias Partially applicable
Adults ≥18 years					
Strom (2020) Systematic review 17 studies, of which 10 are relevant	Total N = 2139 N from relevant studies = 1467 • Samples from OECD countries selected • Participant sex and number of patients with and without pneumonia not reported	Lung ultrasound	Final diagnosis based on clinical, laboratory and microbiological data, including chest x-ray or chest CT	Sensitivity and specificity	Moderate risk of bias Partially applicable

CT = computed tomography; OECD = the organisation for economic co-operation and development

See appendix D for full evidence tables.

Table 3: Summary of studies of babies, children and young people included in Dong (2023) and studies included from the search

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
Studies included in Dong (2023)							
Boursiani 2017 Prospective	Emergency department Greece	N=69 Median age: 4.5 years 27 male, 42 female	62/69	Lung ultrasound by experienced paediatric radiologist 5–8 MHz micro-convex, 5–12 MHz linear array, and 3–5 MHz convex transducers	B-lines, lung consolidation, air or fluid bronchogram, and pleural effusion	Clinical diagnosis + chest x-ray	Low risk of bias Low concern about applicability
Caiulo 2013 Prospective	Paediatric ward Italy	N=102 Mean age: 5 years (SD: 3) 53 male, 49 female	88/102	Lung ultrasound by experienced paediatrician 6–12 MHz linear probe	B-lines, consolidation, air pleural line abnormalities, and pleural effusion	Clinical diagnosis + chest x-ray + blood	Low risk of bias Low concern about applicability
Claes 2017 Prospective	Emergency department Belgium	N=143	52/143	Lung ultrasound by paediatric radiologist	Lung consolidation	Clinical diagnosis + chest x-ray	Low risk of bias Low concern about applicability

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
		Mean age: 3.4 years 77 male, 66 female		5–12 MHz linear probe and 4–9 MHz convex probe			
Copetti 2008 Prospective	Emergency department Italy	N=79 Mean age: 5.1 years (SD: 5.0) 37 male, 42 female	60/79	Lung ultrasound by emergency physician 3.5–5 MHz convex probe and 7.5–10 MHz linear probe	Lung consolidation, bronchograms, and pleural effusion	Clinical diagnosis + chest x-ray	High risk of bias Low concern about applicability
Ellington 2017 Prospective	Emergency department and paediatric ward USA	N=421 Mean age: 20 months (SD: 14.6) 258 male, 163 female	187/421	Lung ultrasound by trained general practitioner HFL38/13–6 MHz linear transducer	Consolidation with a pleural effusion	Clinical diagnosis + chest x-ray + laboratory findings	Low risk of bias Low concern about applicability
Esposito 2014	Intensive care	N=103	50/103	Lung ultrasound by paediatric resident with limited experience	B-lines, interruption of pleural line, Consolidation, and pleural effusion	Chest x-ray	Some concerns about risk of bias

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
Prospective	Italy	Mean age: 5.6 years (SD: 4.6) 56 male, 47 female		2.5–6.6 MHz convex probe and 7.5–12 MHz linear probe			Low concern about applicability
Guerra 2016 Prospective	Emergency department Italy	N=222 Age range: 3 months to 16 years 108 male, 114 female	207/222	Lung ultrasound by experienced paediatrician 7.5–10-MHz linear probe and 3.5–5-MHz convex probe	Lung consolidation, air and fluid bronchogram, pleural effusion, and B-lines	Clinical diagnosis + chest x-ray + blood results	Low risk of bias Low concern about applicability
Gurbuz 2023 Prospective	Emergency department Turkey	N=48 Mean age: 5.4 years (SD: 5.3) 27 male, 21 female	23/48	Lung ultrasound by trained paediatric resident 3–13 MHz Linear probe and 2–6 MHz convex probe	Lung consolidation, subpleural consolidation, pleural effusion, and B-lines	Clinical diagnosis + chest x-ray	Some concerns about risk of bias Low concern about applicability

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
Ianniello 2016 Retrospective	Emergency department Italy	N=84 Mean age: 6 years 44 male, 40 female	60/84	Lung ultrasound by radiologist Curved array 4 MHz multifrequency probe and 7.5–10 MHz linear probe	Lung consolidation, B-lines, air bronchogram, pleural line abnormalities, and pleural effusion	Clinical diagnosis + chest x-ray	High risk of bias Low concern about applicability
Iorio 2015 Retrospective	Paediatric ward Italy	N=52 Mean age: 3.5 years (SD: 3.1) 27 male, 25 female	29/52	Lung ultrasound by experienced paediatrician 5–10 MHz linear probe	Lung consolidation, bronchograms, superficial fluid alveologram, and pleural effusion	Clinical diagnosis + chest x-ray + laboratory findings	High risk of bias Low concern about applicability
Iuri 2009 Prospective	Emergency department Italy	N= 28 Mean age: 4.5 years (SD: 4.9) 17 male, 11 female	22/28	Lung ultrasound by radiologist 2–5 MHz convex probe and 5–12 MHz linear probe	Lung consolidation and pleural effusion	Chest x-ray	Low risk of bias Low concern about applicability

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
Reali 2014 Prospective	Paediatric ward Italy	N=107 Mean age: 4 years (SD: 3) 61 male, 46 female	77/107	Lung ultrasound by pulmonologist 7.5–10 MHz Linear probe	B-lines, consolidation, air pleural line abnormalities, and pleural effusion	Clinical diagnosis + chest x-ray + blood results	Low risk of bias Low concern about applicability
Samson 2016 Prospective	Emergency department Spain	N=200 Median age: 29.5 months 116 male, 84 female	80/200	Lung ultrasound by paediatricians with varying experience 6–15 MHz linear probe	Lung consolidation, air bronchogram, and pleural effusion	Clinical diagnosis + chest x-ray	Low risk of bias Low concern about applicability
Shah 2013 Prospective	Emergency department USA	N=200 Mean age: 2.6 years (SD: 6.2) 122 male, 88 female	49/200	Lung ultrasound by experienced emergency physician 7.5–10 MHz Linear array transducer	Lung consolidation, air bronchogram, and B-lines	Chest x-ray	Some concerns about risk of bias Low concern about applicability

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
Urbankowska 2015 Prospective	Paediatric ward Poland	N=106 Median age: 52.5 months 69 male, 37 female	71/106	Lung ultrasound by paediatric sonographer 3–7 MHz convex probe and 5–9 MHz linear probe	Lung consolidation, bronchograms, pleural effusion, and pleural line abnormalities	Clinical diagnosis + chest x-ray + laboratory findings	Low risk of bias Low concern about applicability
Yilmaz 2017 Prospective	Emergency department Turkey	N=160 Mean age: 3.3 years (SD: 4) 88 male, 72 female	146/160	Lung ultrasound by experienced paediatric emergency physician 6–13 MHz linear probe	Consolidation, air and fluid bronchograms, B-lines, and pleural effusion	Clinical diagnosis + chest x-ray	Some concerns about risk of bias Low concern about applicability
Zhan 2016 Prospective	Emergency department Denmark	N=164 Median age: 1.5 years 93 male, 71 female	40/164	Lung ultrasound by paediatric resident with limited experience Two linear probes (5–10 MHz and 5–13 MHz)	Subpleural consolidation, air bronchogram, and pleural effusion	chest x-ray + blood results + microbiological testing	Some concerns about risk of bias Low concern about applicability

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
Studies included from the search							
Ambroggio 2016 Prospective	Children's hospital ward USA	N=132 Median age: 4.4 years (IQR: 1.6 to 7.9) 74 male, 58 female	47/132	Lung ultrasound by sonographer 2- to 6-MHz convex and 5- to 12-MHz linear array transducers. For smaller children, 4- to 10-MHz curved and 5- and 12-MHz linear array transducers	Lung consolidation, B-lines, and pleural effusion	Chest x-ray + CT scan	Low risk of bias Low concern about applicability
Biagi 2018 Prospective	Paediatric Emergency Unit Italy	N=87 Mean age: 5.7 months (SD: 5.2) 43 male, 44 female	25/87	Lung ultrasound by experienced paediatrician 7.5 MHz to 12 MHz linear probe	Lung consolidation, B-lines, air bronchogram, pleural line abnormalities	Clinical diagnosis + chest x-ray + laboratory findings	Low risk of bias Some concerns about applicability
Calgar 2019 Prospective	Paediatric Emergency Care	N=91 Median age: 3	71/91	Lung ultrasound by trained emergency physician	Lung consolidation, shred sign, air bronchograms, hepatization, B-lines,	Clinical diagnosis + chest x-ray	Low risk of bias Low concern about applicability

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
	Turkey	years (IQR: 1 to 5) 54 male, 37 female		L12-4MHz linear and C5-1MHz curved probes	sinusoidal sign, quad sign		
Lissaman 2019 Prospective	Paediatric emergency department Australia	N=97 Median age: 2.4 years (IQR: 1.1 to 4.3) 50 male, 47 female	57/97	Lung ultrasound by trained paediatrician or medical student L14-5w linear transducer	Lung consolidation, air bronchograms	Chest x-ray	Low risk of bias Low concern about applicability

1 *CT: computed tomography; IQR: interquartile range; SD: standard deviation*

2 See appendix D for full evidence tables.

1 **Table 4: Summary of studies of adults included in Strom (2020) and studies included from the search**

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
Studies included in Strom (2020)							
Benci 1996 Prospective	Italy Department of infectious diseases	N=80 Mean age: 38.5 years 50 male, 30 female	37/80	Lung ultrasound by physicians with considerable experience in LUS Ansaldo AU-560 with convex probe of 3.5 MHz.	Presence of parenchymatous-like hypoechoic lesions indicative of alveolar pneumonia.	Qualitative assessment based on clinical, laboratory and microbiological data, including CXR or CT results	High risk of bias Some concerns about applicability
Bourcier 2014 Prospective	France Emergency departments	N=144 Mean age: 77.6 years (SD: 15.2) 72 males, 72 females	123/144	Lung ultrasound by emergency physicians with 2 days of training. Portable US device SONOSITE M TURBO with convex 3.5 MHz probe.	Presence of a unilateral or bilateral alveolar-interstitial syndrome defined as disappearance of the pleural line associated with aeric or water bronchograms within an image of tissue echogenicity.	Qualitative assessment based on clinical, laboratory and microbiological data, including CXR or CT results	High risk of bias Low concern about applicability
Cipollini 2018	Italy	N=128	128/128	Lung ultrasound by internal medicine specialist with more	Presence of a hypoechoic solid area with shred margins	Qualitative assessment based on clinical,	High risk of bias

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
Retrospective	Medical / geriatric wards	Mean age: 84.8 years (range: 78-94) 61 males, 67 females		than 1 year of bedside LUS experience. Mindray M7 portable device using a 3.5 MHz convex probe	indicative for consolidation.	laboratory and microbiological data, including CXR or CT results	Low concern about applicability
Corradi 2015 Prospective	Italy Emergency departments	N=32 Mean age: 62 years (SD: 19) 17 males, 15 females	44/62 (Hemithoraxes)	Lung ultrasound by an intensivist with more than 10 years of experience and a PhD in ultrasound Logiq-e unit (GE Healthcare) with broadband convex-array probe at 4 MHz and high frequency linear-array probe at 10 MHz	Presence, distribution and extent of artifacts suggestive of interstitial involvement, pleural line abnormalities and alveolar consolidation	CT	High risk of bias High concern about applicability
Cortellaro 2012	Italy	N=120	81/120	Lung ultrasound by one expert operator.	Presence of sub-plural lung consolidation,	Qualitative assessment based on clinical,	Low risk of bias

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
Prospective	Emergency departments	Mean age: 69 years (SD: 18) 77 males, 43 females		Esaote Medical Systems, 3.5-5 MHz convex probe	presenting a tissular pattern.	laboratory and microbiological data, including CXR or CT results	Some concerns about applicability
Nazerian 2015 Prospective	Italy Emergency departments	N=285 Mean age: 71 years (SD:14) 133 males, 152 females	87/285	Lung ultrasound by 4 internal medicine and emergency medicine attending physicians (with at least 5 years of experience in LUS), and 4 resident physicians (with at least 1 year of training in emergency US). MyLab30 Gold (Esaote) and HD7 (Philips).	Presence of at least one subpleural lung consolidations with tissue-like or anechoic pattern and blurred, irregular margins	CT	High risk of bias High concern about applicability
Pagano 2015	Italy	N=104	68/105	Lung ultrasound by 5 trained emergency	Presence of 1) alveolar syndrome: image of tissue	Qualitative assessment based on clinical,	Low risk of bias

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
Prospective	Emergency departments	Mean age: 59 years 59 males, 46 females		physicians with more than 2 years of experience in LUS. C60 Sonosite Micro Maxx with 2-5 MHz convex probe.	echogenicity associated with aerial bronchogram or 2) focal interstitial syndrome presence of 3 or more B-lines in a single lung area.	laboratory and microbiological data, including CXR or CT results	Low concern about applicability
Parlamento 2009 Prospective	Italy Emergency departments	N=49 Mean age: 60.9 years (SD: 21.8) 31 males, 18 females	32/49	Lung ultrasound by emergency physician with 30 years of experience in general and cardiac US, and 10 years of training in LUS. Megas CVX, Esaote Medical Systems, with convex 3.5-5 MHz probe	Presence of subpleural lung consolidation with evidence of static or dynamic air bronchograms.	CXR/CT	High risk of bias Low concern about applicability
Reissig 2012 Prospective	Europe Multicentre[a]	N=356 Mean age: 63.8 years	226/356	Lung ultrasound by physicians with considerable	Unclear definition. Number, shape and size of pneumonic lesions were reported	CXR/CT	High risk of bias

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
		(range: 19-95 years) 228 males, 134 females		experience in US techniques. Machines not reported. 5 or 3.5 MHz convex probe, occasionally 7.5 MHz linear probe.	and incidence of necrotic areas, positive air bronchogram, fluid bronchogram, and local and basal pleural effusion were reported.		Some concerns about applicability
Tincinesi 2016 Prospective	Italy Geriatric ward	N=169 Mean age: 83.0 years (SD:9.2) 80 males, 89 females	97/169	Lung ultrasound by 3 internal and emergency medicine physicians with more than 1 year of experience in LUS. Acuson X300 5.0 (Siemens) with convex 2-5 MHz probe.	Presence of tissue-like echogenicity associated with dynamic air bronchograms, defined as punctiform or linear hyperechoic artifacts with centrifugal inspiratory dynamicity.	Qualitative assessment based on clinical, laboratory and microbiological data, including CXR or CT results	High risk of bias Low concern about applicability
Studies included in the search							
Buda 2020 Prospective	Poland Hospital settings	N=191	115/191	Lung ultrasound by a highly skilled,	(1) subpleural consolidations, often accompanied by C-line artefacts,	Clinical diagnosis based on medical interview, physical examination,	Low risk of bias

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
		Mean age: 80.9 years (10.1) 92 males, 99 females		experienced clinician. Machines not reported. Used convex (2–6 MHz) and linear (4–12 MHz) transducers.	containing dynamic air bronchogram or mixed (dynamic and static) air bronchogram and/or fluid bronchogram, and (2) B-line artefacts patterns, including focal interstitial syndrome or alveolar-interstitial syndrome present in a big lung area, mixed with properly aerated lung tissue (so-called spared areas) and/or focal “white lung.” In addition, pleural effusion, atelectasis, and congestions were assessed, as signs accompanying pneumonia (or indicating	laboratory results and positive chest imaging.	Partially applicable

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
					complicated pneumonia).		
Karademir 2021 Prospective	Turkey Emergency department	N=154 Mean age: 67.6 years (SD:12.5) 105 males, 49 females	112/154	Lung ultrasound by experienced US-certified emergency physician with 4 years of LUS experience. Esaote MyLab 30 Gold Cardiovascular US (Esaote S.p.A., Genova, Italy) and a 2.5–7.5MHz convex probe were used for the measurements.	• A lines with lung sliding and the presence of either pleural effusion or consolidation • Anterior B lines with abolished lung sliding • Presence of predominant unilateral B lines and contralateral A lines • Anterior lung consolidation regardless of size and number	Final diagnosis made by emergency physicians according to clinical, laboratory and radiology findings (CXR and CT images)	Low risk of bias Directly applicable
Linsalata 2020 Prospective	Italy Acute geriatrics unit	N=132	94/132	Lung ultrasound by one of two skilled clinicians with 1 year of certified	Tissue-like echogenicity associated with dynamic air bronchograms, the	CXR (but in cases where there was a mismatch between CXR and LUS, CT was used; n=76)	Low risk of bias Partially applicable

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
		Mean age: 85.3 years (SD: 6.9) 63 males, 69 females		experience of bedside LUS. A convex probe, 3.5 to 5 MHz (Esaote Medical System), was used.	latter defined as punctiform or linear hyperechoic artefacts with centrifugal inspiratory dynamics. Associated abnormalities, such as pleural effusion, atelectasis, and interstitial syndrome, were diagnosed according to guidelines.		
Mancusi 2022 Prospective	Italy Coronary Care Units (CCU)	N=110 Mean age: 70 years (SD: 11) 75 males, 35 females	26/110	Lung ultrasound performed by experienced residents in emergency medicine (>300 LUS performed) and reviewed by a cardiologist physician with long experience in LUS .	Signs of sonographic consolidation and/or focal multiple B-lines were observed. 'Sonographic consolidation' is defined as a small sub-pleural hypoechoic region or large hypoechoic region with liver- or	Discharge diagnosis made by 2 independent physicians who accessed data from radiological (CXR, LUS and CT), microbiological investigations (sputum and blood cultures) and	Moderate risk of bias Partially applicable

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
				LUS images were acquired with a 5–9 MHz convex probe	tissue-like echotexture.	biochemical tests, as well as information on clinical presentation.	
Nazerian 2016 Prospective	Italy Emergency departments	N=128 Mean age: 70.7 years (15.8). Range: 23 to 100 years 64 males, 64 females	61/128	Lung ultrasound by one of 8 sonographers: 4 internal and emergency medicine staff physicians with at least 5 years of experience on point-of-care emergency ultrasonography and four resident physicians with at least 6 months training in emergency ultrasound.	Detection of typical subpleural lung consolidations with tissue-like or anechoic pattern and blurred, irregular margins with associated focal B-lines. Consolidations showing dynamic air bronchograms (branching echogenic structures with centrifuge movement with breathing) or multiple hyperechogenic lentil-sized spots, due to air trapped in the small airways.	Clinical diagnosis based on all available clinical data including chest CT	Moderate risk of bias Partially applicable

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
				MyLab30 Gold (Esaote, Genova, Italy) and HD7 (Philips, Amsterdam, Holland). LUS was performed by using a 4–8 MHz linear probe or a 3.5–5 MHz curved array probe.			
Sezgin 2020 Prospective	Turkey Emergency departments	N=125 Mean age: 71.6 years (SD: 13.44) 81 males, 44 females	101/125	Lung ultrasound by an experienced emergency room physician who had attended many ultrasound workshops and performed more than 100 chest ultrasound procedures. All images were obtained using a	For LUS, dynamic air bronchograms in subpleural hypoechoic areas, the presence of consolidation, the presence of B-3 lines (lung rockets whose elements are about 3 mm apart) and the presence of diffuse interstitial syndrome were indicative of pneumonia.	Clinical signs, radiologic images, laboratory tests and microbiology results. CT was used when further evaluation was required; 61/125 patients underwent CT	Low risk of bias Directly applicable

Study details	Location	Population	Number of patients with final diagnosis of pneumonia	Index test	Diagnostic Criteria	Reference standard	Risk of bias
				convex probe (3.5-5 MHz) with LOGIQ Book XP (GE Healthcare, Istanbul, Turkey).			

1 *CT: computed tomography; CXR: chest X-ray; LUS: lung ultrasound; SD: standard deviation; US: ultrasound*

2 [a] Multicentre: 2 university hospitals, 7 hospitals of internal medicine, 1 hospital of pulmonary medicine, 2 practices, 2 emergency departments.

1.1.6 Summary of the diagnostic evidence

Table 5: Summary of findings for babies, children and young people

Comparison	N of studies	Sample size	Sensitivity (95%CI)	Specificity (95%CI)	Effect size (95%CI)		Quality	
					LR +	LR -	LR +	LR -
Overall								
Lung ultrasound vs Standard care (all reference standards)	21[a]	2711	0.92 (0.87, 0.95)	0.90 (0.85, 0.93)	LR+ 9.15 (6.18, 13.20)	LR- 0.10 (0.06, 0.15)	Low[b]	Low[b]
Subgroup analysis for reference standard								
Lung ultrasound vs chest x-ray alone	4[c]	430	0.91 (0.84, 0.95)	0.86 (0.69, 0.94)	LR+ 6.48 (2.79, 15.06)	LR- 0.12 (0.07, 0.22)	Moderate[e]	Very low[b,e]
Lung ultrasound vs chest x-ray with other diagnostics	17[d]	2281	0.92 (0.86, 0.96)	0.91 (0.86, 0.94)	LR+ 10.10 (6.52, 15.10)	LR- 0.09 (0.05, 0.16)	Low[b]	Low[b]
Subgroup analysis for ultrasound operator								
Lung ultrasound by trained operator vs chest x-ray	6[f]	924	0.87 (0.67, 0.96)	0.90 (0.80, 0.95)	LR+ 9.24 (4.26, 18.10)	LR- 0.16 (0.05, 0.37)	Very low[b,e]	Very low[b,e]
Lung ultrasound by standard operator vs chest x-ray	8[h]	1017	0.95 (0.92, 0.97)	0.88 (0.80, 0.93)	LR+ 8.55 (4.75, 14.60)	LR- 0.06 (0.03, 0.10)	Low[e,g]	Low[e,g]
Lung ultrasound by specialist operator vs chest x-ray	6[i]	570	0.91 (0.81, 0.96)	0.90 (0.82, 0.95)	LR+ 9.70 (4.61, 18.10)	LR- 0.10 (0.04, 0.23)	Low[b]	Low[b]
Subgroup analysis for setting								
Lung ultrasound in emergency	14[j]	1684	0.91 (0.84, 0.95)	0.87 (0.81, 0.92)	LR+ 7.39 (4.90, 10.90)	LR- 0.10 (0.05, 0.18)	Moderate[g]	Low[b]

Comparison	**N of studies**	**Sample size**	**Sensitivity (95%CI)**	**Specificity (95%CI)**	**Effect size (95%CI)**		**Quality**	
					LR +	**LR -**	**LR +**	**LR -**
department vs chest x-ray								
Lung ultrasound on ward vs chest x-ray	5[k]	503	0.92 (0.78, 0.97)	0.93 (0.83, 0.97)	LR+ 15.10 (4.75, 36.60)	LR- 0.10 (0.03, 0.25)	Low[b]	Low[b]

CI: confidence interval; LR: likelihood ratio

a Ambroggio 2016; Biagi 2018; Boursiani 2017; Caglar 2019; Caiulo 2013; Claes 2017; Copetti 2008; Ellington 2017; Esposito 2014; Guerra 2016; Gurbuz 2023; Ianniello 2016; Iorio 2015; Iuri 2009; Lissaman 2019; Reali 2014; Samson 2018; Shah 2013; Urbankowska 2015; Yilmaz 2017; Zhan 2018

b Downgraded twice for inconsistency because I^2 > 66.7%

c Esposito 2014; Iuri 2009; Lissaman 2019; Shah 2013

d Ambroggio 2016; Biagi 2018; Boursiani 2017; Caglar 2019; Caiulo 2013; Claes 2017; Copetti 2008; Ellington 2017; Guerra 2016; Gurbuz 2023; Reali 2014; Iorio 2015; Ianniello 2016; Samson 2018; Urbankowska 2015; Yilmaz 2017; Zhan 2018;

e Downgraded once for risk of bias because >33.3% of the weight in a meta-analysis came from studies at moderate or high risk of bias

f Caglar 2019, Ellington 2017, Esposito 2014, Gurbuz 2023, Lissaman 2019, Zhan 2018

g Downgraded once for inconsistency I^2 between 33.3% and 66.7%

h Biagi 2018, Caiulo 2013, Copetti 2008, Guerra 2016, Iorio 2015, Reali 2014, Shah 2013, Yilmaz 2017

I Ambroggio 2016, Boursiani 2017, Claes 2017, Ianniello 2016, Iuri 2009, Urbankowska 2015

j Biagi 2018, Boursiani 2017, Caglar 2019, Claes 2017, Copetti 2008, Guerra 2016, Gurbuz 2023, Ianniello 2016, Iuri 2009, Lissaman 2019, Samson 2018, Shah 2013, Yilmaz 2017, Zhan 2018

k Ambroggio 2016, Caiulo 2013, Iorio 2015, Reali 2014, Urbankowska 2015

Table 6: Summary of findings for adults ≥18 years

Comparison	N of studies	Sample size	Sensitivity (95%CI)	Specificity (95%CI)	Effect size (95%CI)		Quality	
					LR +	LR -	LR +	LR -
Overall								
Lung ultrasound vs Standard care (all reference standards)	15[a]	2217	0.93 (0.89, 0.96)	0.90 (0.89, 0.94)	LR+ 9.67 (5.34, 16.50)	LR- 0.08 (0.05, 0.13)	Very low[b,c]	Very low[b,c,d]
Subgroup analysis for reference standard								
Lung ultrasound vs Final clinical diagnosis + chest x-ray	4[e]	523	0.97 (0.94, 0.98)	0.87 (0.58, 0.97)	LR+ 6.61 (2.30, 19.03)	LR- 0.04 (0.01, 0.10)	Very low[b,c]	Very low[b,c,d]
Lung ultrasound vs Final clinical diagnosis + chest x-ray & CT	6[f]	806	0.92 (0.86, 0.96)	0.90 (0.79, 0.95)	LR+ 9.69 (4.26, 19.60)	LR- 0.09 (0.04, 0.17)	Low[g,c]	Very low[g,c,d]
Lung ultrasound vs Chest imaging (CXR or CT)	3[h]	539	0.94 (0.91, 0.96)	0.94 (0.72, 0.99)	LR+ 15.19 (3.03, 76.26)	LR- 0.07 (0.05, 0.10)	Low[g,c]	Very low[g,c,d]
Lung ultrasound vs CT only	2[i]	349	0.77 (0.60, 0.88)	0.95 (0.92, 0.98)	LR+ 17.68 (9.59, 32.60)	LR- 0.25 (0.13, 0.45)	Very low[b,j]	Very low[b,j,d]
Subgroup analysis for setting								
Lung ultrasound in emergency department vs Usual care	9[k]	1176	0.92 (0.84, 0.96)	0.86 (0.74, 0.93)	LR+ 6.93 (3.59, 12.70)	LR- 0.10 (0.05, 0.18)	Low[b]	Very low[b,d,j]
Lung ultrasound on ward vs Usual care	6[l]	1041	0.93 (0.91, 0.95)	0.94 (0.85, 0.98)	LR+ 17.70 (6.07, 42.00)	LR- 0.07 (0.05, 0.10)	Very low[b,c]	Very low[b,c,d]

CI: confidence interval; CT: computed tomography; CXR: chest X-ray; LR: likelihood ratio

[a] Benci 1996; Bourcier 2014; Buda 2020; Corradi 2015; Cortellaro 2012; Karademir 2021; Linsalata 2020; Mancusi 2022; Nazerian 2015; Nazerian 2016; Pagano 2015; Parlamento 2009; Reissig 2012; Sezgin 2020; Ticinesi 2016
[b] Downgraded twice for risk of bias as >33.3% of the weight in a meta-analysis came from studies at high risk of bias
[c] Downgraded once for indirectness as >33.3% of the weight in a meta-analysis came from partially direct or indirect studies
[d] Downgraded twice for inconsistency as $I^2 > 66.7\%$
[e] Benci 1996; Bourcier 2014; Buda 2020; Pagano 2015
[f] Cortellaro 2012; Karademir 2021; Mancusi 2022; Nazerian 2016; Sezgin 2020; Ticinesi 2016
[g] Downgraded once for risk of bias as >33.3% of the weight in a meta-analysis came from studies at moderate or high risk of bias
[h] Linsalata 2020; Parlamento 2009; Reissig 2012
[i] Corradi 2015; Nazerian 2015
[j] Downgraded twice for indirectness as >33.3% of the weight in a meta-analysis came from indirect studies
[k] Bourcier 2014; Corradi 2015; Cortellaro 2012; Karademir 2021; Nazerian 2015; Nazerian 2016; Pagano 2015; Parlamento 2009; Sezgin 2020
[l] Benci 1996; Buda 2020; Linsalata 2020, Mancusi 2022; Reissig 2012; Ticinesi 2016

See appendix F for full GRADE tables.

1.1.7 Economic evidence

1.1.7.1 Included studies

A single search was performed to identify published economic evaluations of relevance to any of the questions in this guideline update. See Appendix B – Literature search strategies for the search strategy.

This search retrieved 3,201 studies. Based on title and abstract screening, 3,168 of the studies could confidently be excluded for this question. Thirty-three studies were excluded following the full-text review. See Appendix G – Economic evidence study selection for the study selection process.

1.1.7.2 Excluded studies

See **Error! Reference source not found.** for a list of excluded studies, with reasons for exclusions.

1.1.8 Summary of included economic evidence

No health economic evidence was included.

1.1.9 Economic model

No original health economic modelling was done for this review question.

1.1.10 The committee's discussion and interpretation of the evidence

1.1.10.1. The outcomes that matter most

The committee agreed with the use of likelihood ratios as primary outcome measures for this review because the interpretation of these measures is easier to understand in relation to the meaning of the lung ultrasound test result: a positive lung ultrasound test increases the likelihood of the patient having pneumonia, and a negative lung ultrasound test decreases it. The committee agreed that the positive likelihood ratio was the most important outcome because it could help to identify patients with pneumonia that required treatment, but they agreed that negative likelihood ratios were also important for providing useful information to help with the decision to rule out pneumonia.

The committee considered the consequences of late, missed, or misdiagnosis of pneumonia in babies, children, young people and adults. The committee recognised that there are 4 possible scenarios related to the use of lung ultrasound to diagnose pneumonia:

- The lung ultrasound accurately identifies a person as having pneumonia (a true positive). Antibiotic treatment can be promptly initiated and the correct care pathway is adopted.
- The lung ultrasound correctly rules out the presence of pneumonia (a true negative). Antibiotic treatment is not unnecessarily initiated and other diagnoses can be explored.
- The lung ultrasound suggests the presence of pneumonia in a patient that does not have pneumonia (a false positive). In this scenario, the patient is likely to undergo unnecessary

treatment with antibiotics, which can have side effects and may lead to a greater risk of antimicrobial resistance, with both individual and wider societal consequences. It may also delay the investigation, diagnosis and treatment of their actual illness.

- The lung ultrasound rules out the presence of pneumonia in a patient that does in fact have pneumonia (a false negative). A missed diagnosis of pneumonia may delay treatment initiation, the impact of which can vary depending on a range of factors (such as the patients' age, frailty, and the severity of the infection) but can include additional suffering caused by untreated infection and the development of complications.

The committee agreed that there needs to be an appropriate balance between the sensitivity and specificity of a test to best reduce the number of patients falling into the latter 2 scenarios (false positives and false negatives). With respect to lung ultrasound for diagnosing pneumonia, they agreed that preventing false negatives was marginally more important than avoiding false positives, but that both were of interest when evaluating the diagnostic accuracy of this test.

1.1.10.2 The quality of the evidence

Existing systematic reviews were used to identify key studies for this evidence review. Dong (2023) in babies, children and young people and Strom (2020) in adults matched the criteria for inclusion outlined in the review protocol for this question and were both recent and well conducted reviews. These reviews both included studies from outside the OECD, so a subsection of the most relevant studies from each review was extracted by selecting only studies from OECD countries, as per the protocol. This yielded 17 studies from Dong (2023) and 10 studies from Strom (2020).

In the review of adults, the 10 studies from Strom (2020) were supplemented with 6 studies from the top up search. Of these 16 studies for adults, 9 were considered to be at high risk of bias, 1 was considered to raise some concerns about bias, and the remaining 6 studies were at low risk of bias. The high risk of bias was mainly due to issues with patient selection and the study authors not providing clear information on the inclusion and exclusion criteria. 9 studies raised concerns about applicability due to factors such as being based on an older population aged >80 years, there being a high proportion of bedridden patients, or samples including patients with a range of respiratory complaints or conditions requiring chest imaging that were not specific to pneumonia.

In the review of babies, children and young people, the 17 studies from Dong (2023) were supplemented with 4 studies from the top up search. Of these 21 studies, 3 were considered to be at high risk of bias, 5 were considered to raise some concerns about bias, and the remaining 13 were at low risk of bias. The high risk of bias was mainly due to concerns about patient selection or lack of detail about the reference standard. One of these studies was judged to be indirectly applicable as it contained a population who already had bronchiolitis prior to pneumonia, and all others were directly applicable.

The committee noted that most of the outcomes for babies, children and young people were rated as low or very low using GRADE. The overall likelihood ratios were both low quality. Similarly for adults, all outcomes were either low or very low using GRADE. Common reasons for downgrading were due to the high risk of bias of the included studies, indirectness, and heterogeneity of study results included in the meta-analyses as indicated by very high I^2 values.

The committee considered the reference standards that had been used across the studies. They considered clinical diagnosis plus chest x-ray (CXR) to be most representative of usual care when diagnosing pneumonia. They highlighted that although CT is often considered the gold standard, it is not commonly used in adults for the routine diagnosis of pneumonia and is mainly reserved for use when the CXR is equivocal or when investigating complications in a deteriorating patient. CT is almost never used for the diagnosis of pneumonia in children. The committee agreed that although CXR is usually standard practice for diagnosing pneumonia, it is not a perfect reference standard and both false positives and false negatives occur. They recognised that for the purposes of analysis in a diagnostic test accuracy review, the reference standard is assumed to be 100% sensitive and specific but agreed that in practice CXR is far less so. This lack of an accurate reference standard can affect the classification of index test results, so the committee agreed that the findings for LUS need to be interpreted with this in mind. Despite the limitations of using CXR as a reference standard, the committee nevertheless agreed that the pattern and strength of findings for lung ultrasound (LUS) did not differ significantly across the different reference standards, suggesting that the available evidence was useful as a basis for decision making.

The committee had identified several subgroups of interest in the review protocol. This included subgroup analysis by reference standard, operator experience and training, and age, so subgroup analyses were reported for these domains. The committee were also interested in whether diagnostic accuracy differed depending on the hospital setting where it was conducted, so they added this to subgroup analyses via a protocol deviation. Subgroup analyses could not be done for operator experience for the studies of adults due to lack of available data (all studies were of non-specialist physicians with experience of LUS and could not be meaningfully grouped by level of experience). Subgroup analyses were also not possible for other subgroups listed in the protocol because of a lack of available data: there were no studies of hospital acquired pneumonia (HAP) so it was not possible to subgroup by CAP vs HAP; there was limited data on CAP severity in most of the included studies so it was not possible to subgroup by disease severity; the types of ultrasound device or probe used were too diverse to meaningfully subgroup for analysis, and the studies of children mostly only reported a mean or median age without providing a range, or the range spanned a wide age range, so age could not be subgrouped into those specified in the protocol (0-1, 1-5, 5-18 years).

1.1.10.3 Benefits and harms

The evidence supports lung ultrasound as a good diagnostic tool, with little difference in accuracy from the reference standard of chest x-ray (and clinical diagnosis or CT). Subgroup analyses showed that its accuracy did not differ noticeably between different hospital settings or depending on the experience of the operator for children.

The committee noted the main benefit of using lung ultrasound is that it avoids radiation exposure from x-rays and thus reduces risk and harm to the patient. They also noted that as a point of care tool it can be used during a bedside clinical examination to narrow down a diagnosis when pneumonia is suspected and thus allow for antibiotics to be started promptly if needed. This is particularly valuable in emergency care settings where patients are acutely unwell and rapid treatment provides the greatest benefit. Chest x-ray, by comparison, can take longer to reach a diagnosis due to the process of requesting a test, arranging a transfer to the x-ray department, and then following up on the results, so although the test itself is relatively quick to perform, the entire process can amount to a significant delay to diagnosis. For patients who require a CT scan, this can be even longer due to the high demand for CT which causes long waiting times. Additionally, lung ultrasound can be used in settings where x-ray and CT are not available.

Despite these advantages, the committee noted several concerns about lung ultrasound and agreed not to recommend replacing the current practice of using chest x-ray as the principle diagnostic tool for pneumonia. Their main concern was that lung ultrasound is less able to detect complications or other serious illnesses that may be underlying, such as lymphoma, that would be detected on a chest x-ray. Furthermore, the images on an ultrasound may not be recorded and stored in a way that allows for them to be re-examined by a multidisciplinary team in the way that x-ray images are. The lack of quality assurance by consensus interpretation adds to the risk of missed diagnoses and thus potential for harm.

There are also practical considerations, in that a diagnostic lung ultrasound can be more time consuming to perform than chest x-ray and it can be difficult to scan posteriorly. Compared to x-ray which quickly provides an image of both lungs, lung ultrasound takes longer to examine the whole area of the lungs, particularly with very unwell patients who are laying down and with patients who have a high BMI. This adds to the burden on the clinician’s time, as well as potentially being uncomfortable for the patient who may be very breathless and find it difficult to sit up for long enough. Sitting still while being scanned may be particularly difficult for acutely unwell children.

Overall, the committee concluded that despite the good diagnostic performance of lung ultrasound shown in the evidence, lung ultrasound should not replace chest x-ray as the primary diagnostic tool for pneumonia, particularly due to the risk of missed diagnoses and the resource implications of implementing this approach as standard practice. Nevertheless, they recognised that it could be a valuable option alongside existing diagnostic processes in secondary care, so they made a recommendation about this.

1.1.10.4 Cost effectiveness and resource use

There were no health economic studies included in this review question. The committee acknowledged that lung ultrasound is currently not routinely done and not many members of staff are trained in it. The committee acknowledged the potential benefits of ultrasound over chest x-ray, for example there being no radiation exposure. They also noted that an ultrasound can be done at a patient's bedside whereas porters need to collect someone for an x-ray. The committee noted that lung ultrasound may not be able to identify more serious illnesses, resulting in missed diagnoses, potential harm, and increased costs to the NHS.

The committee also discussed the practicalities of potentially replacing chest x-ray with lung ultrasound as the primary diagnostic tool for pneumonia. For example, lung ultrasound can be more time consuming, difficult to undertake in some people, and it cannot be recorded and stored in a way that allows for them to be re-examined by the multidisciplinary team. Therefore, given the above, and lack of resources and trained personnel, the committee were reluctant to recommend ultrasound as a primary diagnostic tool. Instead, the committee agreed that where available and where there is an accredited operator lung ultrasound could be helpful as an adjunct to usual clinical care in selected cases, in secondary care. Since the recommendation is not implying the acquisition of new lung ultrasound scanners and their use is limited to a subset of people, this recommendation is not expected to result in a significant resource impact.

1.1.12.5 Other factors the committee took into account

The committee raised concerns about the workforce readiness of implementing any recommendations made about lung ultrasound. They highlighted that there may be a lack of healthcare professionals with the appropriate level of training and experience required to perform lung ultrasounds; that the training is comprehensive, can take a long time to complete, and can be quite difficult to access. Though they also noted ongoing efforts by professional bodies to provide training in this area. They discussed that the training of medical students in LUS may equip the future workforce, but that there is currently an insufficient number of trained operators to cope with the likely increase in demand if they were to recommend LUS in place of CXR. They emphasised that using lung ultrasound for diagnosing pneumonia may only be possible in settings where both the device and a suitably trained operator are available.

1.1.13 Draft recommendations supported by this evidence review

This evidence review supports recommendation 1.1.2.

1.1.15 References – included studies

1.1.15.1 Diagnostic

1.1.15.1.1 Babies, children and young people

Studies included from Dong 2023

Boursiani, Contantinia, Tsolia, Maria, Koumanidou, Chrysoula et al. (2017) Lung Ultrasound as First-Line Examination for the Diagnosis of Community-Acquired Pneumonia in Children. Pediatric emergency care 33(1): 62-66

Caiulo, Vito Antonio, Gargani, Luna, Caiulo, Silvana et al. (2013) Lung ultrasound characteristics of community-acquired pneumonia in hospitalized children. Pediatric pulmonology 48(3): 280-7

Claes, Anne-Sophie, Clapuyt, Philippe, Menten, Renaud et al. (2017) Performance of chest ultrasound in pediatric pneumonia. European journal of radiology 88: 82-87

Copetti, R and Cattarossi, L (2008) Ultrasound diagnosis of pneumonia in children. La Radiologia medica 113(2): 190-8

Ellington, Laura E, Gilman, Robert H, Chavez, Miguel A et al. (2017) Lung ultrasound as a diagnostic tool for radiographically-confirmed pneumonia in low resource settings. Respiratory medicine 128: 57-64

Esposito, Susanna, Papa, Simone Sferrazza, Borzani, Irene et al. (2014) Performance of lung ultrasonography in children with community-acquired pneumonia. Italian journal of pediatrics 40: 37

Guerra, Mattia, Crichiutti, Giovanni, Pecile, Paolo et al. (2016) Ultrasound detection of pneumonia in febrile children with respiratory distress: a prospective study. European journal of pediatrics 175(2): 163-70

Gurbuz, N., Zengin, N., Karaburun, N.C. et al. (2023) A Comparison Study in Children with Lower Respiratory Tract Infections: Chest X-ray and Lung Ultrasound. Journal of Pediatric Research 10(2): 102-105

Ianniello, Stefania, Piccolo, Claudia Lucia, Buquicchio, Grazia L et al. (2016) First-line diagnosis of paediatric pneumonia in emergency: lung ultrasound (LUS) in addition to chest-X-ray (CXR) and its role in follow-up. The British journal of radiology 89(1061): 20150998

Iorio, Giulio, Capasso, Maria, De Luca, Giuseppe et al. (2015) Lung ultrasound in the diagnosis of pneumonia in children: proposal for a new diagnostic algorithm. PeerJ 3: e1374

Iuri, D; De Candia, A; Bazzocchi, M (2009) Evaluation of the lung in children with suspected pneumonia: usefulness of ultrasonography. La Radiologia medica 114(2): 321-30

Reali, Francesca, Sferrazza Papa, Giuseppe Francesco, Carlucci, Paolo et al. (2014) Can lung ultrasound replace chest radiography for the diagnosis of pneumonia in hospitalized children?. Respiration; international review of thoracic diseases 88(2): 112-5

Samson, Frederic, Gorostiza, Inigo, Gonzalez, Andres et al. (2018) Prospective evaluation of clinical lung ultrasonography in the diagnosis of community-acquired pneumonia in a pediatric emergency department. European journal of emergency medicine : official journal of the European Society for Emergency Medicine 25(1): 65-70

Shah, Vaishali P; Tunik, Michael G; Tsung, James W (2013) Prospective evaluation of point-of-care ultrasonography for the diagnosis of pneumonia in children and young adults. JAMA pediatrics 167(2): 119-25

Urbankowska, Emilia, Krenke, Katarzyna, Drobczynski, Lukasz et al. (2015) Lung ultrasound in the diagnosis and monitoring of community acquired pneumonia in children. Respiratory medicine 109(9): 1207-12

Yilmaz, Hayri Levent, Ozkaya, Ahmet Kagan, Sari Gokay, Sinem et al. (2017) Point-of-care lung ultrasound in children with community acquired pneumonia. The American journal of emergency medicine 35(7): 964-969

Zhan, Chen; Grundtvig, Natalia; Klug, Bent Helmuth (2018) Performance of Bedside Lung Ultrasound by a Pediatric Resident: A Useful Diagnostic Tool in Children With Suspected Pneumonia. Pediatric emergency care 34(9): 618-622

Studies included from the search

Ambroggio, Lilliam, Sucharew, Heidi, Rattan, Mantosh S et al. (2016) Lung Ultrasonography: A Viable Alternative to Chest Radiography in Children with Suspected Pneumonia?. The Journal of pediatrics 176: 93-98e7

Biagi, Carlotta, Pierantoni, Luca, Baldazzi, Michelangelo et al. (2018) Lung ultrasound for the diagnosis of pneumonia in children with acute bronchiolitis. BMC pulmonary medicine 18(1): 191

Caglar, A., Ulusoy, E., Er, A. et al. (2019) Is lung ultrasonography a useful method to diagnose children with community-acquired pneumonia in emergency settings?. Hong Kong Journal of Emergency Medicine 26(2): 91-97

Dong, Zhenghao, Shen, Cheng, Tang, Jinhai et al. (2023) Accuracy of Thoracic Ultrasonography for the Diagnosis of Pediatric Pneumonia: A Systematic Review and Meta-Analysis. Diagnostics (Basel, Switzerland) 13(22)

Lissaman, Claire, Kanjanauptom, Panida, Ong, Cyril et al. (2019) Prospective observational study of point-of-care ultrasound for diagnosing pneumonia. Archives of disease in childhood 104(1): 12-18

1.1.15.1.2 Adults ≥18 years

Studies included from Strom 2020

Benci A, Caremani M, Menchetti D. (1996) Sonographic diagnosis of pneumonia and bronchopneumonia. European Journal of Ultrasound 4: 169–76.

Bourcier, Jean-Eudes, Paquet, Julie, Seinger, Mickael et al. (2014) Performance comparison of lung ultrasound and chest x-ray for the diagnosis of pneumonia in the ED. The American journal of emergency medicine 32(2): 115-8

Cipollini, F. and Mirauta, C.M. (2018) Bedside lung ultrasound in the diagnosis of pneumonia in very old patients. Italian Journal of Medicine 12(2): 126-130

Corradi, Francesco, Brusasco, Claudia, Garlaschi, Alessandro et al. (2015) Quantitative analysis of lung ultrasonography for the detection of community-acquired pneumonia: a pilot study. BioMed research international 2015: 868707

Cortellaro, Francesca, Colombo, Silvia, Coen, Daniele et al. (2012) Lung ultrasound is an accurate diagnostic tool for the diagnosis of pneumonia in the emergency department. Emergency medicine journal : EMJ 29(1): 19-23

Nazerian, Peiman, Volpicelli, Giovanni, Vanni, Simone et al. (2015) Accuracy of lung ultrasound for the diagnosis of consolidations when compared to chest computed tomography. The American journal of emergency medicine 33(5): 620-5

Pagano, Antonio, Numis, Fabio Giuliano, Visone, Giuseppe et al. (2015) Lung ultrasound for diagnosis of pneumonia in emergency department. Internal and emergency medicine 10(7): 851-4

Parlamento, Stefano; Copetti, Roberto; Di Bartolomeo, Stefano (2009) Evaluation of lung ultrasound for the diagnosis of pneumonia in the ED. The American journal of emergency medicine 27(4): 379-84

Reissig, Angelika, Copetti, Roberto, Mathis, Gebhard et al. (2012) Lung ultrasound in the diagnosis and follow-up of community-acquired pneumonia: a prospective, multicenter, diagnostic accuracy study. Chest 142(4): 965-972

Ticinesi, Andrea, Lauretani, Fulvio, Nouvenne, Antonio et al. (2016) Lung ultrasound and chest x-ray for detecting pneumonia in an acute geriatric ward. Medicine 95(27): e4153

Studies included from the search

Buda, Natalia, Hajduk, Adam, Jaworska, Joanna et al. (2020) Lung Ultrasonography as an Accurate Diagnostic Method for the Diagnosis of Community-Acquired Pneumonia in the Elderly Population. Ultrasound quarterly 36(2): 111-117

Karademir, D., Yilmaz, S., Ozturan, I.U. et al. (2021) Performance of bedside lung ultrasound in emergency (BLUE) protocol in the diagnosis of pneumonia. Notfall und Rettungsmedizin 24(supplement1): 9-14

Linsalata, Giuseppe, Okoye, Chukwuma, Antognoli, Rachele et al. (2020) Pneumonia Lung Ultrasound Score (PLUS): A New Tool for Detecting Pneumonia in the Oldest Patients. Journal of the American Geriatrics Society 68(12): 2855-2862

Mancusi, Costantino, Fucile, Ilaria, Gargiulo, Paola et al. (2022) Lung Ultrasound in Coronary Care Unit, an Important Diagnostic Tool for Concomitant Pneumonia. Diagnostics (Basel, Switzerland) 12(12)

Nazerian, Peiman, Cerini, Gabriele, Vanni, Simone et al. (2016) Diagnostic accuracy of lung ultrasonography combined with procalcitonin for the diagnosis of pneumonia: a pilot study. Critical ultrasound journal 8(1): 17

Sezgin, Canbahar, Gunalp, Muge, Genc, Sinan et al. (2020) Diagnostic Value of Bedside Lung Ultrasonography in Pneumonia. Ultrasound in medicine & biology 46(5): 1189-1196

Strom, Julie Jepsen, Haugen, Pia Sperling, Hansen, Malene Plejdrup et al. (2020) Accuracy of lung ultrasonography in the hands of non-imaging specialists to diagnose and assess the severity of community-acquired pneumonia in adults: a systematic review. BMJ open 10(6): e036067

Unlukaplan, Isik Melike; Dogan, Halil; Ozucelik, Dogac Niyazi (2020) Lung ultrasound for the diagnosis of pneumonia in adults. JPMA. The Journal of the Pakistan Medical Association 70(6): 989-992

1.1.15.2 Economic

No health economic studies were included.

Appendices

Appendix A – Review protocols

Review protocol for diagnostic accuracy of lung ultrasound

ID	Field	Content
1.	Review title	What is the diagnostic accuracy of lung ultrasound compared to chest x-ray for diagnosing community acquired pneumonia (CAP) and hospital acquired pneumonia (HAP)?
2.	Review question	What is the diagnostic accuracy of lung ultrasound compared to chest x-ray for diagnosing community and hospital acquired pneumonia?
3.	Objective	To establish the diagnostic accuracy of lung ultrasound compared to chest x-ray for diagnosing CAP or HAP.
4.	Searches	**Overall approach** The searches will comprise the following elements: • a combined search for cost effectiveness evidence covering all review questions in this guideline. • a combined search for systematic reviews covering all review questions in this guideline. • searches for effectiveness evidence specific to this review question.

		Searches for cost effectiveness evidence A combined search will be undertaken to cover the cost effectiveness aspects of all the review questions in a single search. The following databases will be searched for the cost effectiveness evidence: • Econlit via Ovid • Embase via Ovid • International HTA database via INAHTA website • MEDLINE ALL via Ovid The sensitive version of the validated NICE cost utility filter will be applied to the MEDLINE and Embase search strategies (Hubbard et al., 2022 [doi: 10.1186/s12874-022-01796-2]). Searches for cost effectiveness evidence will be limited to 2014-current (the searches for NICE guideline CG191 were completed in March 2014). The MEDLINE and Embase searches will be limited to evidence from Organisation for Economic Co-operation and Development (OECD) member states using the validated NICE filter (Ayiku et al., 2021 [doi: 10.5195/jmla.2021.1224]). **Effectiveness evidence: combined search for systematic reviews** The search for systematic reviews relating to all review questions in this guideline will cover reviews published since the searches for NICE guideline CG191 were completed in March 2014. The sources for this will be: • Cochrane Database of Systematic Reviews (CDSR) via Wiley

		• Epistemonikos via https://www.epistemonikos.org/ This is the standard NICE practice agreed by the Guidelines Methods Group in September 2022 for identifying systematic reviews for routine guideline searches. **Effectiveness evidence: searches specific to this review question** The searches for effectiveness evidence specific to this review question will use the following databases: • Cochrane Central Register of Controlled Trials (CENTRAL) via Wiley • Embase via Ovid • MEDLINE ALL via Ovid The principal search strategy will be developed in MEDLINE and then adapted, as appropriate, for use in the other sources listed, taking into account their size, search functionality and subject coverage. To ensure potentially relevant records are not missed the following will be checked as required: • The reference lists of any appropriate studies. • Later citations of any key studies. The seed references for these actions could comprise key reviews, trials, protocols or other papers. They will be identified from the search for systematic reviews, the scoping searches for this guideline, or the evidence reviews for previous NICE guidelines. The guideline committee or other stakeholders could also be asked if they are aware of any other potentially relevant studies that could be considered. No date limits will be applied as this is a new review question.

		A validated study filter for diagnostic test accuracy studies will be applied. **Managing all search results** Database functionality will be used, where available, to exclude from all searches: • Animal studies • Conference abstracts and posters • Editorials, letters, news items and commentaries • Registry entries for ongoing clinical trials or those that contain no results • Theses and dissertations • Papers not published in the English language With the agreement of the guideline committee, the searches will be re-run 6-8 weeks before final submission of the review and further studies retrieved for inclusion. The information services team at NICE will quality assure the principal search strategy and peer review the other strategies. Any revisions or additional steps will be agreed by the review team before being implemented. The full search strategies for all databases will be published in the final review.
5.	Condition or domain being studied	Community- or hospital-acquired pneumonia
6.	Population	<u>Inclusion:</u>

		Babies over 28 days (corrected gestational age), children, young people (age <18 years) and adults (≥18 years) with suspected pneumonia (community or hospital acquired) in secondary care settings (e.g. ED, ICU, respiratory wards). • CAP is defined as pneumonia that is acquired outside hospital • HAP is defined as pneumonia that occurs 48 hours or more after admission to hospital and is not incubating at hospital admission, or within 10 days of a previous hospital admission for a different problem. Exclusion: • Babies up to and including 28 days (corrected gestational age). • People with COVID-19 pneumonia. • People who acquire pneumonia while intubated (ventilator-associated pneumonia). • People who are severely immune-compromised (have a primary immune deficiency or secondary immune deficiency related to HIV infection, or severe drug or systemic disease-induced immunosuppression, for example, people who have taken immunosuppressant cancer therapy or undergone organ transplantation).

		• People in whom pneumonia is an expected terminal event. • People with non-pneumonic infective exacerbations of bronchiectasis. • People with non-pneumonic infective exacerbations of chronic obstructive pulmonary disease. • People with pneumonia associated with cystic fibrosis. • People with aspiration pneumonia as a result of inhaling a large bolus of gastric contents.
7.	Intervention/Exposure/Test	Lung ultrasound
8.	Reference standard	Chest imaging: x-ray or CT (with or without clinical diagnosis). Data will be stratified by reference standard used.
9.	Types of study to be included	• Cross sectional studies • Cohort studies (prospective studies are preferred; step down to retrospective if insufficient evidence from prospective, or if included SR contains retrospective). • Systematic reviews of the above

10.	Other exclusion criteria	
11.	Context	Chest radiography is the primary imaging modality used for the evaluation of pneumonia, but lung ultrasound may also be useful for diagnosing pneumonia and is a method that has been gaining popularity in recent years. It has a more favourable safety profile (because it doesn't expose patients to radiation), a lower cost than chest x-ray and CT, and it can be used at the bedside to provide immediate results. However, the diagnostic accuracy of LUS for pneumonia remains uncertain.
12.	Primary outcomes (critical outcomes)	Sensitivity, specificity, LR+, LR- Likelihood ratios are NICE's preferred measures and sens/spec will be converted to LR+/-
13.	Secondary outcomes (important outcomes)	
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.

		The full text of potentially eligible studies will be retrieved and will be assessed in line with the criteria outlined above. Any disagreements will be resolved by discussion with other members of the technical review team. A standardised form will be used to extract data from studies (see Developing NICE guidelines: the manual section 6.4). Study investigators may be contacted for missing data where time and resources allow. The priority screening functionality within the EPPI-reviewer software will not be used for this review.
15.	Risk of bias (quality) assessment	Risk of bias will be assessed using the appropriate checklist as described in Developing NICE guidelines: the manual. For SRs, the ROBIS (Risk of Bias in Systematic Reviews) checklist will be used. For diagnostic accuracy studies, the QUADAS-2 will be used.
16.	Strategy for data synthesis	Meta-analyses of diagnostic test accuracy data will be conducted for all diagnostic test outcomes that are reported by more than one study, with reference to the

		Cochrane Handbook for systematic reviews of diagnostic test accuracy. Random-effects models will be fitted for all analyses. Where data can be disambiguated it will be separated into the subgroups identified in section 17 (below). In any meta-analyses where some (but not all) of the data comes from studies at high risk of bias, a sensitivity analysis will be conducted, excluding those studies from the analysis. Results from both the full and restricted meta-analyses will be reported. Similarly, in any meta-analyses where some (but not all) of the data comes from indirect studies, a sensitivity analysis will be conducted, excluding those studies from the analysis. GRADE will be used to assess the quality of the outcomes. GRADE assessments will only be undertaken for positive and negative likelihood ratios but results for sensitivity and specificity will be presented alongside those data. Where 10 or more studies are included as part of a single meta-analysis, a funnel plot will be produced to graphically (visually) assess the potential for publication bias. Default MIDs will be used: 0.80 and 1.25 for dichotomous outcomes; 0.5 times the control group SD for continuous outcomes. Two clinical decision thresholds will be

		used to judge imprecision for positive and negative likelihood ratios: the likelihood ratio above (or below for negative likelihood ratios) which a test would be recommended, and a second below (or above for negative likelihood ratios) which a test would be considered of no clinical use. Default values of 2 for LR+ and 0.5 for LR- were used, with the line of no effect (being 1.0) as the second clinical decision line in both cases.
17.	Analysis of sub-groups	Where data is available and can be disambiguated, pre-planned analysis of subgroups will be conducted for: • CAP and HAP • CAP severity, measured by PSI or CURB-65 • Age: 0-1; 1-5; 5-18; 18+ • Level of training of the person performing the ultrasound (e.g. novice / non-imaging specialist vs advanced sonographers) • Ultrasound alone vs ultrasound within the context of clinical examination and assessment • Type of US/probe
18.	Type and method of review	☐ Intervention ☒ Diagnostic ☐ Prognostic ☐ Qualitative

		☐ Epidemiologic ☐ Service Delivery ☐ Other (please specify)		
19.	Language	English		
20.	Country	England		
21.	Anticipated or actual start date	TBC		
22.	Anticipated completion date	TBC		
23.	Stage of review at time of this submission	**Review stage**	**Started**	**Completed**
		Preliminary searches	☐	☐
		Piloting of the study selection process	☐	☐

		Formal screening of search results against eligibility criteria	☐	☐
		Data extraction	☐	☐
		Risk of bias (quality) assessment	☐	☐
		Data analysis	☐	☐
24.	Named contact	**5a. Named contact** Guideline Development Team B, Centre for Guidelines, NICE. **5b Named contact e-mail** pneumoniadev@nice.org.uk **5c Organisational affiliation of the review** National Institute for Health and Care Excellence (NICE)		

25.	Review team members	From the Guideline Development Team: • Chris Carmona, Technical Advisor • Hannah Stockton, Technical Analyst • Michellie Young, Technical Analyst • Steph Armstrong, Health Economist • Eric Slade, Health Economic Advisor • Paul Levay, Information specialist • Christine Harris, Project Manager • Adam O'Keefe, Project Manager
26.	Funding sources/sponsor	This systematic review is being completed by the Guideline Development 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 Developing NICE guidelines: the manual. Members of the guideline committee are available on the NICE website: : Project information | Pneumonia: diagnosis and management (update) | Guidance | NICE
29.	Other registration details	
30.	Reference/URL for published protocol	
31.	Dissemination plans	NICE may use a range of different methods to raise awareness of the guideline. These include standard approaches such as: • notifying registered stakeholders of publication • publicising the guideline through NICE's newsletter and alerts • 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.

32.	Keywords	Pneumonia, community acquired infections, hospital acquired infections, lung ultrasound, chest x-ray, chest imaging, diagnosis.
33.	Details of existing review of same topic by same authors	None
34.	Current review status	☒ Ongoing ☐ Completed but not published ☐ Completed and published ☐ Completed, published and being updated ☐ Discontinued

35..	Additional information	
36.	Details of final publication	www.nice.org.uk

CAP: community acquired pneumonia; CDSR: Cochrane Database of Systematic Reviews; CENTRAL: Cochrane Central Register of Controlled Trials; CT: computed tomography; DARE: Database of Abstracts of Reviews of Effects; ED: emergency department; EPPI: Evidence for Policy & Practice Information; GRADE: Grading of Recommendations Assessment, Development and Evaluation; HAP: hospital acquired pneumonia; HIV: human immunodeficiency virus; HTA: Health Technology Assessment; ICU: intensive care unit; INAHTA: International Network of Agencies for Health Technology Assessment; LR: likelihood ratio; LUS: lung ultrasound; MID: minimally important difference; NHS: National health service; NICE: National Institute for Health and Care Excellence; OECD: Organization for Economic Cooperation and Development; QUADAS-2: quality assessment tool for diagnostic accuracy studies; RCT: randomised controlled trial; RoB: risk of bias; ROBIS: risk of bias in systematic reviews; SD: standard deviation; SR: systematic review; US: ultrasound

Appendix B – Literature search strategies

Background and development

Overall approach

Each evidence review for this guideline has a search conducted in three parts:

- Part 1: Systematic review searches

A single search for all systematic reviews relating to pneumonia published from 2014-current was done separately in November 2023 and re-run in October 2024. The results were screened for relevance to all the review questions. The potentially relevant results from this search were also used to create the seed references for reference list checking and forward citation searching for the diagnostic evidence searches.

- Part 2: Diagnostic evidence searches

This search was developed separately and tailored to each evidence review. The searches for Diagnostic evidence (Part 2) were run on 19 April 2024 and re-run on 7 August 2024.

- Part 3: Cost effectiveness searches

A single search covering the cost effectiveness elements of all review questions was done separately in November 2023 and re-run in October 2024. This was a top-level search for all cost utility studies published from 2014-current.

Search design and peer review

A NICE Senior Information Specialist (SIS) conducted the literature searches for each part.

This search report is based on the requirements of the PRISMA Statement for Reporting Literature Searches in Systematic Reviews (for further details see: Rethlefsen M et al. PRISMA-S. *Systematic Reviews*, 10(1), 39).

The MEDLINE strategies below were quality assured (QA) by a trained NICE SIS. The principal search strategies were developed in MEDLINE (Ovid interface) and adapted, as appropriate, for use in the other sources listed in the protocol, taking into account their size, search functionality and subject coverage. All translated search strategies were peer reviewed by another SIS to ensure their accuracy. The QA procedures were adapted from the Peer Review of Electronic Search Strategies Guideline Statement (for further details see: McGowan J et al. PRESS 2015 Guideline Statement. *Journal of Clinical Epidemiology*, 75, 40-46).

Review management

All search results were managed in EPPI-Reviewer v5. Duplicates were removed in EPPI-R5 using a two-step process. First, automated deduplication is performed using a high-value algorithm. Second, manual deduplication is used to assess 'low-probability' matches. All decisions made for the review can be accessed via the deduplication history.

Search limits, restrictions and filters

Formats

Limits were applied in adherence to standard NICE practice (as set out in the Identifying the evidence chapter of the manual) and the eligibility criteria listed in the review protocol to exclude:

- Animal studies
- Case reports
- Conference abstracts and posters
- Editorials, letters, news items and commentaries
- References not published in the English language
- Registry entries for ongoing clinical trials or those that contain no results
- Theses and dissertations.

The limit to remove animal studies in the searches was the standard NICE practice, which has been adapted from:

> Dickersin K, Scherer R & Lefebvre C. (1994) Systematic Reviews: Identifying relevant studies for systematic reviews. *BMJ*, 309(6964), 1286.

OECD countries

For the Cost Effectiveness (Part 3) searches, the validated NICE OECD filters were used in MEDLINE and Embase to remove references exclusively set in countries that are not members of the Organisation for Economic Co-operation and Development (OECD), in line with the search protocol. The filters were used without amendment. The filters are not available for the other databases used. The OECD filters were not applied to the Systematic Review (Part 1) or Effectiveness (Part 2) searches.

> Ayiku L et al. (2021) The NICE OECD countries' geographic search filters: Part 2 - Validation of the MEDLINE and Embase (Ovid) filters. *Journal of the Medical Library Association*, 109(4), 583–589.

The OECD filter was not applied to the Systematic Review (Part 1) or Effectiveness (Part 2) searches.

Date limits

A date limit of 2014-current was applied to the Systematic Review (Part 1) and Cost Effectiveness (Part 3) searches. This date limit was used because the searches for NICE

CG191 Pneumonia in adults: diagnosis and management (published in December 2014) were last run on 17 March 2014.

The Effectiveness searches (Part 2) did not apply any date limits as this was a new question that had not been covered in CG191.

Study-type filters

The Systematic Review (Part 1) searches had no filters, as the content for CDSR and Epistemonikos is pre-filtered.

The searches for Effectiveness (Part 2) applied a Diagnostic Test Accuracy filter in MEDLINE and Embase, as specified in the protocol. The filter was the one used in standard practice for NICE.

Cost effectiveness searches

In line with the protocol, the validated NICE Cost Utility Filter was used in the MEDLINE and Embase searches for Cost Effectiveness (Part 3). The sensitive version of the filter was selected and it was used without amendment. Subject coverage in the Econlit, International HTA Database and NHS EED databases is already pre-specified and so it is not appropriate to apply filters in them.

> Hubbard W et al. (2022) Development and validation of paired MEDLINE and Embase search filters for cost-utility studies. *BMC Medical Research Methodology*, 22(1), 310.

Key decisions

Part 1: Systematic review searches

This search was conducted according to the standard NICE practice since the "Proposal to limit systematic review (SR) searching for routine guideline searches" was accepted by the NICE Guideline Methods Group (GMG) in September 2022. This process means that only sources which aggregate systematic reviews are searched in addition to the Cochrane Database of Systematic Reviews. The methods used to aggregate reviews for Epistemonikos are sufficiently sensitive with higher precision (Rada et al., 2020) compared to using standard Boolean search filters in general medical databases (Lee et al., 2012). Testing during scoping showed that other aggregators of systematic reviews, such as the Campbell Collaboration, Dopher and Health Evidence, would not be relevant for inclusion in this protocol.

> Lee E. et al. (2012) An optimal search filter for retrieving systematic reviews and meta-analyses. *BMC Medical Research Methodology,* 12(1), 51.
>
> Rada G et al. (2020) Epistemonikos: a comprehensive database of systematic reviews for health decision-making. *BMC Medical Research Methodology*, 20, 286.

Parts 1-3: Pneumonia terms

The same set of pneumonia terms was developed in November 2023 to use in all evidence reviews for this guideline. These terms aimed to cover all the included populations named in the final scope (section 3.1), namely babies over 28 days (corrected gestational age), children, young people and adults with suspected or diagnosed community-acquired or hospital acquired pneumonia.

A set containing 183 items was created to test the comprehensiveness of the searches. The 183 records were derived from the papers included in CG191 and the papers included in the 10 most recent Cochrane reviews about pneumonia.

The search terms built on the search strategies developed for NICE CG191 Pneumonia in adults and two antibiotic prescribing guidelines (NG138 and NG139).

The CG191 searches had a line to NOT out the MeSH term "pneumonia, ventilator-associated". This was not retained in the search as it was inadvertently excluding relevant papers that discussed several types of pneumonia (e.g. see PMIDs 29722052 or 32822880 or 28655326 or 34823043).

The CG191 searches truncated the free text to pneumoni* but this was amended following clinical advice that pneumonia is a form of pneumonitis but not all pneumonitis is pneumonia.

The CG191 searches had an additional line describing chest infection. It was not necessary to retain this line in order to retrieve any of the 183 items in the test set and so it was removed, which reduced the population search by around 41,000 results in MEDLINE.

The previous strategies could not be used directly because of changes to Medical Subject Headings (MeSH) since 2019. Using the previous searches would now retrieve all MEDLINE results about COVID-19, as well as pneumonia. It is now necessary to choose individual MeSH headings from the hierarchy. The choice of headings was made in conjunction with the technical team in the scoping searches in October 2023. Headings for Aspiration, Lipid, Enzootic and Swine Pneumonia, as well as Pneumocystis and COVID-19 were not included. This approach reduced the number of results with just the population terms from 340,000 with the CG191 approach to 124,000. None of the test set were lost by adopting this approach.

Seven options were then tested to optimise the precision of the pneumonia free-text terms. The options tested the feasibility of excluding free-text terms for aspects known to be out of scope (such as COVID-19 or ventilator-associated pneumonia). None of the options made a sufficient difference to the volume to justify making the strategies much more complicated and risk missing relevant papers (the most plausible option only reduced the entire pneumonia literature from 227,500 to 225,900 results). The option to add further free text to define the relevant types of pneumonia (such as bacterial pneumonia) was rejected as it risked missing relevant papers because some abstracts just referred to treating pneumonia, without specifying which type or subtype it was.

At the committee meeting GCOMM1 on 20 December 2023 feedback was received from the committee that rickettsial and cryptogenic organizing pneumonia were not relevant to the UK context and could safely be removed from the search strategies. These terms feature in the Part 1 systematic review and Part 3 cost effectiveness searches as these were completed before the meeting (and were retained in the re-runs for consistency).

The same approach to subject headings was applied in Embase, although the COVID-19 headings are not part of the pneumonia hierarchy in Emtree. The following headings from the pneumonia hierarchy were not chosen: Acute chest syndrome, Acute lupus pneumonitis, Allergic pneumonitis, Aspiration pneumonia, Chemical pneumonitis, Enzootic pneumonia, Eosinophilic pneumonia, Loeffler pneumonia, Experimental pneumonia, Lung infiltrate, Pneumonic effusion, Radiation pneumonia, Parasitic pneumonia, Pneumocystis pneumonia, Pulmonary candidiasis, Pulmonary toxoplasmosis, Legionnaire disease, Pulmonary actinomycosis, Ventilator associated pneumonia, Ventilator associated bacterial pneumonia, Checkpoint inhibitor pneumonitis, and Severe acute respiratory syndrome. Searches after 20/12/23 also excluded Rickettsial pneumonia and Bronchiolitis obliterans organizing pneumonia.

The same free-text terms developed initially in MEDLINE were used in Embase.

Part 2: Diagnostic evidence searches

The strategies are in the structure: Pneumonia AND Ultrasound AND Diagnostic Filter AND Limits. The technical team confirmed they did not want studies on x-ray or CT scan alone, only where they were the reference standard for lung ultrasound.

The relevant subject headings were chosen from the hierarchy rather than exploding Ultrasonography in MeSH and Echography in Emtree. This was to maintain precision by not including headings for therapeutic ultrasonography. The terms were checked with the technical team for relevance to the protocol and only headings relevant to lung ultrasound for detecting congestion or consolidation in the airspaces were used, which ruled out headings such as elasticity imaging techniques, acoustic microscopy, acoustic radiation force imaging and doppler ultrasonography. Similarly, terms for elastograph and elastography were not included, as this paper showed they are new technologies that are not being in practice.

> Huerta-Calpe S et al. (2023) Sono-elastography: an ultrasound quantitative non-invasive measurement to guide bacterial pneumonia diagnosis in children. *Children*, 10(8).

Screening the systematic reviews for Part 1 had 24 potentially relevant results. These were used as the test papers for this search and they are listed in the forward citation and reference list checking table below. From the items in the test set that could be accessed and fully reported a search strategy, the following three were checked for useful free text:

> Chavez MA et al. (2014) Lung ultrasound for the diagnosis of pneumonia in adults: a systematic review and meta-analysis. *Respiratory Research*, 15, 50.

> Long L et al. (2017) Lung ultrasound for the diagnosis of pneumonia in adults: a meta-analysis. *Medicine*, 96(3), e5713.

> Strom JJ et al. (2020) Accuracy of lung ultrasonography in the hands of non-imaging specialists to diagnose and assess the severity of community-acquired pneumonia in adults: a systematic review. *BMJ Open*, 10(6), e036067.

CDSR was searched for recent Cochrane reviews of diagnostic ultrasound using (ultrasound* or ultrasonog*):ti on 15/4/24 and the appendix for this review was checked:

> Tsujimoto H et al. (2017) Ultrasonography for confirmation of gastric tube placement. *Cochrane Database of Systematic Reviews*, Issue 4. Art. No.: CD012083.

The approach in Chavez et al. and Strom et al. of combining the ultrasound terms with free text for chest or lung was not adopted as the number of results was feasible for screening without using this approach. It was felt that titles and abstracts might assume it was obvious that the ultrasound was being performed on the lungs if pneumonia was suspected, without having to state that.

From the 24 test papers, 23 were available on MEDLINE and these were run through the Yale MeSH Analyzer at https://mesh.med.yale.edu on 15/4/24 in two batches to identify relevant MeSH headings, using these PubMed IDs.

> (28244009 OR 29696826 OR 24758612 OR 35371734 OR 24482696 OR 36560909 OR 27818332 OR 28099332 OR 34619690 OR 30672870 OR 29931473 OR 29189351 OR 25780071 OR 36909899 OR 30314929 OR 32554727 OR 32781037 OR 31211896 OR 32030227 OR 27867558 OR 29112644 OR 33327356 OR 26107512).ui

The one paper (Orso et al., 2018) indexed with "Ultrasonography, Doppler", was indexed with the high-level heading "Echography" in Embase and so that MeSH term was not used.

> Orso D et al. (2018) Lung ultrasound in diagnosing pneumonia in the emergency department: a systematic review and meta-analysis. European Journal of Emergency Medicine, 25(5), 312-321.

On 15/4/24 the same 23 test papers were run through PubMed PubReMiner at https://hgserver2.amc.nl/cgi-bin/miner/miner2.cgi using the TI and AB fields. This identified 70 terms in the 23 titles, finding "ultrasound" in 15, "ultrasonography" in 8 and "sonographer" in 1. This meant that all the test papers could be retrieved just by using these three terms in the titles.

There were 730 free-text terms in title and abstract fields, with 375 occurring more than once. The most frequently occurring were "ultrasound" in 19, "ultrasonography" in 11, "sonographer" in 4 and "sonographic" in a further 2. The abbreviation LUS appeared 99 times in 17 papers so was also added to the strategy. The Web of Science citation searching later identified the abbreviation POCUS and this was also added to the strategies:

> Mohamed SA et al. (2023) The reliability of POCUS in the diagnosis of community-acquired pneumonia in critically ill pediatric patients: a cross-sectional study. Egypt Pediatric Association Gazette 71, 83.

The standard NICE diagnostics filter was compared to the McMaster sensitive version (doi: 10.1136/bmj.38068.557998.EE). McMaster retrieved 656 more in MEDLINE and a sample of these was screened, without identifying any potentially relevant studies. The OECD filter was not used, as it would have only reduced MEDLINE by 62, in which were 10 potentially relevant studies from countries including Mozambique, Pakistan, China and Egypt.

The Emtree headings were focussed in the Embase search. This reduced the number of results by about 1000, without affecting retrieval of the test papers (which remained at 22 of 22). Just using the search *Echography/ or (Ultrasound* or ultrasonongraph*).ti,ab would find all of the test papers and so anything in addition to this increases sensitivity. A sample of the papers that would be missed was reviewed and none were relevant to this protocol. The risk of missing a relevant paper was minimal as it would have to be: not retrieved or unavailable from MEDLINE or CENTRAL; not have any relevant free-text terms; and not be indexed with a focussed Emtree heading.

The final search strategies retrieve all 23 of the 24 test papers available on MEDLINE and 22 of the 22 on Embase.

The re-run searches were identical to the main search strategies. Re-runs are date limited to the first day of the month in which the main search was run to the current date. In MEDLINE the create date (.dt) and entry date (.ed) fields were used. In Embase the date created (.dc) field was used. In those fields the dates 20240401-20240807 were used. In CENTRAL, the post-search filter "Date added to CENTRAL trials database" was used.

Part 1: Systematic review searches

Database results

Databases	Date searched	Database platform	Database segment or version	No. of results downloaded
Cochrane Database of Systematic Reviews (CDSR)	20/11/2023	Wiley	Cochrane Database of Systematic Reviews Issue 11 of 12, November 2023	177
Epistemonikos	20/11/2023	Epistemonikos	Version available on 20/11/23	2096

Re-run results

Databases	Date searched	Database platform	Database segment or version	No. of results downloaded
Cochrane Database of Systematic Reviews (CDSR)	15/10/2024	Wiley	Cochrane Database of Systematic Reviews Issue 10 of 12, October 2024	8
Epistemonikos	15/10/2024	Epistemonikos	Version available on 15/10/2024	2571

Search strategy history

Database name: Cochrane Database of Systematic Reviews (CDSR)

Searches
#1 [mh ^pneumonia] or [mh ^bronchopneumonia] or [mh ^pleuropneumonia] or [mh ^"pneumonia, bacterial"] or [mh ^"chlamydial pneumonia"] or [mh ^"pneumonia, mycoplasma"] or [mh ^"pneumonia, pneumococcal"] or [mh ^"pneumonia, rickettsial"] or [mh ^"pneumonia, staphylococcal"] or [mh ^"pneumonia, necrotizing"] or [mh ^"pneumonia, viral"] or [mh ^"organizing pneumonia"] or [mh ^"cryptogenic organizing pneumonia"] or [mh ^"healthcare-associated pneumonia"] 5252
#2 (pneumonia or pneumonias or bronchopneumon* or pleuropneumon*):ti,ab 15137

Searches
#3 #1 or #2 16754
#4 #1 or #2 in Cochrane Reviews 244
#5 #1 or #2 with Cochrane Library publication date Between Jan 2014 and Nov 2023, in Cochrane Reviews 177
Note: in the re-run Line #5 was changed to #1 or #2 with Cochrane Library publication date Between Nov 2023 and Oct 2024, in Cochrane Reviews.

Database name: Epistemonikos

Searches
These are the lines as they were input into the interface for the re-run:
1 title:(bronchopneumonia* OR pleuropneumonia* OR broncho-pneumonia OR pleuro-pneumonia or broncho-pneumonias OR pleuro-pneumonias OR "broncho pneumonia" OR "pleuro pneumonia" or "broncho pneumonias" OR "pleuro pneumonias")
2 abstract:(bronchopneumonia* OR pleuropneumonia* OR broncho-pneumonia OR pleuro-pneumonia or broncho-pneumonias OR pleuro-pneumonias OR "broncho pneumonia" OR "pleuro pneumonia" or "broncho pneumonias" OR "pleuro pneumonias")
3 title:(pneumonia OR pneumonias)
4 abstract:((pneumonia OR pneumonias) AND (HAP OR nosocomial* OR crossinfect* OR cross-infection OR cross-infected OR cross-infecting OR "cross infection" OR "cross infected" OR "cross infecting" or hospitalised* or hospitalized* or hospitalisation* or hospitalization*))
5 abstract:((pneumonia OR pneumonias) AND ("healthcare acquire" OR "healthcare acquired" OR "healthcare acquiring" OR "healthcare onset" OR "healthcare associate" OR "healthcare associated" OR "healthcare associating"))
6 abstract:((pneumonia OR pneumonias) AND ("health care acquire" OR "health care acquired" OR "health care acquiring" OR "health care onset" OR "health care associate" OR "health care associated" OR "health care associating"))
7 abstract:((pneumonia OR pneumonias) AND ("hospital acquire" OR "hospital acquired" OR "hospital acquiring" OR "hospital onset" OR "hospital associate" OR "hospital associated" OR "hospital associating"))
8 abstract:((pneumonia OR pneumonias) AND ("inpatient acquire" OR "inpatient acquired" OR "inpatient acquiring" OR "inpatient onset" OR "inpatient associate" OR "inpatient associated" OR "inpatient associating"))
9 abstract:((pneumonia OR pneumonias) AND (healthcare-acquire OR healthcare-acquired OR healthcare-acquiring OR healthcare-onset OR healthcare-associate OR healthcare-associated OR healthcare-associating))
10 abstract:((pneumonia OR pneumonias) AND (health-care-acquire OR health-care-acquired OR health-care-acquiring OR health-care-onset OR health-care-associate OR health-care-associated OR health-care-associating))
11 abstract:((pneumonia OR pneumonias) AND (hospital-acquire OR hospital-acquired OR hospital-acquiring OR hospital-onset OR hospital-associate OR hospital-associated OR hospital-associating))
12 abstract:((pneumonia OR pneumonias) AND (inpatient-acquire OR inpatient-acquired OR inpatient-acquiring OR inpatient-onset OR inpatient-associate OR inpatient-associated OR inpatient-associating))
13 abstract:((pneumonia OR pneumonias) AND (CAP OR community* OR communities* OR outpatient* OR nonhospital* OR "non hospital" OR non-hospital OR "non hospitalised" OR non-hospitalised OR "non hospitalized" OR non-hospitalized OR "non hospitalisation" OR non-hospitalisation OR "non hospitalization" OR non-hospitalization))

Searches
14 abstract:((pneumonia OR pneumonias) AND (bacterial* OR chlamydial* OR mycoplasma* OR pneumococcal* OR rickettsial* OR staphylococcal* OR staphylococcus* OR necrotiz* OR necrotis* OR viral* OR organizing* OR organising* OR cryptogenic* OR bilateral* OR granulomatous* OR infectious* OR interstitial* OR neonatal* OR obstructive* OR lobar* OR escherichia* OR haemophilus* OR hemophilus* OR influenzae* OR nocardiosis* OR streptococcus* OR streptococcal*)) **This is the final search as formatted by Epistemonikos:** title:((bronchopneumonia* OR pleuropneumonia* OR broncho-pneumonia OR pleuro-pneumonia OR broncho-pneumonias OR pleuro-pneumonias OR "broncho pneumonia" OR "pleuro pneumonia" OR "broncho pneumonias" OR "pleuro pneumonias")) OR abstract:((bronchopneumonia* OR pleuropneumonia* OR broncho-pneumonia OR pleuro-pneumonia OR broncho-pneumonias OR pleuro-pneumonias OR "broncho pneumonia" OR "pleuro pneumonia" OR "broncho pneumonias" OR "pleuro pneumonias")) OR title:((pneumonia OR pneumonias)) OR abstract:(((pneumonia OR pneumonias) AND (HAP OR nosocomial* OR crossinfect* OR cross-infection OR cross-infected OR cross-infecting OR "cross infection" OR "cross infected" OR "cross infecting" OR hospitalised* OR hospitalized* OR hospitalisation* OR hospitalization*))) OR abstract:(((pneumonia OR pneumonias) AND ("healthcare acquire" OR "healthcare acquired" OR "healthcare acquiring" OR "healthcare onset" OR "healthcare associate" OR "healthcare associated" OR "healthcare associating"))) OR abstract:(((pneumonia OR pneumonias) AND ("health care acquire" OR "health care acquired" OR "health care acquiring" OR "health care onset" OR "health care associate" OR "health care associated" OR "health care associating"))) OR abstract:(((pneumonia OR pneumonias) AND ("hospital acquire" OR "hospital acquired" OR "hospital acquiring" OR "hospital onset" OR "hospital associate" OR "hospital associated" OR "hospital associating"))) OR abstract:(((pneumonia OR pneumonias) AND ("inpatient acquire" OR "inpatient acquired" OR "inpatient acquiring" OR "inpatient onset" OR "inpatient associate" OR "inpatient associated" OR "inpatient associating"))) OR abstract:(((pneumonia OR pneumonias) AND (healthcare-acquire OR healthcare-acquired OR healthcare-acquiring OR healthcare-onset OR healthcare-associate OR healthcare-associated OR healthcare-associating))) OR abstract:(((pneumonia OR pneumonias) AND (health-care-acquire OR health-care-acquired OR health-care-acquiring OR health-care-onset OR health-care-associate OR health-care-associated OR health-care-associating))) OR abstract:(((pneumonia OR pneumonias) AND (hospital-acquire OR hospital-acquired OR hospital-acquiring OR hospital-onset OR hospital-associate OR hospital-associated OR hospital-associating))) OR abstract:(((pneumonia OR pneumonias) AND (inpatient-acquire OR inpatient-acquired OR inpatient-acquiring OR inpatient-onset OR inpatient-associate OR inpatient-associated OR inpatient-associating))) OR abstract:(((pneumonia OR pneumonias) AND (CAP OR community* OR communities* OR outpatient* OR nonhospital* OR "non hospital" OR non-hospital OR "non hospitalised" OR non-hospitalised OR "non hospitalized" OR non-hospitalized OR "non hospitalisation" OR non-hospitalisation OR "non hospitalization" OR non-hospitalization))) OR abstract:(((pneumonia OR pneumonias) AND (bacterial* OR chlamydial* OR mycoplasma* OR pneumococcal* OR rickettsial* OR staphylococcal* OR staphylococcus* OR necrotiz* OR necrotis* OR viral* OR organizing* OR organising* OR cryptogenic* OR bilateral* OR granulomatous* OR infectious* OR interstitial* OR neonatal* OR obstructive* OR lobar* OR escherichia* OR haemophilus* OR hemophilus* OR influenzae* OR nocardiosis* OR streptococcus* OR streptococcal*))) **Results:** Total: 48055 Apply Publication Year limits of 2014-2024: 30820 Download 1: Apply Publication type - Systematic Review: 2307

Searches
Download 2: Apply Publication type - Broad Synthesis: 223 Download 3: Apply Publication type - Structured Summary: 41 **Note:** The re-run search covered the whole timespan 2014-2024 as the phrases in the free text were updated to use a version with a hyphen and to spell out the words rather than truncating them. The main search had used Publication Year limits of 2014-2023.

Part 2: Diagnostic evidence searches

Database results

Databases	Date searched	Database platform	Database segment or version	No. of results downloaded
Cochrane Central Register of Controlled Trials (CENTRAL)	19/4/24	Wiley	Cochrane Central Register of Controlled Trials Issue 3 of 12, March 2024	110
Embase	19/4/24	Ovid	Embase 1974 to 2024 April 18	1859
MEDLINE ALL	19/4/24	Ovid	Ovid MEDLINE(R) ALL 1946 to April 18, 2024	1024

Additional search techniques

Databases	Date searched	Database platform	Database segment or version	No. of results downloaded
Forward citation searching	18/4/24	Web of Science (WOS) Core Collection (1990-present)	Data updated 2024-04-13	137
Reference list checking	18/4/24	Web of Science (WOS) Core Collection (1990-present)	Data updated 2024-04-13	159

Re-run results

Databases	Date searched	Database platform	Database segment or version	No. of results downloaded
Cochrane Central Register of Controlled	07/08/24	Wiley	Cochrane Central Register of Controlled	6

Databases	Date searched	Database platform	Database segment or version	No. of results downloaded
Trials (CENTRAL)			Trials Issue 7 of 12, July 2024	
Embase	07/08/24	Ovid	Embase 1974 to 2024 April 18	58
MEDLINE ALL	07/08/24	Ovid	Ovid MEDLINE(R) ALL 1946 to August 06, 2024	24
Forward citation searching	07/08/24	Web of Science (WOS) Core Collection (1990-present)	Data updated 2024-08-04	0
Reference list checking	07/08/24	Web of Science (WOS) Core Collection (1990-present)	Data updated 2024-08-04	60

Search strategy history

Database name: Cochrane Central Register of Controlled Trials (CENTRAL)

Searches
#1 [mh ^pneumonia] or [mh ^bronchopneumonia] or [mh ^pleuropneumonia] or [mh ^"pneumonia, bacterial"] or [mh ^"chlamydial pneumonia"] or [mh ^"pneumonia, mycoplasma"] or [mh ^"pneumonia, pneumococcal"] or [mh ^"pneumonia, staphylococcal"] or [mh ^"pneumonia, necrotizing"] or [mh ^"pneumonia, viral"] or [mh ^"organizing pneumonia"] or [mh ^"healthcare-associated pneumonia"] 4413
#2 (pneumonia or pneumonias or bronchopneumon* or pleuropneumon*):ti,ab 15791
#3 #1 or #2 17033
#4 [mh ^Ultrasonography] 6513
#5 [mh Echocardiography] 5267
#6 [mh ^Endosonography] 566
#7 (ultrasound* or ultrasonic* or ultrasonograph* or ultrasonogram* or ultrasonoscop* or ultratomograph* or ultrasonficat* or ultra-sound* or ultra-sonic* or ultra-sonograph* or ultra-sonogram* or ultra-sonoscop* or ultra-tomograph* or ultra-sonficat*):ti,ab 53946
#8 (sonograph* or sonogram* or sonoscop* or sonoficat* or sono-graph* or sono-gram* or sono-scop* or sono-ficat*):ti,ab 4644
#9 (echocardiosound* or echocardiosonic* or echocardiograph* or echocardiogram* or echocardioscop* or echocardiosonoscop* or echocardiotomograph* or echocardiosonificat* or echo-cardiosound* or echo-cardiosonic* or echo-cardiograph* or echo-cardiogram* or echo-cardioscop* or echo-cardoisonoscop* or echo-cardiotomograph* or echo-cardiosonificat*):ti,ab 15289
#10 (echosound* or echosonic* or echograph* or echogram* or echoscop* or echosonoscop* or echotomograph* or echcosonificat* or echo-sound* or echo-sonic* or

Searches
echo-graph* or echo-gram* or echo-scop* or echo-sonoscop* or echo-tomograph* or echo-sonificat*):ti,ab 482
#11 (endosound* or endosonic* or endosonograph* or endosonogram* or endosonoscop* or endosonotomograph* or endosonoficat* or endo-sound* or endo-sonic* or endo-sonograph* or endo-sonogram* or endo-sonoscop* or endo-sonotomograph* or endo-sonoficat*):ti,ab 287
#12 (echoendosound* or echoendosonic* or echoendograph* or echoendogram* or echoendoscop* or echoendosonoscop* or echoendotomograph* or echoendosonificat* or echo-endosound* or echo-endosonic* or echo-endograph* or echo-endogram* or echo-endoscop* or echo-endosonoscop* or echo-endotomograph* or echo-endosonificat*):ti,ab 93
#13 (doptone* or bscan* or b-scan* or LUS or POCUS):ti,ab 665
#14 {or #4-#13} 74139
#15 #3 and #14 390
#16 ((clinicaltrials or trialsearch* or trial-registry or trials-registry or clinicalstudies or trialsregister* or trialregister* or trial-number* or studyregister* or study-register* or controlled-trials-com or current-controlled-trial or AMCTR or ANZCTR or ChiCTR* or CRiS or CTIS or CTRI* or DRKS* or EU-CTR* or EUCTR* or EUDRACT* or ICTRP or IRCT* or JAPIC* or JMCTR* or JRCT or ISRCTN* or LBCTR* or NTR* or ReBec* or REPEC* or RPCEC* or SLCTR or TCTR* or UMIN*):so or (ctgov or ictrp)):an 504076
#17 #15 not #16 164
#18 "conference":pt 241280
#19 #17 not #18 115
#20 #17 not #18 in Trials 110
Note: in the re-run added Post search filter: Date added to CENTRAL trials database: 01/04/2014 to 07/08/2024

Database name: Embase

Searches
Searches Results
1 pneumonia/ or bilateral pneumonia/ or bronchopneumonia/ or granulomatous pneumonia/ or infectious pneumonia/ or interstitial pneumonia/ or necrotizing pneumonia/ or neonatal pneumonia/ or obstructive pneumonia/ or organizing pneumonia/ or bacterial pneumonia/ or community acquired pneumonia/ or health care associated pneumonia/ or exp lobar pneumonia/ or virus pneumonia/ or chlamydial pneumonia/ or escherichia coli pneumonia/ or haemophilus influenzae pneumonia/ or pulmonary nocardiosis/ or mycoplasma pneumonia/ or exp staphylococcal pneumonia/ or exp streptococcus pneumonia/ or hospital acquired pneumonia/ 322932
2 (pneumonia or pneumonias or bronchopneumon* or pleuropneumon*).ti,ab. 239438
3 1 or 2 406810
4 *echography/ 98797
5 *b scan/ 2064
6 *compression ultrasonography/ 56
7 exp *contrast-enhanced ultrasound/ 4342
8 exp *echocardiography/ 87533
9 *echotomography/ 718

Searches	
10	*endobronchial ultrasonography/3574
11	*endoscopic ultrasonography/ 6285
12	*gray scale echography/968
13	*high frequency ultrasound/ 666
14	*real time echography/ 2309
15	exp *three dimensional echography/ 6163
16	*lung ultrasound score/ 285
17	*ultrasound scanner/ 903
18	*portable ultrasound scanner/ 167
19	*real time ultrasound scanner/ 935
20	*robotic ultrasound/ 46
21	*echograph/ 314
22	*echocardiograph/ 339
23	*echoendoscope/ 224
24	(ultrasound* or ultrasonic* or ultrasonograph* or ultrasonogram* or ultrasonoscop* or ultratomograph* or ultrasonficat* or ultra-sound* or ultra-sonic* or ultra-sonograph* or ultra-sonogram* or ultra-sonoscop* or ultratomograph* or ultra-sonficat*).ti,ab. 692455
25	(sonograph* or sonogram* or sonoscop* or sonoficat* or sono-graph* or sono-gram* or sono-scop* or sono-ficat*).ti,ab. 89069
26	(echocardiosound* or echocardiosonic* or echocardiograph* or echocardiogram* or echocardioscop* or echocardiosonoscop* or echocardiotomograph* or echocardiosonificat* or echo-cardiosound* or echo-cardiosonic* or echo-cardiograph* or echo-cardiogram* or echo-cardioscop* or echo-cardoisonoscop* or echo-cardiotomograph* or echo-cardiosonificat*).ti,ab. 326536
27	(echosound* or echosonic* or echograph* or echogram* or echoscop* or echosonoscop* or echotomograph* or echcosonificat* or echo-sound* or echo-sonic* or echo-graph* or echo-gram* or echo-scop* or echo-sonoscop* or echo-tomograph* or echo-sonificat*).ti,ab. 15559
28	(endosound* or endosonic* or endosonograph* or endosonogram* or endosonoscop* or endosonotomograph* or endosonoficat* or endo-sound* or endo-sonic* or endo-sonograph* or endo-sonogram* or endo-sonoscop* or endo-sonotomograph* or endo-sonoficat*).ti,ab. 4767
29	(echoendosound* or echoendosonic* or echoendograph* or echoendogram* or echoendoscop* or echoendosonoscop* or echoendotomograph* or echoendosonificat* or echo-endosound* or echo-endosonic* or echo-endograph* or echo-endogram* or echo-endoscop* or echo-endosonoscop* or echo-endotomograph* or echo-endosonificat*).ti,ab. 2135
30	(doptone* or bscan* or b-scan* or LUS or POCUS).ti,ab. 12423
31	or/4-30 1082249
32	3 and 31 10923
33	"SENSITIVITY AND SPECIFICITY"/ 508910
34	(sensitivity or specificity).ti,ab. 1654508
35	((pre test or pretest or post test or posttest) adj probability).ti,ab. 6289
36	(predictive value* or PPV or NPV).ti,ab. 235592
37	likelihood ratio*.ti,ab. 27824
38	STATISTICAL MODEL/ 176983
39	(ROC curve* or AUC).ti,ab. 260750

Searches
40 diagnos*.ti. 844261
41 (diagnos* adj2 (performance* or accurac* or utilit* or value* or efficien* or effectiveness)).ti,ab. 221088
42 gold standard.ab. 151570
43 DIAGNOSTIC ACCURACY/ or DIAGNOSTIC TEST ACCURACY STUDY/ 486165
44 di.fs. 3741633
45 or/33-44 6132678
46 32 and 45 4649
47 limit 46 to english language 4260
48 (letter or editorial).pt. 2120771
49 47 not 48 4113
50 Case report/ 2989058
51 49 not 50 2494
52 nonhuman/ not human/ 5428979
53 51 not 52 2363
54 (conference abstract* or conference review or conference paper or conference proceeding).db,pt,su. 5900037
55 53 not 54 1859
Note: in the re-run added Line 56: limit 55 to dc=20240401-20240807

Database name: MEDLINE ALL

Searches
Searches Results
1 pneumonia/ or bronchopneumonia/ or pleuropneumonia/ or pneumonia, bacterial/ or chlamydial pneumonia/ or pneumonia, mycoplasma/ or pneumonia, pneumococcal/ or pneumonia, staphylococcal/ or pneumonia, necrotizing/ or pneumonia, viral/ or organizing pneumonia/ or healthcare-associated pneumonia/ 125186
2 (pneumonia or pneumonias or bronchopneumon* or pleuropneumon*).ti,ab. 162994
3 1 or 2 232978
4 Ultrasonography/ 203367
5 exp Echocardiography/ 150986
6 Endosonography/ 14892
7 (ultrasound* or ultrasonic* or ultrasonograph* or ultrasonogram* or ultrasonoscop* or ultratomograph* or ultrasonficat* or ultra-sound* or ultra-sonic* or ultra-sonograph* or ultra-sonogram* or ultra-sonoscop* or ultra-tomograph* or ultra-sonficat*).ti,ab. 471328
8 (sonograph* or sonogram* or sonoscop* or sonoficat* or sono-graph* or sono-gram* or sono-scop* or sono-ficat*).ti,ab. 62651
9 (echocardiosound* or echocardiosonic* or echocardiograph* or echocardiogram* or echocardioscop* or echocardiosonoscop* or echocardiotomograph* or echocardiosonificat* or echo-cardiosound* or echo-cardiosonic* or echo-cardiograph* or echo-cardiogram* or echo-cardioscop* or echo-cardoisonoscop* or echo-cardiotomograph* or echo-cardiosonificat*).ti,ab. 182303
10 (echosound* or echosonic* or echograph* or echogram* or echoscop* or echosonoscop* or echotomograph* or echcosonificat* or echo-sound* or echo-sonic* or

Searches
echo-graph* or echo-gram* or echo-scop* or echo-sonoscop* or echo-tomograph* or echo-sonificat*).ti,ab. 11804
11 (endosound* or endosonic* or endosonograph* or endosonogram* or endosonoscop* or endosonotomograph* or endosonoficat* or endo-sound* or endo-sonic* or endo-sonograph* or endo-sonogram* or endo-sonoscop* or endo-sonotomograph* or endo-sonoficat*).ti,ab. 2894
12 (echoendosound* or echoendosonic* or echoendograph* or echoendogram* or echoendoscop* or echoendosonoscop* or echoendotomograph* or echoendosonificat* or echo-endosound* or echo-endosonic* or echo-endograph* or echo-endogram* or echo-endoscop* or echo-endosonoscop* or echo-endotomograph* or echo-endosonificat*).ti,ab. 882
13 (doptone* or bscan* or b-scan* or LUS or POCUS).ti,ab. 8445
14 or/4-13 790944
15 3 and 14 4264
16 exp "SENSITIVITY AND SPECIFICITY"/ 654230
17 (sensitivity or specificity).ti,ab. 1299563
18 ((pre test or pretest or post test or posttest) adj probability).ti,ab. 3707
19 (predictive value* or PPV or NPV).ti,ab. 153701
20 likelihood ratio*.ti,ab. 20425
21 LIKELIHOOD FUNCTIONS/ 23935
22 (ROC curve* or AUC).ti,ab. 165321
23 diagnos*.ti. 711383
24 (diagnos* adj2 (performance* or accurac* or utilit* or value* or efficien* or effectiveness)).ti,ab. 157834
25 gold standard.ab. 92304
26 di.fs. 3013147
27 or/16-26 4880630
28 15 and 27 1965
29 limit 28 to english language 1670
30 limit 29 to (letter or historical article or comment or editorial or news or case reports) 598
31 29 not 30 1072
32 Animals/ not (Animals/ and Humans/) 5178905
33 31 not 32 1024
Note: the re-run included an additional step:
33 31 not 32
34 limit 33 to ed=20240401-20240807
35 limit 33 to dt=20240401-20240807
36 34 or 35

Additional search techniques

Forward citation searching and reference list checking main search

Date of search	18/4/24

How the searches were managed	Forward citation searching and reference list checking were done separately as two different operations using the same sources, seed references and decision-making criteria, and so they are reported in a single table here.
How the seed papers were identified	Identified from the papers selected for this question from the search for systematic reviews done at the first stage.
Databases used	Web of Science (WOS) Core Collection (1990-present) • Science Citation Index Expanded (1990-present) • Social Sciences Citation Index (1990-present) • Arts & Humanities Citation Index (1990-present) • Emerging Sources Citation Index (2019-present)
Date of last update	Data updated 2024-04-13
How results were managed	Only those references that could be accessed through the NICE subscription to WOS were added to the search results. Duplicates were removed from the marked list in WOS before downloading the results.
How the results were selected	Included any papers potentially relevant to lung ultrasound diagnosis of pneumonia. Did not include any papers about the types of pneumonia excluded in the protocol, including COVID-19, ventilator-associated and aspiration pneumonia. Did not include studies about acute respiratory failure but did include lower respiratory tract infections. Did not include any studies about non-pneumonia conditions e.g. asthma, TB, cardiology etc. Did not include chest x-ray or CT studies that did not compare them to ultrasound. Did not make any decisions based on the location of the study. Did not include any papers that were about methods or epidemiology. Did not include animal studies, letters, commentaries or editorials. Did not include anything that was not written in English.
List of seed papers used	Alzahrani SA et al. (2017) Systematic review and meta-analysis for the use of ultrasound versus radiology in diagnosing of pneumonia. Critical Ultrasound Journal, 9(1), 6.

	Balk DS et al. (2018) Lung ultrasound compared to chest x-ray for diagnosis of pediatric pneumonia: a meta-analysis. Pediatric Pulmonology, 53(8), 1130-1139. Chavez MA et al. (2014) Lung ultrasound for the diagnosis of pneumonia in adults: a systematic review and meta-analysis. Respiratory Research, 15, 50. Elabbas A et al. (2022) Lung ultrasonography beyond the diagnosis of pediatrics pneumonia. Cureus, 14(2), e22460. Hu QJ et al. (2014) Diagnostic performance of lung ultrasound in the diagnosis of pneumonia: a bivariate meta-analysis. International Journal of Clinical and Experimental Medicine, 7(1), 115-21. Kazi S et al. (2022) The utility of chest x-ray and lung ultrasound in the management of infants and children presenting with severe pneumonia in low-and middle-income countries: a pragmatic scoping review. Journal of Global Health, 12, 10013. Llamas-Alvarez AM et al. (2017) Accuracy of lung ultrasonography in the diagnosis of pneumonia in adults: systematic review and meta-analysis. Chest, 151(2), 374-382. Long L et al. (2017) Lung ultrasound for the diagnosis of pneumonia in adults: a meta-analysis. Medicine, 96(3), e5713. Lu X et al. (2022) Diagnostic accuracy of lung ultrasonography in childhood pneumonia: a meta-analysis. European Journal of Emergency Medicine, 29(2), 105-117. Najgrodzka P et al. (2019) Lung ultrasonography in the diagnosis of pneumonia in children-a metaanalysis and a review of pediatric lung imaging. Ultrasound Quarterly, 35(2), 157-163.

	Orso D et al. (2018) Lung ultrasound in diagnosing pneumonia in childhood: a systematic review and meta-analysis. Journal of Ultrasound, 21(3), 183-195. Orso D et al. (2018) Lung ultrasound in diagnosing pneumonia in the emergency department: a systematic review and meta-analysis. European Journal of Emergency Medicine, 25(5), 312-321. Pereda MA et al. (2015) Lung ultrasound for the diagnosis of pneumonia in children: a meta-analysis. Pediatrics, 135(4), 714-22. Ru Q et al. (2023) Diagnosis of asthmatic pneumonia in children by lung ultrasound vs. chest x-ray: an updated systematic review and meta-analysis. Postepy Dermatologii I Alergologii, 40(1), 28-34. Sistani SS & Parooie F (2021) Diagnostic Performance of Ultrasonography in Patients With Pneumonia: An Updated Comparative Systematic Review and Meta-analysis. Journal of Diagnostic Medical Sonography, 37(4), 371-381. Staub LJ et al. (2019) Lung ultrasound for the emergency diagnosis of pneumonia, acute heart failure, and exacerbations of chronic obstructive pulmonary disease/asthma in adults: a systematic review and meta-analysis. Journal of Emergency Medicine, 56(1), 53-69. Strom JJ et al. (2020) Accuracy of lung ultrasonography in the hands of non-imaging specialists to diagnose and assess the severity of community-acquired pneumonia in adults: a systematic review. BMJ Open, 10(6), e036067. Toro MS et al. (2021) Point-of-care ultrasound by the pediatrician in the diagnosis and follow-up of community-acquired pneumonia. Jornal de Pediatria, 97(1), 13-21. Tsou PY et al. (2019) Diagnostic accuracy of lung ultrasound performed by novice versus advanced sonographers for pneumonia in

	children: a systematic review and meta-analysis. Academic Emergency Medicine, 26(9), 1074-1088. Wang L et al. (2019) Lung ultrasonography versus chest radiography for the diagnosis of pediatric community acquired pneumonia in emergency department: a meta-analysis. Journal of Thoracic Disease, 11(12), 5107-5114. Xia Y et al. (2016) Effectiveness of lung ultrasonography for diagnosis of pneumonia in adults: a systematic review and meta-analysis. Journal of Thoracic Disease, 8(10), 2822-2831. Xin H et al. (2018) Is lung ultrasound useful for diagnosing pneumonia in children?: a meta-analysis and systematic review. Ultrasound Quarterly, 34(1), 3-10. Yan JH, Yu N, Wang YH, Gao YB & Pan L (2020) Lung ultrasound vs chest radiography in the diagnosis of children pneumonia: systematic evidence. Medicine, 99(50), e23671. Ye X et al. (2015) Accuracy of lung ultrasonography versus chest radiography for the diagnosis of adult community-acquired pneumonia: review of the literature and meta-analysis. PLoS ONE, 10(6), e0130066.
No. of forward citation searching results	137
No. of reference list checking results	159

Forward citation searching and reference list checking update

Date of search	07/08/24
How the searches were managed	As table above for main search
How the seed papers were identified	Included any reviews that had been marked as potentially of relevance from screening the main search results at the point of doing the re-runs, then excluded any that had already been used in Web of Science derived from the main SR search.
Databases used	As table above for main search
Date of last update	Data updated 2024-08-04
How results were managed	As table above for main search

How the results were selected	As table above for main search
List of seed papers used	Abid I et al. (2024) Point-of-care lung ultrasound in detecting pneumonia: A systematic review. Canadian Journal of Respiratory Therapy, 60(1), 37-48. Asmara OD et al. (2022) Accuracy of Bedside Lung Ultrasound in Emergency (BLUE) Protocol to Diagnose the Cause of Acute Respiratory Distress Syndrome (ARDS): A Meta-Analysis. Acta medica Indonesiana, 54(2), 266-282. Desai D et al. (2024) Lung Ultrasonography Accuracy for Diagnosis of Adult Pneumonia: Systematic Review and Meta-Analysis. Advances in Respiratory Medicine, 92(3), 241-253. Dong Z et al. (2023) Accuracy of Thoracic Ultrasonography for the Diagnosis of Pediatric Pneumonia: A Systematic Review and Meta-Analysis. Diagnostics, 13(22), no pagination. Yang Y (2024) Comparison of lung ultrasound and chest radiography for detecting pneumonia in children: a systematic review and meta-analysis. Italian Journal of Pediatrics, 50(1), no pagination
No. of forward citation searching results	0
No. of reference list checking results	60

Part 3: Cost effectiveness searches

Database results

Databases	Date searched	Database platform	Database segment or version	No. of results downloaded
Econlit	20/11/2023	Ovid	Econlit 1886 to November 11, 2023	90
Embase	20/11/2023	Ovid	Embase 1974 to 2023 November 17	2288
International HTA Database	20/11/2023	INAHTA	Version available on 20/11/23 with 21319 records	30

Databases	Date searched	Database platform	Database segment or version	No. of results downloaded
MEDLINE ALL	20/11/2023	Ovid	Ovid MEDLINE(R) ALL 1946 to November 17, 2023	1534
NHS Economic Evaluation Database (NHS EED)	20/11/2023	CRD	Archived – last updated 31 March 2015	11

Re-run results

Databases	Date searched	Database platform	Database segment or version	No. of results downloaded
Econlit	14/10/2024	Ovid	Econlit 1886 to October 03, 2024	6
Embase	14/10/2024	Ovid	Embase 1974 to 2024 October 11	306
International HTA Database	14/10/2024	INAHTA	Version available on 14/10/24 with 23533 records	6
MEDLINE ALL	14/10/2024	Ovid	Ovid MEDLINE(R) ALL 1946 to October 11, 2024	157

Search strategy history

Database name: Econlit

Searches
1 (pneumonia or pneumonias or bronchopneumon* or pleuropneumon*).af. 150
2 limit 1 to yr="2014 -Current" 90
Note: in the re-run Line 2 was changed to limit 1 to yr="2023 -Current".

Database name: Embase

Searches
1 pneumonia/ or bilateral pneumonia/ or bronchopneumonia/ or granulomatous pneumonia/ or infectious pneumonia/ or interstitial pneumonia/ or necrotizing pneumonia/ or neonatal pneumonia/ or obstructive pneumonia/ or exp organizing pneumonia/ or bacterial pneumonia/ or community acquired pneumonia/ or health care associated pneumonia/ or hospital acquired pneumonia/ or exp lobar pneumonia/ or virus pneumonia/ or chlamydial

Searches
pneumonia/ or escherichia coli pneumonia/ or haemophilus influenzae pneumonia/ or pulmonary nocardiosis/ or mycoplasma pneumonia/ or rickettsial pneumonia/ or exp staphylococcal pneumonia/ or exp streptococcus pneumonia/ 314875
2 (pneumonia or pneumonias or bronchopneumon* or pleuropneumon*).ti,ab. 232562
3 1 or 2 395881
4 cost utility analysis/ 12471
5 quality adjusted life year/ 35716
6 cost*.ti. 195365
7 (cost* adj2 utilit*).tw. 12784
8 (cost* adj2 (effective* or assess* or evaluat* or analys* or model* or benefit* or threshold* or quality or expens* or saving* or reduc*)).tw. 385741
9 (economic* adj2 (evaluat* or assess* or analys* or model* or outcome* or benefit* or threshold* or expens* or saving* or reduc*)).tw. 66452
10 (qualit* adj2 adjust* adj2 life*).tw. 27335
11 QALY*.tw. 26801
12 (incremental* adj2 cost*).tw. 28720
13 ICER.tw. 13032
14 utilities.tw. 15135
15 markov*.tw. 40152
16 (dollar* or USD or cents or pound or pounds or GBP or sterling* or pence or euro or euros or yen or JPY).tw. 72706
17 ((utility or effective*) adj2 analys*).tw. 37800
18 (willing* adj2 pay*).tw. 14735
19 (EQ5D* or EQ-5D*).tw. 26137
20 ((euroqol or euro-qol or euroquol or euro-quol or eurocol or euro-col) adj3 ("5" or five)).tw. 5262
21 (european* adj2 quality adj3 ("5" or five)).tw. 996
22 or/4-21 635358
23 3 and 22 7788
24 afghanistan/ or africa/ or "africa south of the sahara"/ or albania/ or algeria/ or andorra/ or angola/ or argentina/ or "antigua and barbuda"/ or armenia/ or exp azerbaijan/ or bahamas/ or bahrain/ or bangladesh/ or barbados/ or belarus/ or belize/ or benin/ or bhutan/ or bolivia/ or borneo/ or exp "bosnia and herzegovina"/ or botswana/ or exp brazil/ or brunei darussalam/ or bulgaria/ or burkina faso/ or burundi/ or cambodia/ or cameroon/ or cape verde/ or central africa/ or central african republic/ or chad/ or exp china/ or comoros/ or congo/ or cook islands/ or cote d'ivoire/ or croatia/ or cuba/ or cyprus/ or democratic republic congo/ or djibouti/ or dominica/ or dominican republic/ or ecuador/ or el salvador/ or egypt/ or equatorial guinea/ or eritrea/ or eswatini/ or ethiopia/ or exp "federated states of micronesia"/ or fiji/ or gabon/ or gambia/ or exp "georgia (republic)"/ or ghana/ or grenada/ or guatemala/ or guinea/ or guinea-bissau/ or guyana/ or haiti/ or honduras/ or exp india/ or exp indonesia/ or iran/ or exp iraq/ or jamaica/ or jordan/ or kazakhstan/ or kenya/ or kiribati/ or kosovo/ or kuwait/ or kyrgyzstan/ or laos/ or lebanon/ or liechtenstein/ or lesotho/ or liberia/ or libyan arab jamahiriya/ or madagascar/ or malawi/ or exp malaysia/ or maldives/ or mali/ or malta/ or mauritania/ or mauritius/ or melanesia/ or moldova/ or monaco/ or mongolia/ or "montenegro (republic)"/ or morocco/ or mozambique/ or myanmar/ or namibia/ or nauru/ or nepal/ or nicaragua/ or niger/ or nigeria/ or niue/ or north africa/ or oman/ or exp pakistan/ or palau/ or palestine/ or panama/ or papua new guinea/ or paraguay/ or peru/ or philippines/ or polynesia/ or qatar/ or "republic of north macedonia"/ or romania/ or exp

Searches
russian federation/ or rwanda/ or sahel/ or "saint kitts and nevis"/ or "saint lucia"/ or "saint vincent and the grenadines"/ or saudi arabia/ or senegal/ or exp serbia/ or seychelles/ or sierra leone/ or singapore/ or "sao tome and principe"/ or solomon islands/ or exp somalia/ or south africa/ or south asia/ or south sudan/ or exp southeast asia/ or sri lanka/ or sudan/ or suriname/ or syrian arab republic/ or taiwan/ or tajikistan/ or tanzania/ or thailand/ or timor-leste/ or togo/ or tonga/ or "trinidad and tobago"/ or tunisia/ or turkmenistan/ or tuvalu/ or uganda/ or exp ukraine/ or exp united arab emirates/ or uruguay/ or exp uzbekistan/ or vanuatu/ or venezuela/ or viet nam/ or western sahara/ or yemen/ or zambia/ or zimbabwe/ 1716014
25 exp "organisation for economic co-operation and development"/ 2774
26 exp australia/ or "australia and new zealand"/ or austria/ or baltic states/ or exp belgium/ or exp canada/ or chile/ or colombia/ or costa rica/ or czech republic/ or denmark/ or estonia/ or europe/ or exp finland/ or exp france/ or exp germany/ or greece/ or hungary/ or iceland/ or ireland/ or israel/ or exp italy/ or japan/ or korea/ or latvia/ or lithuania/ or luxembourg/ or exp mexico/ or netherlands/ or new zealand/ or north america/ or exp norway/ or poland/ or exp portugal/ or scandinavia/ or sweden/ or slovakia/ or slovenia/ or south korea/ or exp spain/ or switzerland/ or "Turkey (republic)"/ or exp united kingdom/ or exp united states/ or western europe/ 3801223
27 european union/ 31487
28 developed country/ 35727
29 or/25-28 3834983
30 24 not 29 1561961
31 23 not 30 6971
32 limit 31 to english language 6647
33 (letter or editorial).pt. 2081948
34 32 not 33 6549
35 Case report/ 2939178
36 34 not 35 6182
37 nonhuman/ not human/ 5325269
38 36 not 37 6027
39 (conference abstract* or conference review or conference paper or conference proceeding).db,pt,su. 5742113
40 38 not 39 4181
41 limit 40 to yr="2014 -Current" 2288
Note: in the re-run Line 41 was changed to limit 40 to dc=20231101-20241014.

Database name: International HTA Database

Searches
1 (pneumonia or pneumonias or bronchopneumon* or pleuropneumon*)[abs] AND (English)[Language] FROM 2014 TO 2023 15
2 (pneumonia or pneumonias or bronchopneumon* or pleuropneumon*)[Title] AND (English)[Language] FROM 2014 TO 2023 7
3 ("pneumonia"[mh] or "bronchopneumonia"[mh] or "pleuropneumonia"[mh] or "pneumonia bacterial"[mh] or "chlamydial pneumonia"[mh] or "pneumonia mycoplasma"[mh] or "pneumonia pneumococcal"[mh] or "pneumonia rickettsial"[mh] or "pneumonia staphylococcal"[mh] or "pneumonia necrotizing"[mh] or "pneumonia viral"[mh] or "organizing pneumonia"[mh] or "cryptogenic organizing pneumonia"[mh] or "healthcare-associated pneumonia"[mh]) AND (English)[Language] FROM 2014 TO 2023 21

Searches
4 1 OR 2 OR 3 30
Note: in the re-run the date was changed to FROM 2023 TO 2024.

Database name: MEDLINE ALL

Searches
1 pneumonia/ or bronchopneumonia/ or pleuropneumonia/ or pneumonia, bacterial/ or chlamydial pneumonia/ or pneumonia, mycoplasma/ or pneumonia, pneumococcal/ or pneumonia, rickettsial/ or pneumonia, staphylococcal/ or pneumonia, necrotizing/ or pneumonia, viral/ or organizing pneumonia/ or cryptogenic organizing pneumonia/ or healthcare-associated pneumonia/ 125178
2 (pneumonia or pneumonias or bronchopneumon* or pleuropneumon*).ti,ab. 159311
3 1 or 2 229286
4 Cost-Benefit Analysis/ 93463
5 Quality-Adjusted Life Years/ 15940
6 Markov Chains/ 16047
7 exp Models, Economic/ 16244
8 cost*.ti. 146284
9 (cost* adj2 utilit*).tw. 7812
10 (cost* adj2 (effective* or assess* or evaluat* or analys* or model* or benefit* or threshold* or quality or expens* or saving* or reduc*)).tw.279720
11 (economic* adj2 (evaluat* or assess* or analys* or model* or outcome* or benefit* or threshold* or expens* or saving* or reduc*)).tw. 47585
12 (qualit* adj2 adjust* adj2 life*).tw. 18059
13 QALY*.tw. 14611
14 (incremental* adj2 cost*).tw. 17628
15 ICER.tw. 6134
16 utilities.tw. 9537
17 markov*.tw. 32169
18 (dollar* or USD or cents or pound or pounds or GBP or sterling* or pence or euro or euros or yen or JPY).tw. 54722
19 ((utility or effective*) adj2 analys*).tw. 25292
20 (willing* adj2 pay*).tw. 9954
21 (EQ5D* or EQ-5D*).tw. 13646
22 ((euroqol or euro-qol or euroquol or euro-quol or eurocol or euro-col) adj3 ("5" or five)).tw. 3930
23 (european* adj2 quality adj3 ("5" or five)).tw. 723
24 or/4-23 506237
25 3 and 24 3855
26 afghanistan/ or africa/ or africa, northern/ or africa, central/ or africa, eastern/ or "africa south of the sahara"/ or africa, southern/ or africa, western/ or albania/ or algeria/ or andorra/ or angola/ or "antigua and barbuda"/ or argentina/ or armenia/ or azerbaijan/ or bahamas/ or bahrain/ or bangladesh/ or barbados/ or belize/ or benin/ or bhutan/ or bolivia/ or borneo/ or "bosnia and herzegovina"/ or botswana/ or brazil/ or brunei/ or bulgaria/ or burkina faso/ or burundi/ or cabo verde/ or cambodia/ or cameroon/ or central african republic/ or chad/ or exp china/ or comoros/ or congo/ or cote d'ivoire/ or croatia/ or cuba/ or

Searches
"democratic republic of the congo"/ or cyprus/ or djibouti/ or dominica/ or dominican republic/ or ecuador/ or egypt/ or el salvador/ or equatorial guinea/ or eritrea/ or eswatini/ or ethiopia/ or fiji/ or gabon/ or gambia/ or "georgia (republic)"/ or ghana/ or grenada/ or guatemala/ or guinea/ or guinea-bissau/ or guyana/ or haiti/ or honduras/ or independent state of samoa/ or exp india/ or indian ocean islands/ or indochina/ or indonesia/ or iran/ or iraq/ or jamaica/ or jordan/ or kazakhstan/ or kenya/ or kosovo/ or kuwait/ or kyrgyzstan/ or laos/ or lebanon/ or liechtenstein/ or lesotho/ or liberia/ or libya/ or madagascar/ or malaysia/ or malawi/ or mali/ or malta/ or mauritania/ or mauritius/ or mekong valley/ or melanesia/ or micronesia/ or monaco/ or mongolia/ or montenegro/ or morocco/ or mozambique/ or myanmar/ or namibia/ or nepal/ or nicaragua/ or niger/ or nigeria/ or oman/ or pakistan/ or palau/ or exp panama/ or papua new guinea/ or paraguay/ or peru/ or philippines/ or qatar/ or "republic of belarus"/ or "republic of north macedonia"/ or romania/ or exp russia/ or rwanda/ or "saint kitts and nevis"/ or saint lucia/ or "saint vincent and the grenadines"/ or "sao tome and principe"/ or saudi arabia/ or serbia/ or sierra leone/ or senegal/ or seychelles/ or singapore/ or somalia/ or south africa/ or south sudan/ or sri lanka/ or sudan/ or suriname/ or syria/ or taiwan/ or tajikistan/ or tanzania/ or thailand/ or timor-leste/ or togo/ or tonga/ or "trinidad and tobago"/ or tunisia/ or turkmenistan/ or uganda/ or ukraine/ or united arab emirates/ or uruguay/ or uzbekistan/ or vanuatu/ or venezuela/ or vietnam/ or west indies/ or yemen/ or zambia/ or zimbabwe/ 1312779
27 "organisation for economic co-operation and development"/ 565
28 australasia/ or exp australia/ or austria/ or baltic states/ or belgium/ or exp canada/ or chile/ or colombia/ or costa rica/ or czech republic/ or exp denmark/ or estonia/ or europe/ or finland/ or exp france/ or exp germany/ or greece/ or hungary/ or iceland/ or ireland/ or israel/ or exp italy/ or exp japan/ or korea/ or latvia/ or lithuania/ or luxembourg/ or mexico/ or netherlands/ or new zealand/ or north america/ or exp norway/ or poland/ or portugal/ or exp "republic of korea"/ or "scandinavian and nordic countries"/ or slovakia/ or slovenia/ or spain/ or sweden/ or switzerland/ or turkey/ or exp united kingdom/ or exp united states/ 3515662
29 european union/ 17814
30 developed countries/ 21444
31 or/27-30 3531767
32 26 not 31 1222696
33 25 not 32 3418
34 limit 33 to english language 3185
35 limit 34 to (letter or historical article or comment or editorial or news or case reports) 181
36 34 not 35 3004
37 Animals/ not (Animals/ and Humans/) 5137547
38 36 not 37 2921
39 limit 38 to yr="2014 -Current" 1534
Note: in the re-run the following lines were used:
38 36 not 37
39 limit 38 to ed=20231101-20241014
40 limit 38 to dt=20231101-20241014
41 39 or 40

Database name: NHS Economic Evaluation Database (NHS EED)

Searches
1 MeSH DESCRIPTOR Pneumonia 252
2 MeSH DESCRIPTOR bronchopneumonia 1
3 MeSH DESCRIPTOR pleuropneumonia 0
4 MeSH DESCRIPTOR pneumonia, bacterial 90
5 MeSH DESCRIPTOR chlamydial pneumonia 0
6 MeSH DESCRIPTOR pneumonia, mycoplasma 3
7 MeSH DESCRIPTOR pneumonia, pneumococcal 48
8 MeSH DESCRIPTOR pneumonia, rickettsial 0
9 MeSH DESCRIPTOR pneumonia, staphylococcal 10
10 MeSH DESCRIPTOR pneumonia, necrotizing 0
11 MeSH DESCRIPTOR pneumonia, viral 9
12 MeSH DESCRIPTOR Cryptogenic Organizing Pneumonia 0
13 MeSH DESCRIPTOR healthcare-associated pneumonia 0
14 (pneumonia) OR (pneumonias) 1118
15 (bronchopneumon*) OR (pleuropneumon*) 3
16 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 1120
17 (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15) IN NHSEED 425
18 (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15) IN NHSEED FROM 2014 TO 2024 11
Note: no re-run required as the database has been archived and not updated since 31 March 2015.

Appendix C - Diagnostic evidence study selection

Figure 1: Systematic review and primary study identification

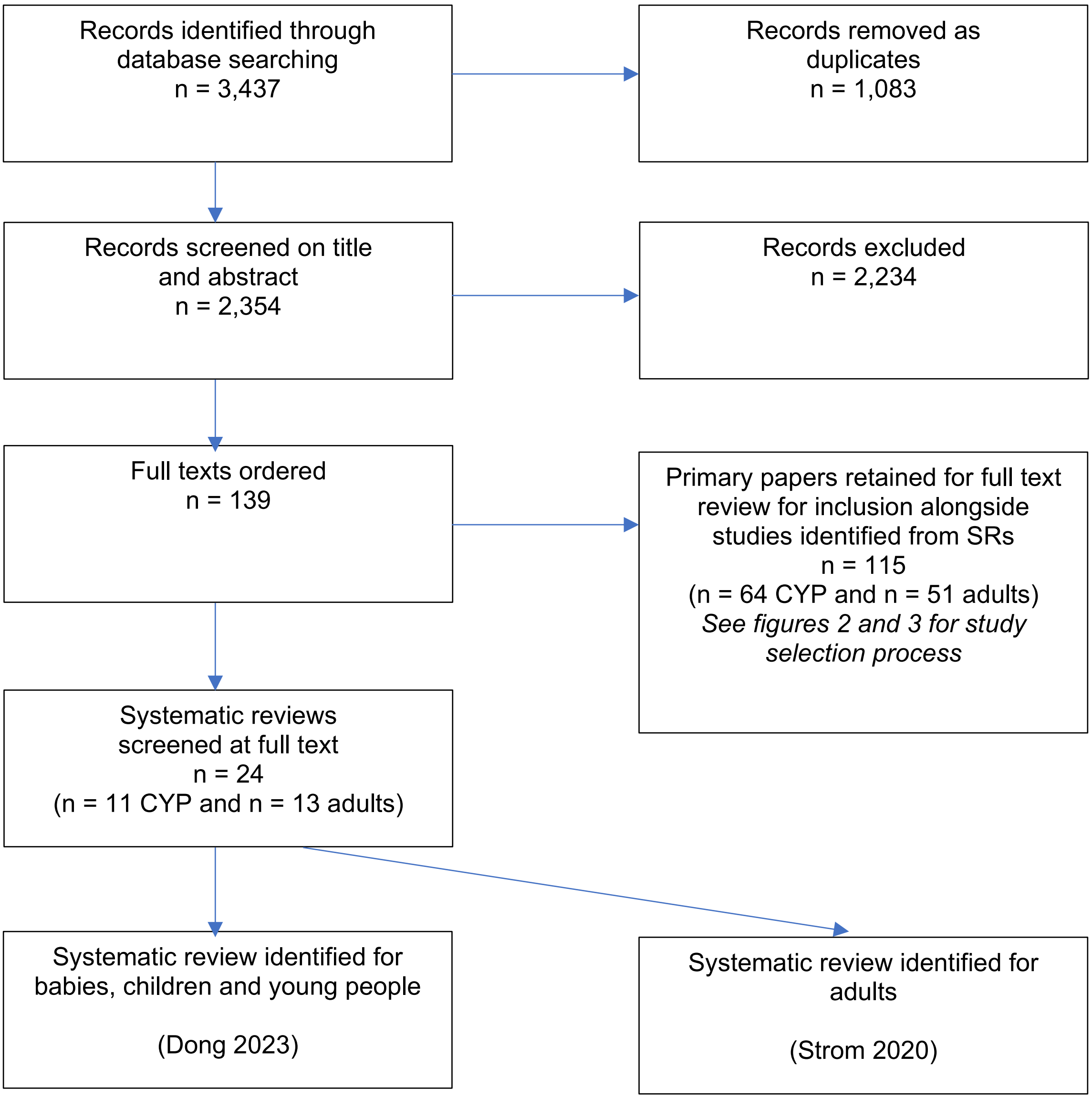


Figure 2: Study selection for babies, children and young people

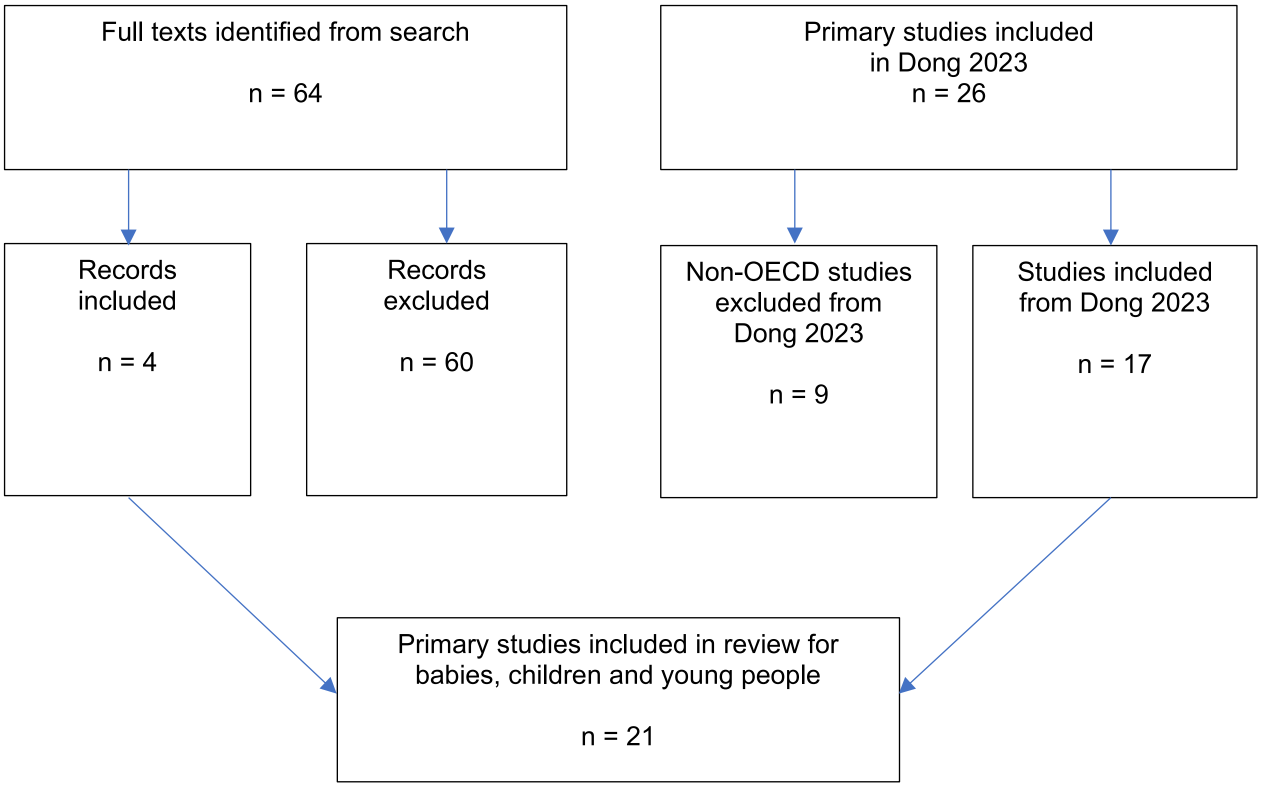
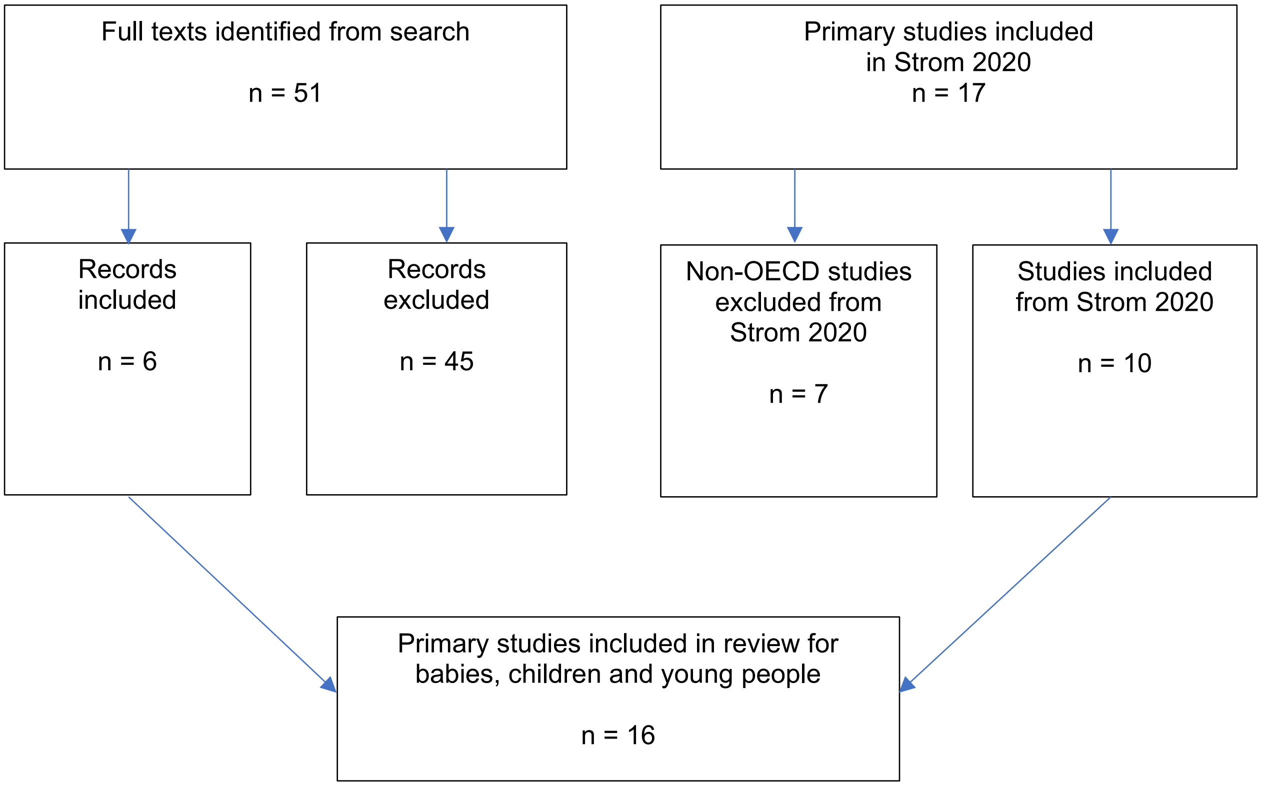


Figure 3: Study selection for adults > 18 years



Appendix D – Diagnostic evidence

D.1 Systematic reviews

Dong, 2023

Bibliographic Reference	Dong, Zhenghao; Shen, Cheng; Tang, Jinhai; Wang, Beinuo; Liao, Hu; Accuracy of Thoracic Ultrasonography for the Diagnosis of Pediatric Pneumonia: A Systematic Review and Meta-Analysis.; Diagnostics (Basel, Switzerland); 2023; vol. 13 (no. 22)

Study Characteristics

Study design	Systematic review
Study details	Dates searched: articles published up to July 2023 Databases searched: Embase, PubMed, and Web of Science Sources of funding: This research received no external funding
Inclusion criteria	Patients aged below 16 years presenting symptoms and signs suggestive of pneumonia (including but not limited to fever, tachypnoea or dyspnoea, cough, diminished breath sounds, and rales). Exhibiting positive findings on thoracic ultrasound (such as lung consolidation, air bronchogram sign, pleural effusion, abnormal pleural line, and B-lines etc). Clinical diagnoses along with laboratory and chest imaging examinations were used as reference
Exclusion criteria	Patients with severe respiratory diseases other than pneumonia Patients with congenital anomalies or chronic lung diseases Patients over 16 years of age Patients who had not undertaken thoracic ultrasound as a diagnostic tool Case reports and studies without original data (such as reviews, comments, etc.) Studies with incomplete data (did not report the sensitivity and specificity as the results or did not provide enough information to calculate the sensitivity and specificity) or where statistical effect size pooling was not feasible
Intervention(s)	Test: Lung ultrasound

	Reference standard: Chest X-ray, clinical diagnosis and lab results
Outcome(s)	Sensitivity and specificity
Number of studies included in the systematic review	26 articles included in the original review
Studies from the systematic review that are relevant for use in the current review	Boursiani 2017 Caiulo 2013 Claes 2017 Copetti 2008 Ellington 2017 Esposito 2014 Guerra 2016 Gurbuz 2023 Ianniello 2016 Iorio 2015 Iuri 2009 Reali 2014 Samson 2016 Shah 2013 Urbankowska 2015 Zhan 2016 Yilmaz 2017
Studies from the systematic review that are not relevant for use in the current review	Studies from non-OECD countries: • Amatya 2023 • Jiang and Wei 2022 • Liu 2014 • Man 2017 • Osman 2020

	• Talwar 2022 • Thareeb 2022 • Yadav 2017 • Yan 2020

OECD: Organisation for Economic Co-operation and Development

Critical appraisal - ROBIS checklist

Section	Question	Answer
Overall study ratings	Overall risk of bias	Low
Overall study ratings	Applicability as a source of data	Partially applicable *(Selectively using data, excluding studies from non-OECD countries.)*

OECD: Organisation for Economic Co-operation and Development

Strom, 2020

Bibliographic Reference	Strom, Julie Jepsen; Haugen, Pia Sperling; Hansen, Malene Plejdrup; Graumann, Ole; Jensen, Martin Bach B; Aakjaer Andersen, Camilla; Accuracy of lung ultrasonography in the hands of non-imaging specialists to diagnose and assess the severity of community-acquired pneumonia in adults: a systematic review.; BMJ open; 2020; vol. 10 (no. 6); e036067

Study Characteristics

Study design	Systematic review
Study details	Dates searched: Initial search February 2017 and updated search in May 2019 Databases searched: MEDLINE and Embase via Ovid, CINAHL via Ebsco, Web of Science and Cochrane Central Register of Controlled Trials Sources of funding: The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.
Inclusion criteria	Diagnostic accuracy studies that described the use of LUS for diagnosing CAP in adults (≥18 years) Diagnosis of CAP confirmed by other means than LUS, e.g. other imaging.
Exclusion criteria	Studies not published in English, Danish, Norwegian or Swedish Studies of patients where LUS had been performed for other indications than suspicion of pneumonia

	Studies where the imaging had been performed by an imaging specialist (sonographer or radiologist). Only studies of non-imaging specialists included (e.g. emergency physicians, internal medicine physicians and intensivists). If the pneumonia was considered to be ventilator-associated or nosocomial
Intervention(s)	Test: Lung ultrasound Reference standard: CT, qualitative assessment of the final diagnosis based on clinical, laboratory and microbiological data, including CXR or chest CT results, and CXR combined with CT when LUS and CXR were discordant.
Outcome(s)	Sensitivity and specificity
Number of studies included in the systematic review	17 articles included in the review
Studies from the systematic review that are relevant for use in the current review	Benci 1996 Bourcier 2014 Cipollini 2018 Corradi 2015 Cortellaro 2012 Nazerian 2015 Pagano 2015 Parlamento 2009 Reissig 2012 Ticinesi 2016
Studies from the systematic review that are not relevant for use in the current review	Studies from non-OECD countries: • Amatya 2018 • Bitar 2018 • Fares 2015 • Karimi 2019 • Liu 2015 • Taghizadieh 2015 • Unluer 2013

Additional comments	Definition of pneumonia based on LUS varied across studies. Still, presence of subpleural or alveolar consolidation or a tissue-like lesion was part of the definition in all studies except one, in which no definition was described. Review focused on use of LUS in the hands of non-imaging specialist physicians working clinically. The review reported that there was no overall difference in diagnostic accuracy when taking into account the physicians' specialty, experience or training (although not all studies reported information on prior experience or training).

CAP: community acquired pneumonia; CT: computed tomography; CXR: chest X-ray; LUS: lung ultrasound; OECD: Organisation for Economic Co-operation and Development

Critical appraisal - ROBIS checklist

Section	Question	Answer
Overall study ratings	Overall risk of bias	Moderate *(Some concerns about the quality of the synthesis due to heterogeneity in study populations, settings, and reference standard - was not possible to meta-analyse)*
Overall study ratings	Applicability as a source of data	Partially applicable *(Restricted to studies of non-imaging specialists only - sonographers and radiologists excluded.)*

D.2 Primary diagnostic accuracy studies

D.2.1 Babies, children and young people <18 years

Ambroggio, 2016

Bibliographic Reference	Ambroggio, Lilliam; Sucharew, Heidi; Rattan, Mantosh S; O'Hara, Sara M; Babcock, Diane S; Clohessy, Caitlin; Steinhoff, Mark C; Macaluso, Maurizio; Shah, Samir S; Coley, Brian D; Lung Ultrasonography: A Viable Alternative to Chest Radiography in Children with Suspected Pneumonia?.; The Journal of pediatrics; 2016; vol. 176; 93-98e7

Study Characteristics

Study type	Prospective cohort study
Study details	Study location Cincinnati, USA

	Setting Cincinnati Children's Hospital Medical Center Study dates between May 1, 2012, and January 31, 2014 Sources of funding Funded by the Thrasher Research Fund and the Bureau of Health Professions, Health Resources and Services Administration, and the Department of Health and Human Services
Inclusion criteria	underwent LUS underwent CXR aged 3 months to 18 years had a CT scan ordered for a clinical reason (e.g., pneumonia, tumour) or who were hospitalized with a respiratory diagnosis (i.e., pneumonia, wheezing, asthma, bronchiolitis, pleural effusion, parapneumonic effusion)
Exclusion criteria	imaging not being performed within the 36-hour time frame Children aged <3 months Children imaged by portable CXR
Number of participants	A total of 266 patients were approached, and 144 patients (54%) were enrolled; 12 patients were excluded because of imaging not being performed within the 36-hour time frame. Of the 132 patients who underwent both LUS and CXR , 36 (27%) also had a CT performed for clinical reasons.
Length of follow-up	n/a
Loss to follow-up	n/a
Index test(s)	LUS performed by 1 of 5 sonographers trained to perform the study protocol using an Aplio XG ultrasound machine with 2- to 6-MHz convex and 5- to 12-MHz linear array transducers. For smaller children, 4- to 10-MHz curved and 5- and 12-MHz linear array transducers were used.
Reference standard (s)	Anteroposterior and lateral chest radiographs
Subgroup analyses	None

CT: computed tomography; CXR: chest X-ray; LUS: lung ultrasound; n/a: not available; OECD: Organisation for Economic Co-operation and Development

Population characteristics

Study-level characteristics

Characteristic	Study (N = 132)
% Female Nominal	44
Median age (IQR)	4.4 (1.6 to 7.9)

IQR: interquartile range

Critical appraisal - GDT Crit App - QUADAS-2

Section	Question	Answer
Overall risk of bias and directness	Risk of Bias	Low
Overall risk of bias and directness	Directness	Directly applicable

Biagi, 2018

Bibliographic Reference	Biagi, Carlotta; Pierantoni, Luca; Baldazzi, Michelangelo; Greco, Laura; Dormi, Ada; Dondi, Arianna; Faldella, Giacomo; Lanari, Marcello; Lung ultrasound for the diagnosis of pneumonia in children with acute bronchiolitis.; BMC pulmonary medicine; 2018; vol. 18 (no. 1); 191

Study Characteristics

Study type	Prospective cohort study
Study details	Study location Italy Setting Hospital Pediatric Emergency Unit Study dates two consecutive autumn and winter seasons (2016–2017)

	Sources of funding The authors received no specific funding for this work.
Inclusion criteria	birth to 24 months of age diagnosis of bronchiolitis undergone posteroanterior CXR because of clinical suspicion of concomitant bacterial pneumonia
Exclusion criteria	chronic respiratory disease congenital heart diseases severe neuromuscular disease congenital or acquired immunodeficiency.
Number of participants	A total of 87 patients were enrolled in the study. The reasons for performing CXR were: fever > 38.5 °C or > 38 °C for 2 or more days in 20 patients, persistent $SatO_2$ < 92% in 27 cases, asymmetric breath sounds on auscultation in 33 patients, WBC > 15,000/mmc in 25 cases, CRP > 4 mg/dl in 14 cases and septic appearance in 2 cases. A final diagnosis of concomitant bacterial pneumonia was done in 25/87 patients with bronchiolitis
Length of follow-up	n/a
Loss to follow-up	n/a
Index test(s)	LUS was performed by a pediatrician with specific LUS expertise, using a linear probe with frequencies ranging from 7.5 MHz to 12 MHz.
Reference standard (s)	Chest x-ray
Subgroup analyses	None

CRP: C-reactive protein; CXR: chest X-ray; LUS: lung ultrasound; n/a: not available; SatO2: oxygen saturation; WBC: white blood cell

Population characteristics

Study-level characteristics

Characteristic	Study (N = 87)
% Female Nominal	50

Characteristic	Study (N = 87)
Mean age (SD) (Months) Mean (SD)	5.7 (5.2)

SD: standard deviation

Critical appraisal - GDT Crit App - QUADAS-2

Section	Question	Answer
Overall risk of bias and directness	Risk of Bias	Low
Overall risk of bias and directness	Directness	Partially applicable *(Children have bronchiolitis)*

Caglar, 2019

Bibliographic Reference	Caglar, A.; Ulusoy, E.; Er, A.; Akgul, F.; Citlenbik, H.; Yilmaz, D.; Duman, M.; Is lung ultrasonography a useful method to diagnose children with community-acquired pneumonia in emergency settings?; Hong Kong Journal of Emergency Medicine; 2019; vol. 26 (no. 2); 91-97

Study Characteristics

Study type	Prospective cohort study
Study details	Study location Turkey Setting Hospital - Department of Pediatric Emergency Care Study dates Between September 2015 and April 2016 Sources of funding The author(s) received no financial support for the research, authorship, and/or publication of this article.

Inclusion criteria	Under 18 years Suspected CAP
Exclusion criteria	COPD external thoracic wall malformations and thoracic trauma patients who did not undergo both CXR and LUS on admission
Number of participants	This study included 91 patients with suspicion of CAP. The median (IQR) age of the patients was 3.0 (1.0–5.0) years and 59% of the subjects were boys. In all, 70 (78.0%) patients were diagnosed to have CAP according to clinical and CXR findings, 11 (12.0%) patients with fever and respiratory distress were diagnosed to have bronchiolitis, while 10 patients (11.0%) were diagnosed to have asthma.
Length of follow-up	n/a
Loss to follow-up	n/a
Index test(s)	LUS performed by pediatric emergency physician who had taken course. LUS with linear (L12-4MHz) and curved (C5-1MHz) probes
Reference standard (s)	Chest x-ray
Subgroup analyses	Types of pneumonia

CAP: community acquired pneumonia; COPD: chronic obstructive pulmonary disease; CXR: chest X-ray; IQR: interquartile range; LUS: lung ultrasound; SD: standard deviation

Population characteristics

Study-level characteristics

Characteristic	Study (N = 91)
% Female Nominal	41
Mean age (SD) Median (IQR)	3 (1 to 5)

IQR: interquartile range; SD: standard deviation

Critical appraisal - GDT Crit App - QUADAS-2

Section	Question	Answer
Overall risk of bias and directness	Risk of Bias	Low
Overall risk of bias and directness	Directness	Directly applicable

Lissaman, 2019

Bibliographic Reference	Lissaman, Claire; Kanjanauptom, Panida; Ong, Cyril; Tessaro, Mark; Long, Elliot; O'Brien, Adam; Prospective observational study of point-of-care ultrasound for diagnosing pneumonia.; Archives of disease in childhood; 2019; vol. 104 (no. 1); 12-18

Study Characteristics

Study type	Prospective cohort study
Study details	Study location Australia Setting paediatric emergency department Study dates March to July 2016 Sources of funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors
Inclusion criteria	1 month to 12 years Received chest radiograph for possible pneumonia
Exclusion criteria	Prior CR for same issue required life support
Number of participants	142 participants were considered for eligibility. Thirty-eight patients were excluded prior to LUS. Ultrasound was incomplete in four patients due to accidental omission of one to two lung views and consent was withdrawn in three. Ninety-seven patients had complete data for the primary outcome
Length of follow-up	Follow-up data were obtained from the patient’s medical record and a telephone call to the parent/guardian within 2–3 weeks.

Loss to follow-up	Unclear
Reference standard (s)	single anteroposterior CR
Subgroup analyses	None

CR: chest radiograph; LUS: lung ultrasound

Population characteristics

Study-level characteristics

Characteristic	**Study (N = 97)**
% Female Nominal	48
Median age (IQR)	2.4 (1.1 to 4.3)
Duration of symptoms Median (IQR)	4 (3 to 7)
History of respiratory disease % Nominal	11

IQR: interquartile range

Critical appraisal - GDT Crit App - QUADAS-2

Section	**Question**	**Answer**
Overall risk of bias and directness	Risk of Bias	Low
Overall risk of bias and directness	Directness	Directly applicable

D.2.2 Adults ≥18 years

Buda, 2020	
Bibliographic Reference	Buda, Natalia; Hajduk, Adam; Jaworska, Joanna; Zdrojewski, Zbigniew; Lung Ultrasonography as an Accurate Diagnostic Method for the Diagnosis of Community-Acquired Pneumonia in the Elderly Population.; Ultrasound quarterly; 2020; vol. 36 (no. 2); 111-117

Study Characteristics

Study type	Prospective cohort study
Study details	Study location: Poland Setting: Hospital setting; elderly patients admitted to clinical ward with suspicion of CAP Study dates: Autumn 2017 Sources of funding: Not reported
Inclusion criteria	Clinical suspicion of CAP in adult patients older than 65 years
Exclusion criteria	Younger than 65 years, or pneumothorax, or disseminated neoplastic disease
Number of participants	N = 191. Patients were transferred from the ED, via the radiology department, to the clinical ward.
Index test(s)	<u>Lung ultrasound</u> LUS was conducted for each patient as soon as possible after admission to the ward (within 1 hour) and therefore 30-90 minutes after CXR (which was done in radiology after ED and before ward admission). LUS was performed by a highly skilled, experienced clinician, blinded to CXR results. Lung ultrasonography was classified as having pulmonary inflammatory lesions if findings typical for pneumonia were detected, that is, (1) subpleural consolidations, often accompanied by C-line artefacts, containing dynamic air bronchogram or mixed (dynamic and static) air bronchogram and/or fluid bronchogram, with normal vasculature on CD option, and (2) B-line artefacts patterns, including focal interstitial syndrome or alveolar-interstitial syndrome present in a big lung area, mixed with properly aerated lung tissue (so-called spared areas) and/or focal “white lung.” In addition, pleural effusion, atelectasis, and congestions were assessed, as signs accompanying pneumonia (or indicating complicated pneumonia).
Reference standard (s)	Clinical diagnosis of pneumonia was primarily based on data collected during the medical interview and those obtained from the physical examination and laboratory tests results. The final diagnosis was additionally confirmed with positive chest imaging. CXR was classified as having pulmonary inflammatory lesions if the interpretation indicated the presence of the following: pulmonary opacity, pulmonary infiltrate, pulmonary consolidation, pneumonia, or bronchopneumonia. In addition, pleural effusion and congestion were assessed, as signs accompanying pneumonia (or indicating complicated pneumonia).
Additional comments	This was a geriatric population

CAP: community acquired pneumonia; CD: colour doppler; CXR: chest X-ray; ED: emergency department; CR: chest radiograph; LUS: lung ultrasound

Population characteristics

Study-level characteristics

Characteristic	Study (N = 191)
% Female No of events	n = 99 ; % = 51.8
Mean age (SD) Mean (SD)	80.9 (10.1)
Pneumonia diagnosis at discharge No of events	n = 115 ; % = 60.2
Bedridden patients No of events	n = 113 ; % = 59.2

SD: standard deviation

Critical appraisal - QUADAS-2

Section	Question	Answer
Overall risk of bias and directness	Risk of Bias	Low
Overall risk of bias and directness	Directness	Partially applicable *(Geriatric population, many bedridden.)*

Istrail, 2023

Bibliographic Reference	Istrail, L.; Chakravorty, S.; Stepanova, M.; Negative predictive value Of Point-of-care ultrasound normal exam to exclude PneumoniA (NO-PNA); medRxiv; 2023

Study Characteristics

Study type	Prospective cohort study
Study details	Study location: United States Setting: Hospital Study dates: Not reported Sources of funding: Not reported

Inclusion criteria	Patients admitted to the hospital and undergoing chest CT for any reason BMI of 35 or under
Exclusion criteria	Patients who were intubated or on positive pressure ventilation Patients who had dressings or wounds preventing a full ultrasound exam of the thorax, or had chest tubes present
Number of participants	61 patients were consented and enrolled. Two patients were excluded due to inability to visualize the lung (one for bilateral breast implants and one for large bandage over a port that covered the anterior chest wall), and 59 were included in the analysis.
Index test(s)	<u>Lung ultrasound</u> The Butterfly IQ+ probe was used - a handheld, smartphone-connected ultrasound probe. All ultrasound scans were performed by one physician certified in Point of Care Lung Ultrasound (POCUS) by the Society of Hospital Medicine and CHEST with 6 years of POCUS experience. They were blinded to type of CT scan, admitting diagnosis and all other medical information. A normal lung exam was deemed present in each section if there was presence of A-lines and lung sliding. An exam was deemed abnormal and consistent with a possible lung consolidation or pneumonia if any of the following were detected: 1. Localised, pathologic B lines defined as 3 or more B-lines in a given rib space 2. Jagged, irregular pleura with associated B -lines or subpleural consolidation 3. Confluent B lines in a given rib space 4. Subpleural (< 1cm) or large (> 1cm in any dimension) consolidation
Reference standard (s)	Chest CT
Additional comments	The LUS scanner was completely blinded to all clinical information; the study enrolled any patient who had chest CT for any reason and there was a high prevalence of non-infectious lung disease: study subjects included patients with pulmonary fibrosis, cardiogenic pulmonary oedema, pulmonary sarcoidosis, lung cancer, and pulmonary contusions after motor vehicle accidents, all of which cause lung parenchymal changes that can mimic the appearance of a lung consolidation related to pneumonia and reduce the specificity of these findings. Only enrolling patients with clinical evidence of pneumonia may have improved specificity.

BMI: body mass index; CT: computed tomography; IQ: intelligence quotient; LUS: lung ultrasound

Population characteristics

Study-level characteristics

Characteristic	Study (N = 59)
% Female No of events	n = 20 ; % = 34
Mean age (SD) Mean (SD)	63.9 (17.2)
BMI Mean (SD)	23.2 (4.7)

BMI: body mass index; SD: standard deviation

Critical appraisal - QUADAS-2

Section	Question	Answer
Overall risk of bias and directness	Risk of Bias	Moderate *(The study recruited all patients who underwent CT of their chest for any reason, and the proportion of patients with pneumonia is not reported. Other non-infectious lung conditions such as pulmonary fibrosis, cardiogenic pulmonary oedema, pulmonary sarcoidosis, lung cancer, and pulmonary contusions after motor vehicle accidents, may all cause lung parenchymal changes that can mimic the appearance of a lung consolidation related to pneumonia and could reduce the specificity of these findings.)*
Overall risk of bias and directness	Directness	Partially applicable *(Sample included all patients undergoing chest CT - not specific to patients with suspected pneumonia.)*

CT: computed tomography

Karademir, 2021

Bibliographic Reference	Karademir, D.; Yilmaz, S.; Ozturan, I.U.; Dogan, N.O.; Yaka, E.; Pekdemir, M.; Performance of bedside lung ultrasound in emergency (BLUE) protocol in the diagnosis of pneumonia; Notfall und Rettungsmedizin; 2021; vol. 24 (no. supplement1); 9-14

Study Characteristics

Study type	Prospective cohort study

Study details	Study location: Turkey Setting: Emergency Department Study dates: December 2018 to March 2019 Sources of funding: Not reported
Inclusion criteria	Patients >18 years of age admitted to the ED with at least 2 of the 5 symptoms of dyspnoea, cough, sputum, fever and chest pain.
Exclusion criteria	Critically ill patients requiring cardiopulmonary resuscitation, mechanical ventilation for respiratory failure, pregnant patients, and those who did not consent to participate were excluded.
Number of participants	A total of 154 patients were included in the study. A definitive diagnosis of pneumonia was made in 112 (72.7%) patients
Index test(s)	<u>Lung ultrasound</u> A 4-year experienced US-certified emergency physician who was blinded to the patients' clinical information performed the LUS using the BLUE protocol. The ultrasound (US) operator had also completed 7 hours of theoretical and practical LUS training prior to study initiation. Esaote MyLab 30 Gold Cardiovascular US and a 2.5–7.5MHz convex probe were used for the measurements. LUS findings supporting pneumonia were recorded as: • A lines with lung sliding and the presence of either pleural effusion or consolidation • Anterior B lines with abolished lung sliding • Presence of predominant unilateral B lines and contralateral A lines • Anterior lung consolidation regardless of size and number
Reference standard (s)	A definitive diagnosis was made by treating emergency physicians according to clinical, laboratory and radiology findings (CXR and CT images)
Subgroup analyses	BLUE protocol profiles (4 diagnostic criteria for LUS e.g. A lines, B lines, consolidation)

BLUE: Bedside Lung Ultrasound in Emergency; CT: computed tomography; CXR: chest X-ray; ED: emergency department; LUS: lung ultrasound; US: ultrasound

Population characteristics

Study-level characteristics

Characteristic	Study (N = 154)
% Female No of events	n = 49 ; % = 32
Mean age (SD) Mean (SD)	67.6 (12.5)

Characteristic	Study (N = 154)
Definitive diagnosis of pneumonia No of events	n = 112 ; % = 72.7

SD: standard deviation

Critical appraisal - QUADAS-2

Section	Question	Answer
Overall risk of bias and directness	Risk of Bias	Low
Overall risk of bias and directness	Directness	Directly applicable

Linsalata, 2020

Bibliographic Reference	Linsalata, Giuseppe; Okoye, Chukwuma; Antognoli, Rachele; Guarino, Daniela; Ravenna, Virginia; Orsitto, Eugenio; Calsolaro, Valeria; Monzani, Fabio; Pneumonia Lung Ultrasound Score (PLUS): A New Tool for Detecting Pneumonia in the Oldest Patients.; Journal of the American Geriatrics Society; 2020; vol. 68 (no. 12); 2855-2862

Study Characteristics

Study type	Prospective cohort study
Study details	Study location: Italy Setting: Acute geriatrics unit Study dates: 10th July 2018 to 15th January 2019 Sources of funding: Not reported
Inclusion criteria	Patients admitted to the acute geriatric unit with symptoms suggestive of pneumonia: dyspnoea, cough, mental confusion, unexplained fever in the absence of localised breath sounds, or crackles on lung auscultation and without extra-thoracic symptoms >65 years
Exclusion criteria	Patients with a history of lung cancer, with or without metastases
Number of participants	214 patients with acute respiratory symptoms were initially enrolled; 132 patients met inclusion and exclusion criteria and so were included in statistical analysis. Acute pneumonia was diagnosed in 94 of 132 cases (71%).
Index test(s)	<u>Lung ultrasound</u>

	LUS was performed by one of two skilled clinicians with 1 year of certified experience of bedside LUS, blinded to CXR result and clinical data. A convex probe, 3.5 to 5 MHz (Esaote Medical System), was used for chest scanning. The ultrasound diagnosis of pneumonia was made by operators on observation of an image of tissue-like echogenicity associated with dynamic air bronchograms, the latter defined as punctiform or linear hyperechoic artefacts with centrifugal inspiratory dynamics. Associated abnormalities, such as pleural effusion, atelectasis, and interstitial syndrome, were diagnosed according to guidelines.
Reference standard (s)	CXR (but in cases where there was a mismatch between CXR and LUS, CT was used)
Subgroup analyses	Multidimensional Prognostic Index (MPI) scores

CT: computed tomography; CXR: chest X-ray; LUS: lung ultrasound;

Population characteristics

Study-level characteristics

Characteristic	Study (N = 132)
% Female No of events	n = 69 ; % = 52.3
Mean age (SD) Mean (SD)	85.3 (6.9)
Aspiration pneumonia No of events	n = 21 ; % = 15.9

SD: standard deviation

Critical appraisal - QUADAS-2

Section	Question	Answer
Overall risk of bias and directness	Risk of Bias	Low
Overall risk of bias and directness	Directness	Partially applicable *(Geriatric sample; mean age 85.3 years. 15.9% of sample had aspiration pneumonia.)*

Mancusi, 2022

Bibliographic Reference	Mancusi, Costantino; Fucile, Ilaria; Gargiulo, Paola; Mosca, Mariangela; Migliaccio, Biagio; Basile, Christian; Gargiulo, Giuseppe; Santoro, Ciro; Morisco, Carmine; De Luca, Nicola; Esposito, Giovanni; Lung Ultrasound in Coronary Care Unit, an Important Diagnostic Tool for Concomitant Pneumonia.; Diagnostics (Basel, Switzerland); 2022; vol. 12 (no. 12)

Study Characteristics

Study type	Prospective cohort study
Study details	Study location: Italy Setting: Coronary Care Units (CCU) Study dates: January 2021 to June 2022 Sources of funding: This research received no external funding.
Inclusion criteria	Patients admitted to the CCU who underwent LUS and CXR
Exclusion criteria	No exclusion criteria reported
Number of participants	In total, 117 patients were analysed by 2 independent and blinded physicians with a concordance of 0.94 (k-Cohen 0.841), of which 7 patients were then excluded due to disagreement on the final diagnosis. Thus, the final study population consisted of 110 patients.
Index test(s)	Lung ultrasound LUS images were acquired with a 5–9 MHz convex probe, following a standardised protocol. The examinations were performed by experienced residents in emergency medicine and reviewed offline by one cardiologist physician with a long experience in LUS. Residents involved in the study have performed >300 LUS with more than 2 years of experience, while the cardiologist has full competence in LUS with teaching, research and development as ‘expert’ in the field. LUS examination was considered to be positive if signs of sonographic consolidation and/or focal multiple B-lines were observed. ‘Sonographic consolidation’ is defined as a small sub-pleural hypoechoic region or large hypoechoic region with liver- or tissue-like echotexture.
Reference standard (s)	Discharge diagnosis made by 2 independent physicians who accessed data from radiological (CXR, LUS and CT), microbiological diagnostics investigations (sputum and blood cultures) and biochemical tests, as well as information on clinical presentation.

Subgroup analyses	Patients who underwent CT scan Presence or absence of pleural effusion
Additional comments	The main reasons for admission to CCU were acute coronary syndrome, acute heart failure and severe valvular heart disease. Pneumonia was clinically diagnosed in 26 (23%) patients.

CCU: coronary care units; CXR: chest X-ray; LUS: lung ultrasound

Population characteristics

Study-level characteristics

Characteristic	Study (N = 110)
% Female No of events	n = 35 ; % = 31.8
Mean age (SD) Mean (SD)	70 (11)
Concomitant heart failure No of events	n = 54 ; % = 49
Pleural effusion No of events	n = 60 ; % = 54.8

SD: standard deviation

Critical appraisal - QUADAS-2

Section	Question	Answer
Overall risk of bias and directness	Risk of Bias	Moderate *(Limited information given on inclusion and exclusion criteria. Low proportion of patients with clinically confirmed pneumonia (26/110; 23%).)*
Overall risk of bias and directness	Directness	Partially applicable *(Patients were recruited from Coronary Care Units; main reasons for admission were acute coronary syndrome, acute heart failure and severe valvular heart disease.)*

Nazerian, 2016

Bibliographic Reference	Nazerian, Peiman; Cerini, Gabriele; Vanni, Simone; Gigli, Chiara; Zanobetti, Maurizio; Bartolucci, Maurizio; Grifoni, Stefano; Volpicelli, Giovanni; Diagnostic accuracy of lung ultrasonography combined with

procalcitonin for the diagnosis of pneumonia: a pilot study.; Critical ultrasound journal; 2016; vol. 8 (no. 1); 17

Study Characteristics

Study type	Prospective cohort study
Study details	Study location: Italy Setting: Emergency departments Study dates: December 2011 to August 2012 Sources of funding: Not reported
Inclusion criteria	Consecutive patients aged >18 years with at least 1 unexplained respiratory complaint among dyspnoea, chest pain, cough or haemoptysis with or without fever, for which the attending emergency physician ordered a chest CT. Patients also had to have a procalcitonin (PCT) level at admission available
Exclusion criteria	Patients where the LUS was not performed before the chest CT or within the time limit
Number of participants	A total of 308 patients with respiratory complains underwent chest CT in the ED during the study period. Four patients did not consent to participate. In 19 patients LUS was not performed before chest CT or within the time limit (3 hours). In 157 patients PCT was not requested by the attending emergency physician at presentation in the ED. Thus, 128 patients were included in the final analysis.
Index test(s)	<u>Lung ultrasound</u> Lung ultrasonography was performed before and within 3h from chest CT by one of eight sonographer investigators who participated to the study. The investigators were four internal and emergency medicine staff physicians with at least 5 years experience on point-of-care emergency ultrasonography and four resident physicians with at least 6 months training in emergency ultrasound. The investigators were aware of the presenting symptoms and the evident physical signs, but were blinded to all the other general clinical information including any radiologic finding and laboratory results. The following multi-probe machines were used: MyLab30 Gold and HD7. LUS was performed by using a 4–8 MHz linear probe or a 3.5–5 MHz curved array probe. The LUS examination was targeted to the detection of typical subpleural lung consolidations with tissue-like or anechoic pattern and blurred, irregular margins with associated focal B-lines. The consolidations due to infection usually show dynamic air bronchograms (branching echogenic structures with centrifuge movement with breathing) or multiple hyperechogenic lentilsized spots, due to air trapped in the small airways. LUS was considered positive when at least one consolidation showing the above-described features was detected.

Reference standard (s)	Clinical diagnosis of pneumonia including CT scan The final diagnoses of pneumonia were determined by two expert internal medicine physicians, blinded to CXR, LUS and PCT results, who independently reviewed all available clinical data including CT data and medical records for hospitalised patients. In case of discordance, a third senior physician adjudicated the diagnosis.
Additional comments	Patients were not enrolled on the basis of a direct suspicion for pneumonia - patients were those with respiratory complaints undergoing CT scan. Furthermore, patients underwent chest CT after the physician was aware of CXR results, suggesting that the population may have been limited to those where the CXR was not diagnostic. This may have contributed to the low sensitivity of CXR. However, the authors note that the role of LUS is often to confirm negative CXRs in patients with high suspicion of pneumonia, so it is more akin to real world scenario.

CT: computed tomography; CXR: chest X-ray; ED: emergency department; LUS: lung ultrasound; PCT: procalcitonin

Population characteristics

Study-level characteristics

Characteristic	Study (N = 128)
% Female No of events	n = 64 ; % = 50
Age range	23 to 100
Mean age (SD) Mean (SD)	70.7 (15.8)
Final diagnosis of pneumonia No of events	n = 61 ; % = 47.7
Pulmonary embolism No of events	n = 21 ; % = 16.4
Heart failure No of events	n = 9 ; % = 7
Pleural effusion No of events	n = 8 ; % = 6.3
Sepsis with no pulmonary involvement No of events	n = 8 ; % = 6.2

Characteristic	Study (N = 128)
COPD No of events	n = 4 ; % = 3.1
Acute Coronary Syndrome No of events	n = 3 ; % = 2.3
Tachyarrhythmia No of events	n = 1 ; % = 0.8
Respiratory failure in pulmonary malignancy No of events	n = 1 ; % = 0.8
Pericardial effusion / pericarditis No of events	n = 1 ; % = 0.8
Miscellaneous No of events	n = 11 ; % = 8.6

COPD: chronic obstructive pulmonary disease; SD: standard deviation

Critical appraisal - QUADAS-2

Section	Question	Answer
Overall risk of bias and directness	Risk of Bias	Moderate *(Patients with CT were those for whom CXR was unable to determine a diagnosis.)*
Overall risk of bias and directness	Directness	Partially applicable *(Study included patients with respiratory complaints; not specific to pneumonia (47.7% had final diagnosis of pneumonia).)*

CT: computed tomography; CXR: chest X-ray

Sezgin, 2020

Bibliographic Reference	Sezgin, Canbahar; Gunalp, Muge; Genc, Sinan; Acar, Nurdan; Ustuner, Evren; Oguz, Ahmet Burak; Tanriverdi, Ayca Koca; Demirkan, Arda; Polat, Onur; Diagnostic Value of Bedside Lung Ultrasonography in Pneumonia.; Ultrasound in medicine & biology; 2020; vol. 46 (no. 5); 1189-1196

Study Characteristics

Study type	Prospective cohort study
Study details	Study location: Turkey

	Setting: Emergency departments Study dates: July 2015 to April 2016 Sources of funding: This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.
Inclusion criteria	Patients who were 18 years or older and clinically suspected of having CAP: body temperature of 38°C and above, and symptoms of cough, pleuritic pain and sputum production
Exclusion criteria	Pregnancy, the presence of primary or metastatic carcinoma of the lung, and the presence of a diagnosed interstitial lung disease.
Number of participants	127 patients pre-diagnosed with pneumonia in the emergency department were evaluated after completing the consent forms. Two patients were excluded from the study because of lung cancer detected by CT scan. A total of 125 patients were evaluated by chest X-rays and LUS.
Index test(s)	Lung ultrasound LUS was performed by an experienced emergency room physician who had attended many ultrasound workshops and performed more than 100 chest ultrasound procedures. It was performed immediately after the patients' arrival at the ED and before the CXRs. LUS was performed at all intercostal spaces on the anterior, lateral and posterior sides of both hemi-thoraxes. All images were obtained using a convex probe (3.5-5 MHz) with LOGIQ Book XP. For LUS, dynamic air bronchograms in subpleural hypoechoic areas, the presence of consolidation, the presence of B-3 lines (lung rockets whose elements are about 3 mm apart) and the presence of diffuse interstitial syndrome were indicative of pneumonia.
Reference standard (s)	Final diagnosis of pneumonia was made by independent physicians based on patients’ clinical signs, radiologic images, laboratory tests and microbiology results CT was used when further evaluation was required; 61/125 patients underwent CT
Subgroup analyses	By reference standard (clinical diagnosis, or CT)

CAP: community acquired pneumonia; CT: computed tomography; CXR: chest X-ray; ED: emergency department; LUS: lung ultrasound; SD: standard deviation

Population characteristics

Study-level characteristics

Characteristic	Study (N = 125)
% Female No of events	n = 44 ; % = 35.2

Characteristic	Study (N = 125)
Mean age (SD) Mean (SD)	71.6 (13.44)
Clinical diagnosis of pneumonia No of events	n = 101 ; % = 80.8

SD: standard deviation

Critical appraisal - QUADAS-2

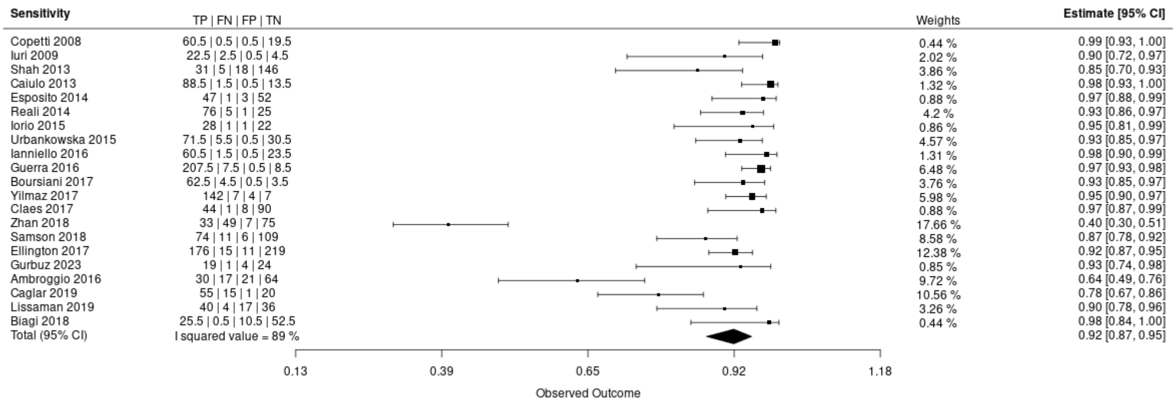
Section	Question	Answer
Overall risk of bias and directness	Risk of Bias	Low
Overall risk of bias and directness	Directness	Directly applicable

Appendix E – Forest plots

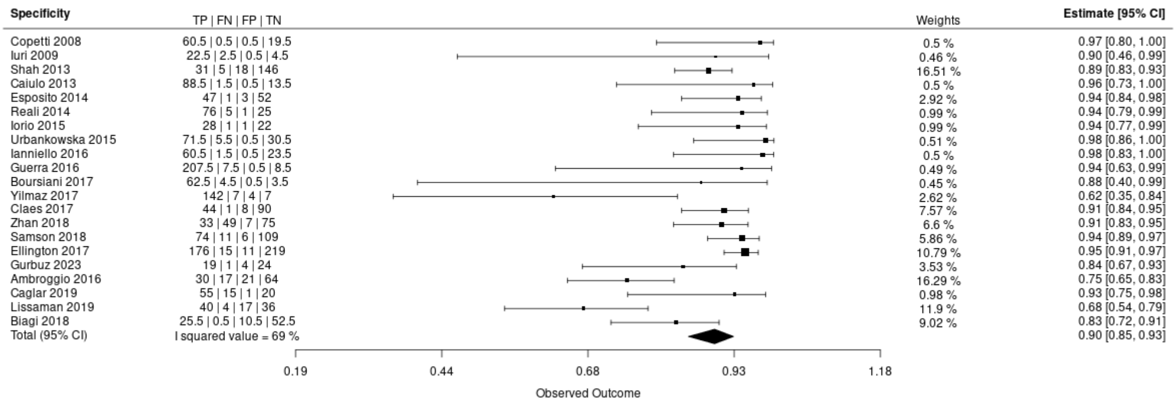
E.1. Forest plots for babies, children and young people

E.1.1 Lung ultrasound vs. Standard care (all reference standards)

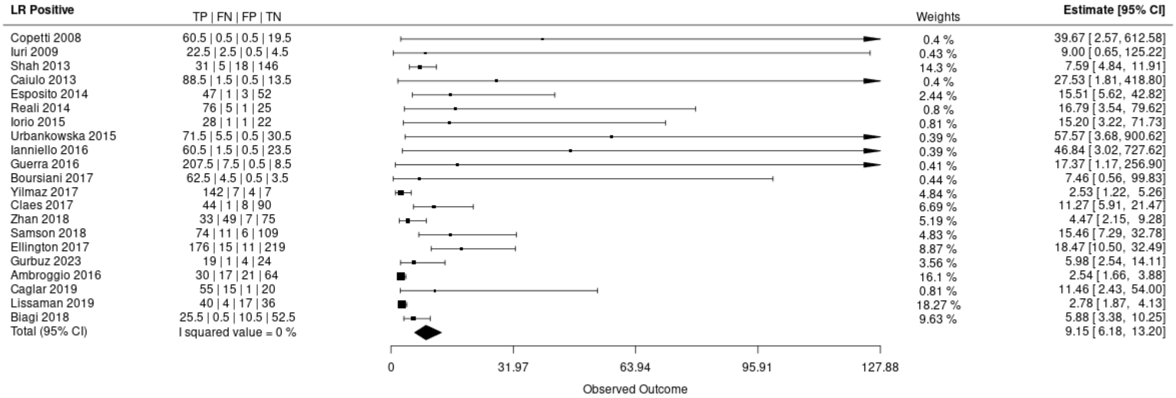
Sensitivity



Specificity



Positive likelihood ratio



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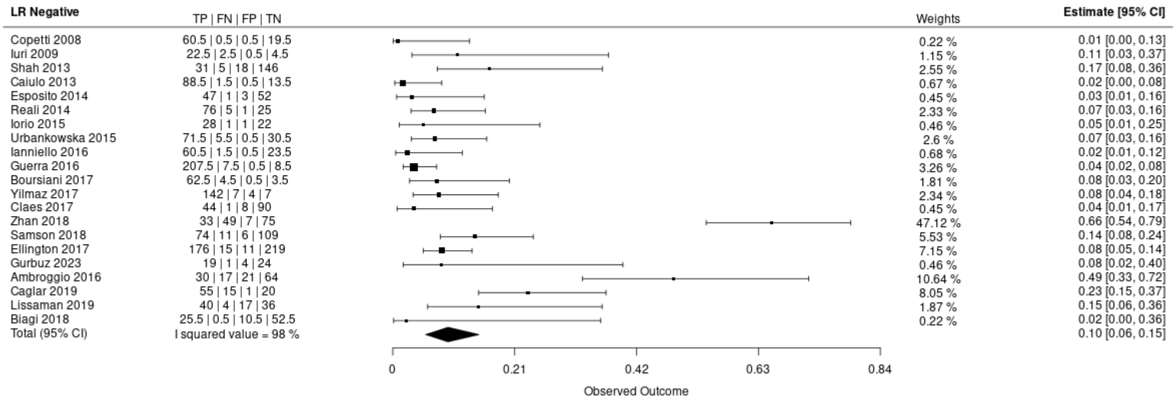
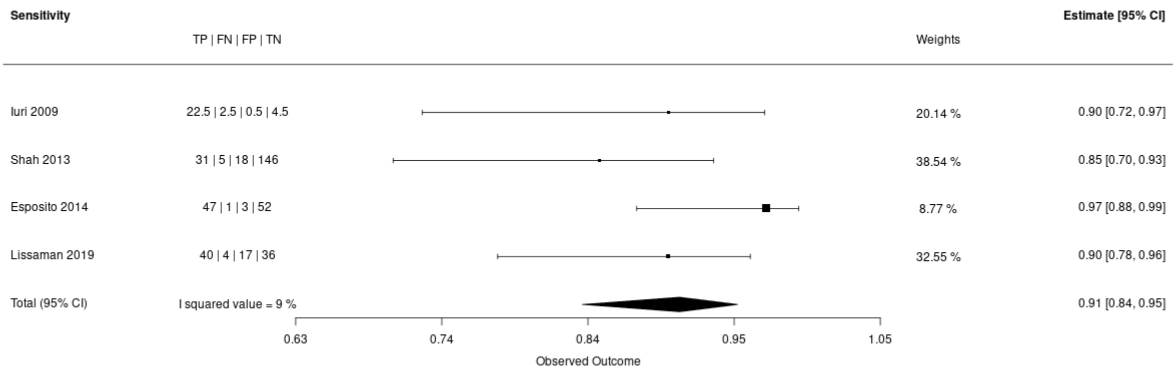
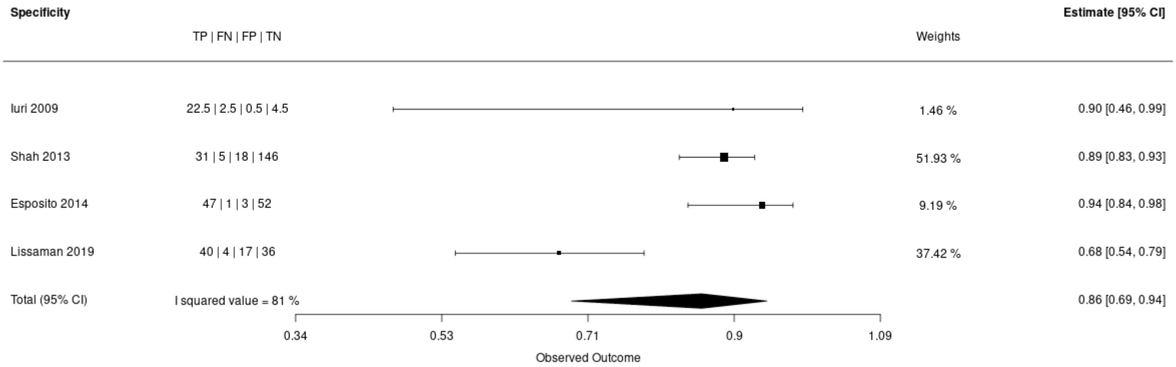


E.1.3 Subgroup by reference: Lung ultrasound vs. chest x-ray alone

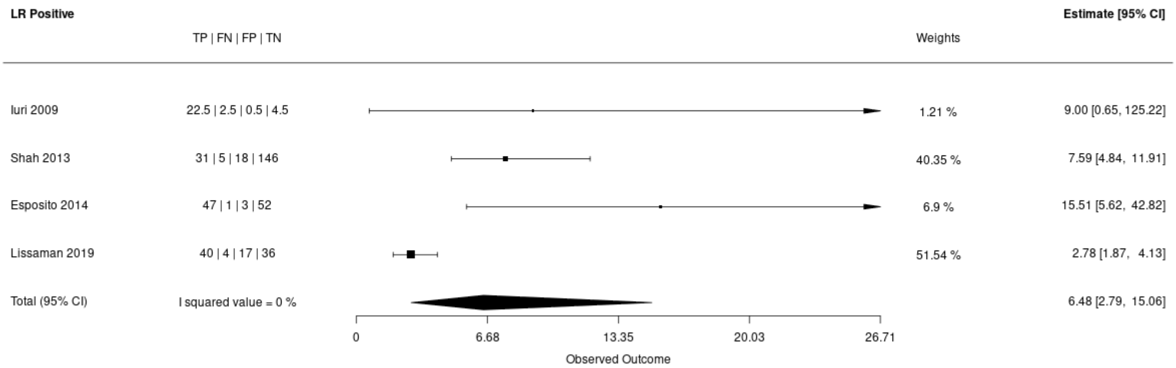
Sensitivity



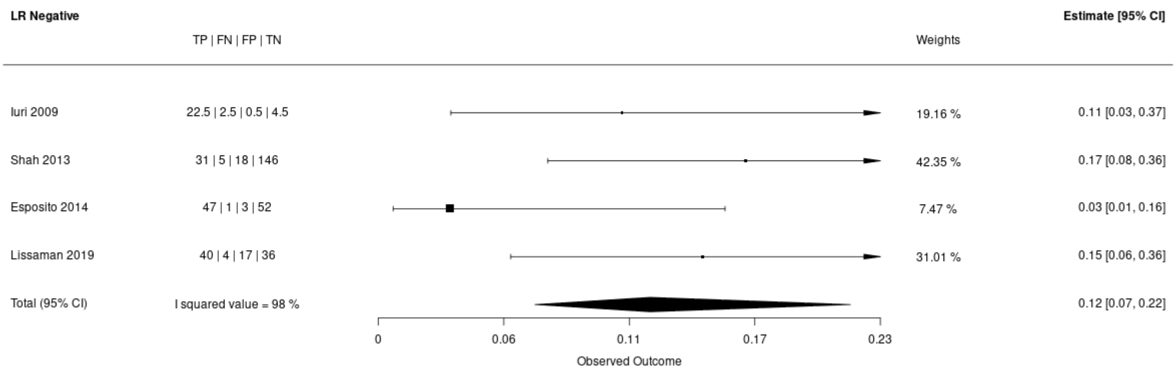
Specificity



Positive likelihood ratio

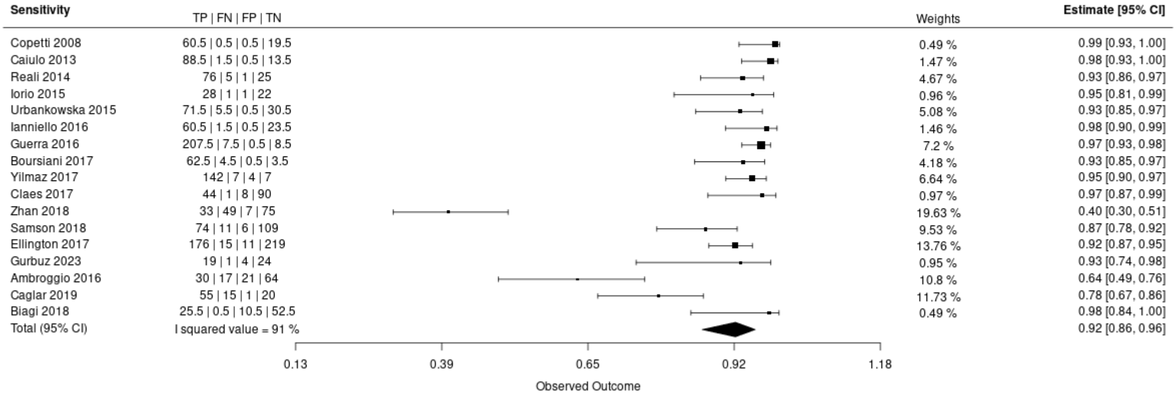


Negative likelihood ratio

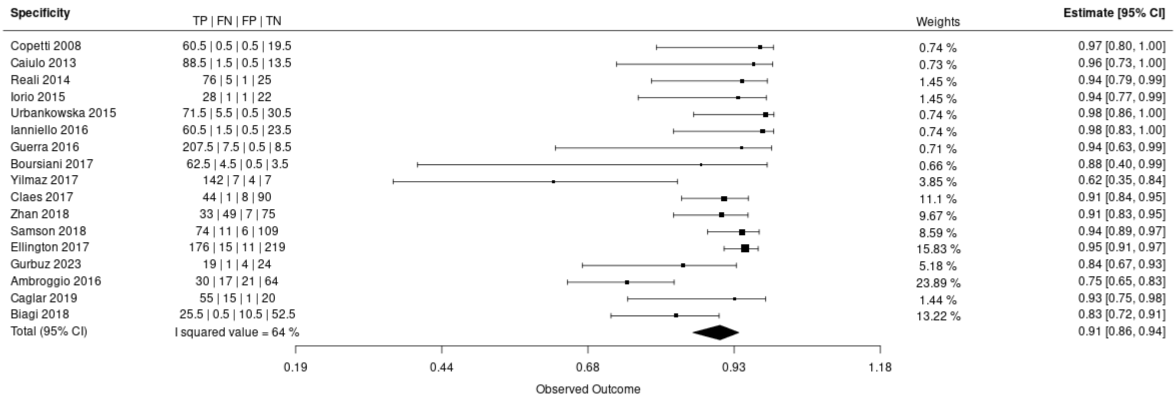


E.1.4 1 Subgroup by reference: Lung ultrasound vs. chest x-ray with other diagnostics

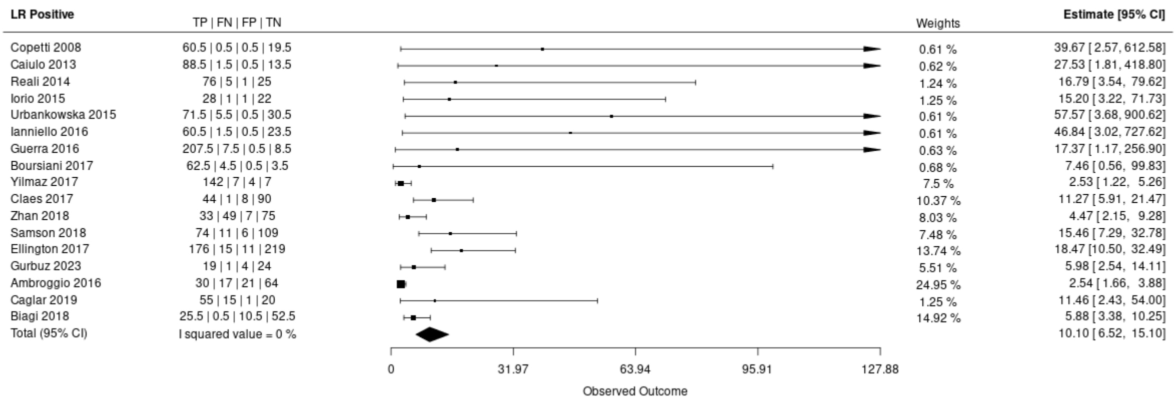
Sensitivity



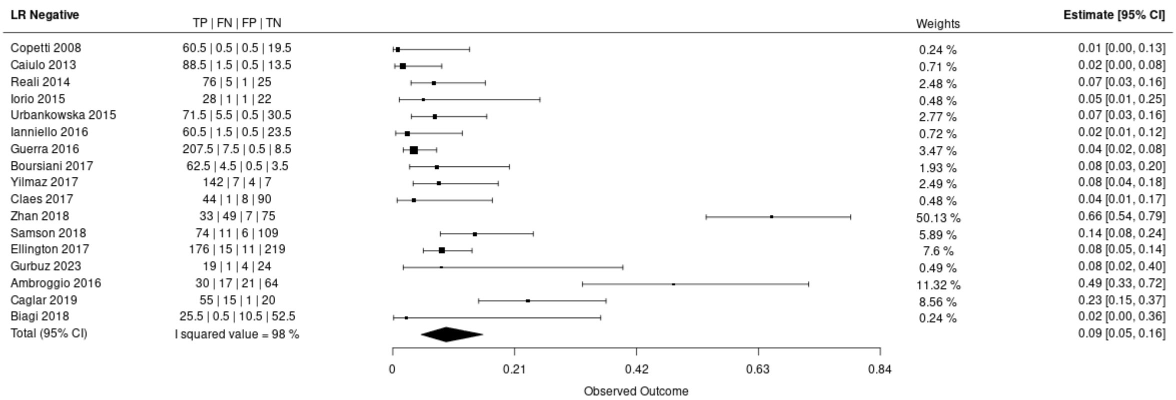
Specificity



Positive likelihood ratio

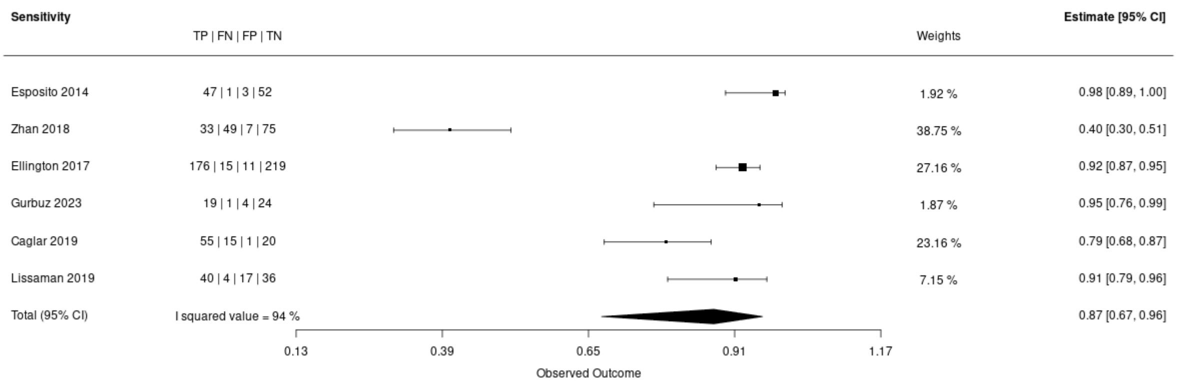


Negative likelihood ratio

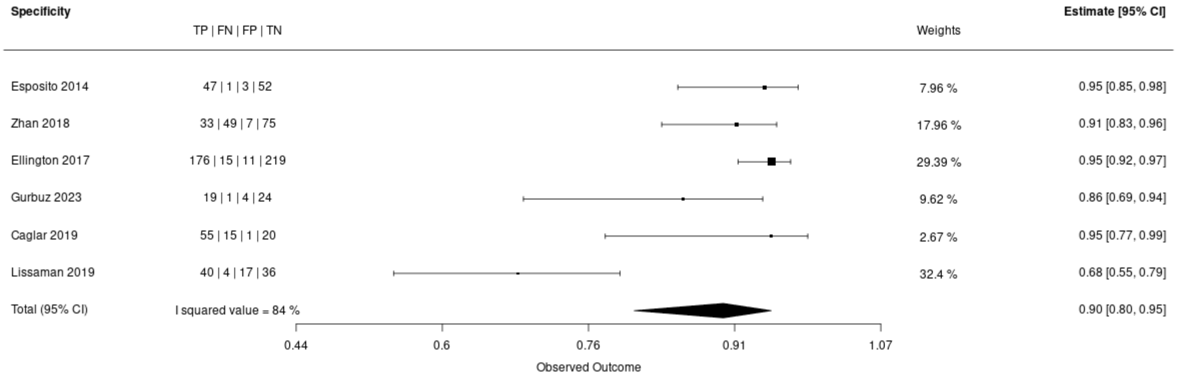


E.1.5 Subgroup by operator: Lung ultrasound by trained operator vs. chest x-ray

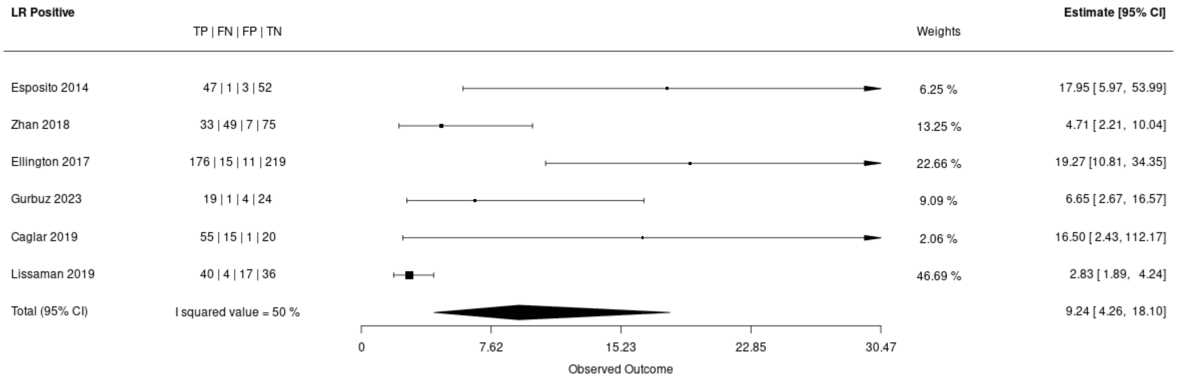
Sensitivity



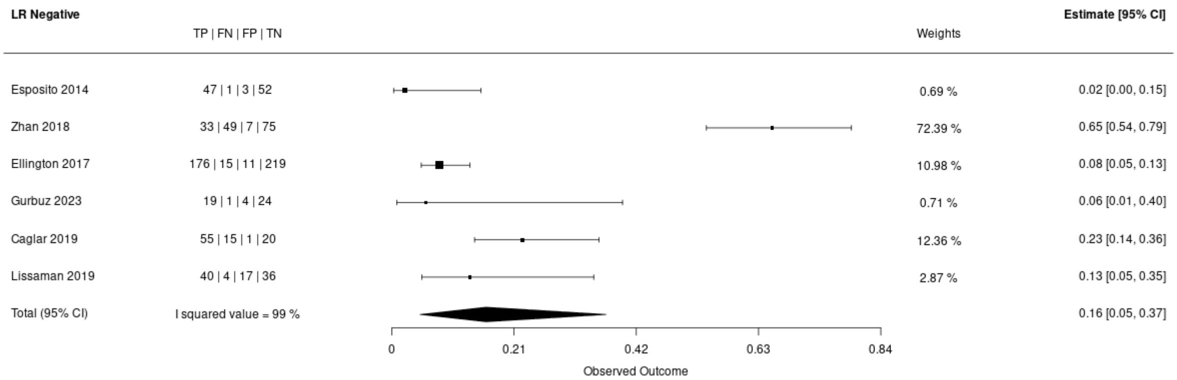
Specificity



Positive likelihood ratio

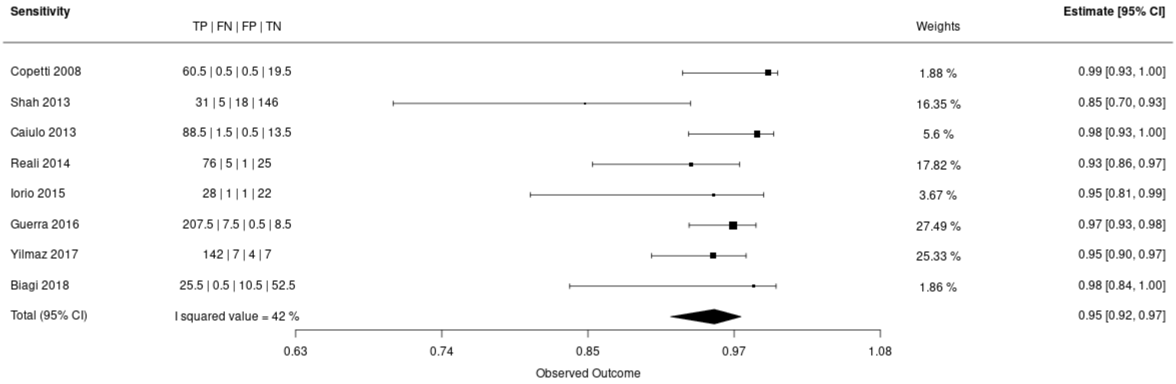


Negative likelihood ratio

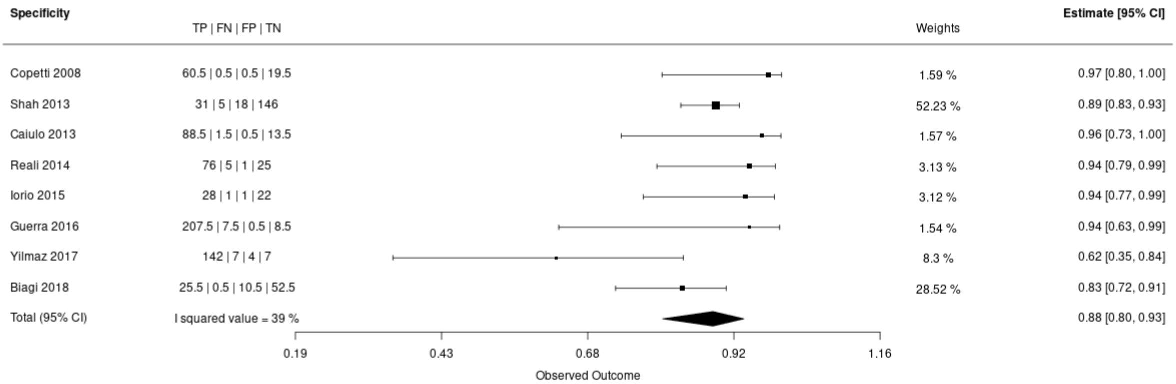


E.1.6 Subgroup by operator: Lung ultrasound by standard operator vs. chest x-ray

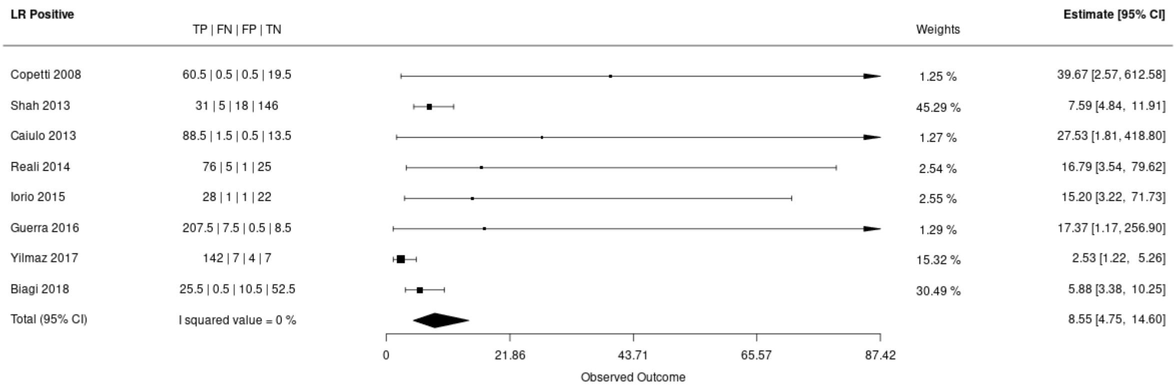
Sensitivity



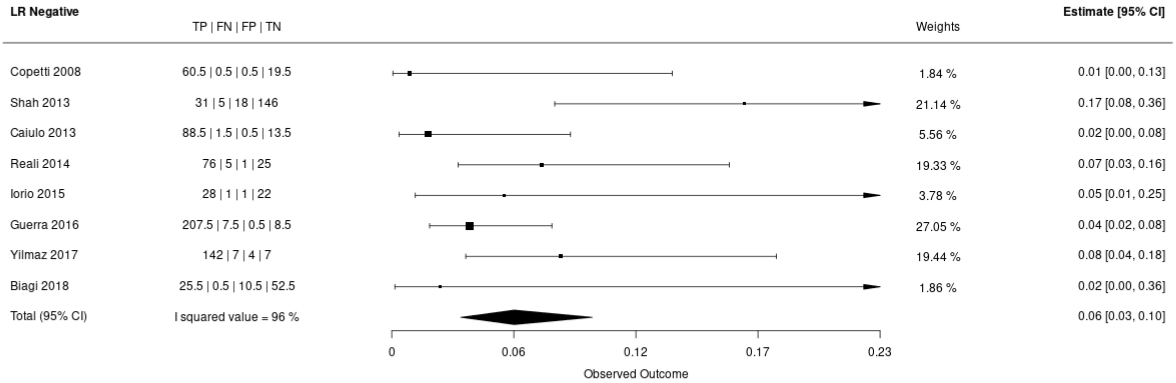
Specificity



Positive likelihood ratio

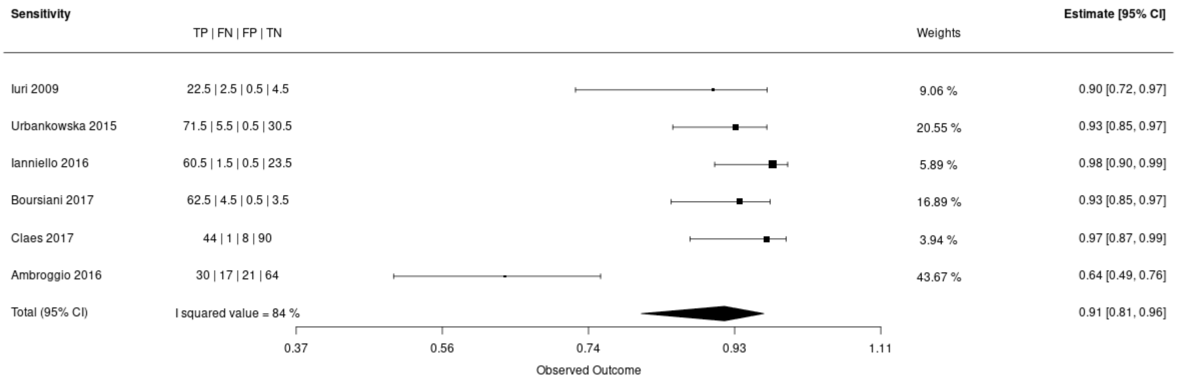


Negative likelihood ratio

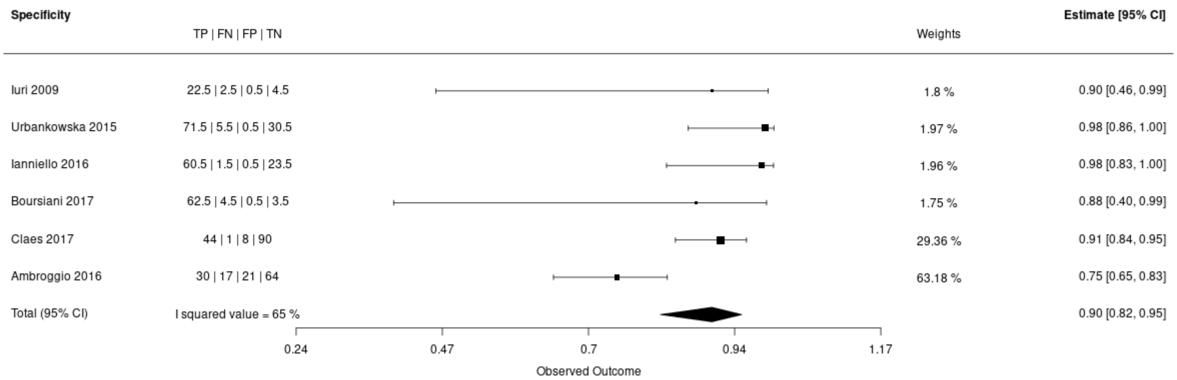


E.1.7 Subgroup by operator: Lung ultrasound by specialist operator vs. chest x-ray

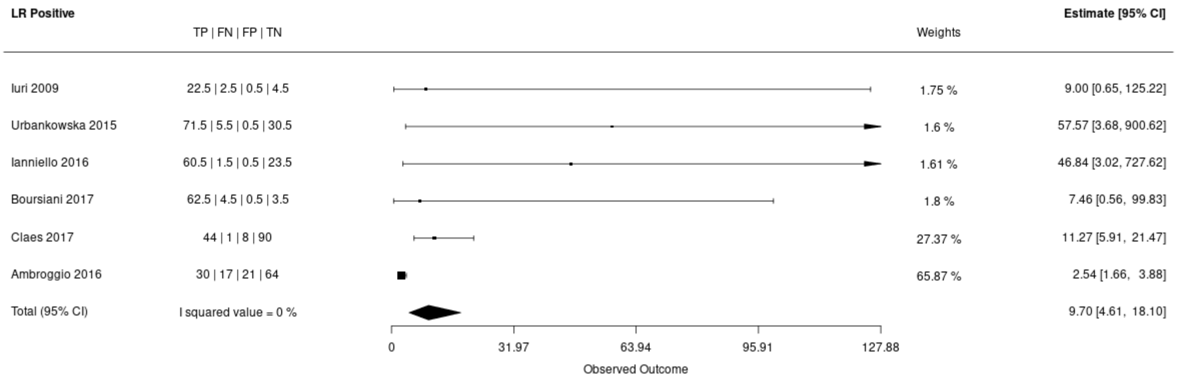
Sensitivity



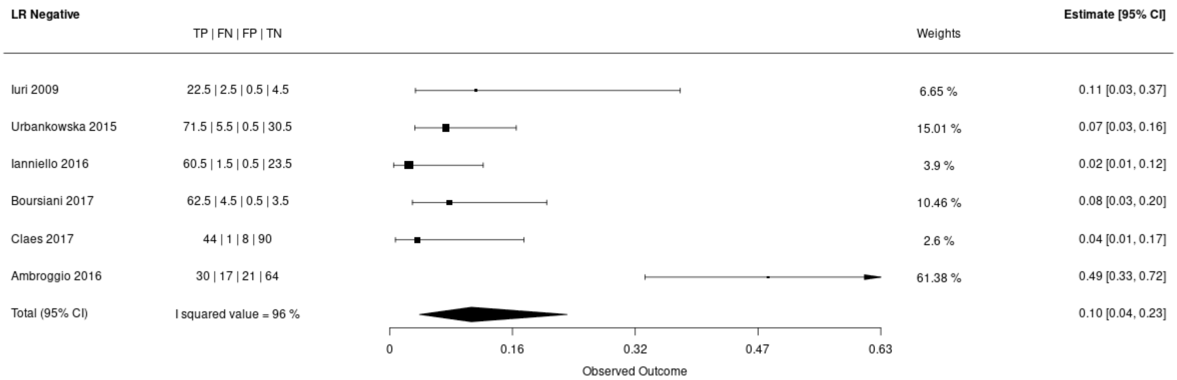
Specificity



Positive likelihood ratio

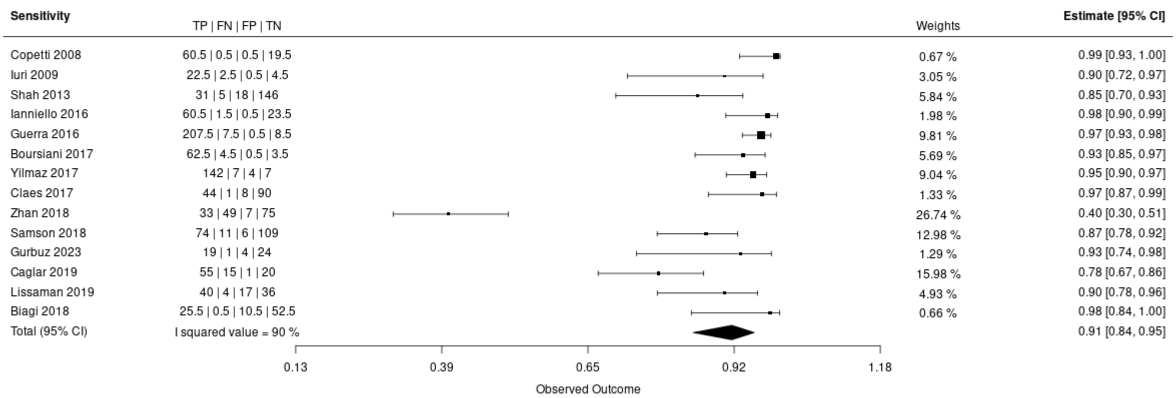


Negative likelihood ratio

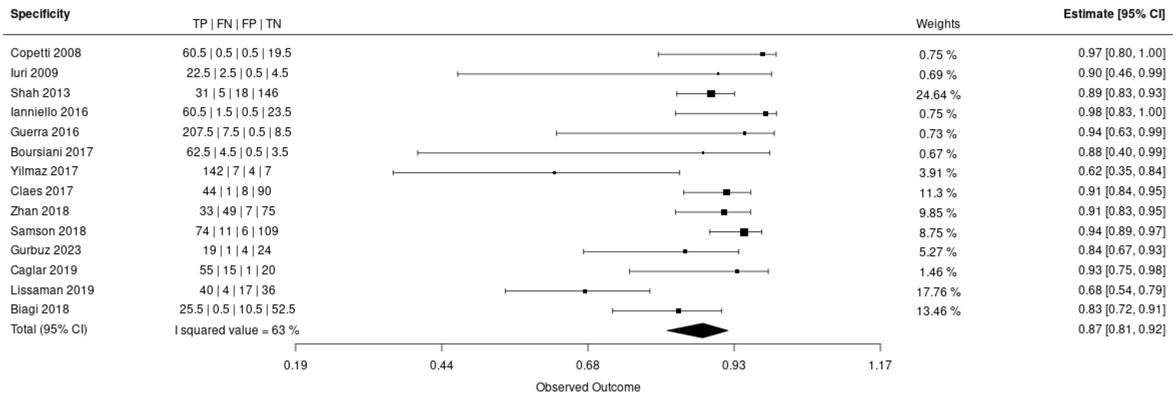


E.1.8 Subgroup by setting: Lung ultrasound in emergency department vs. chest x-ray

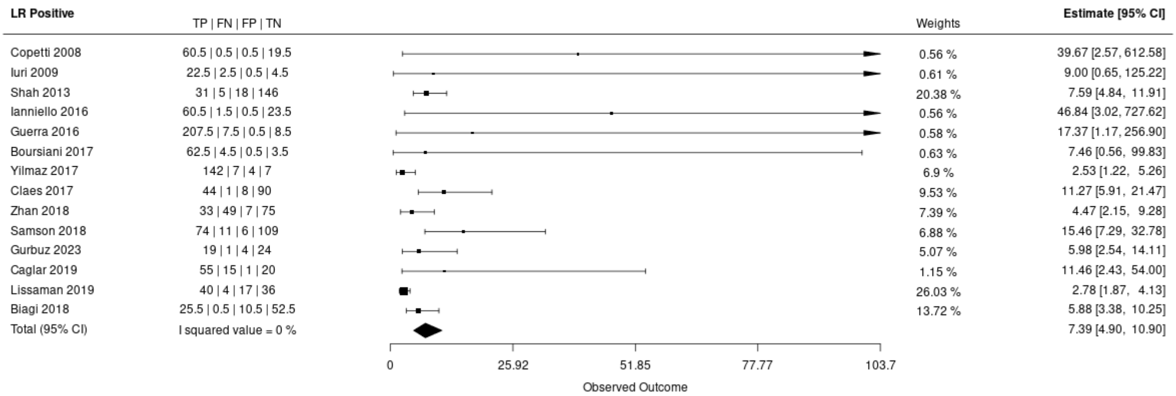
Sensitivity



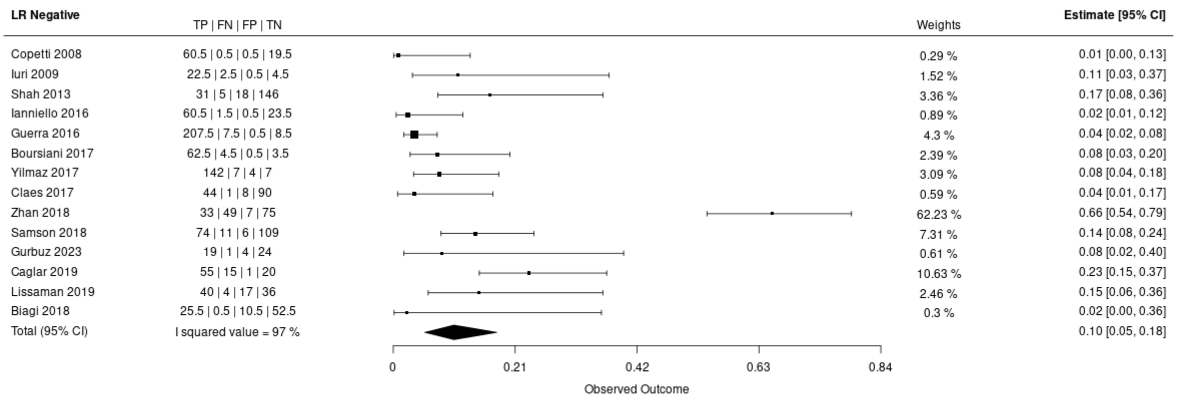
Specificity



Positive likelihood ratio

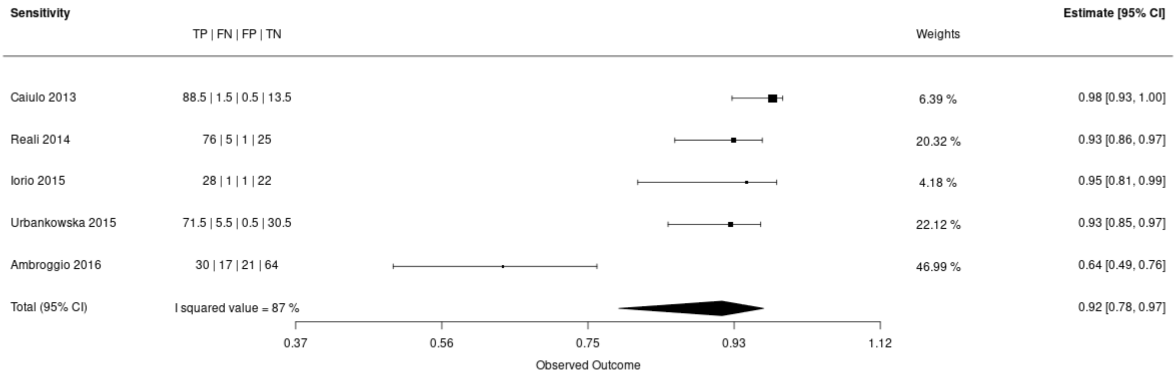


Negative likelihood ratio

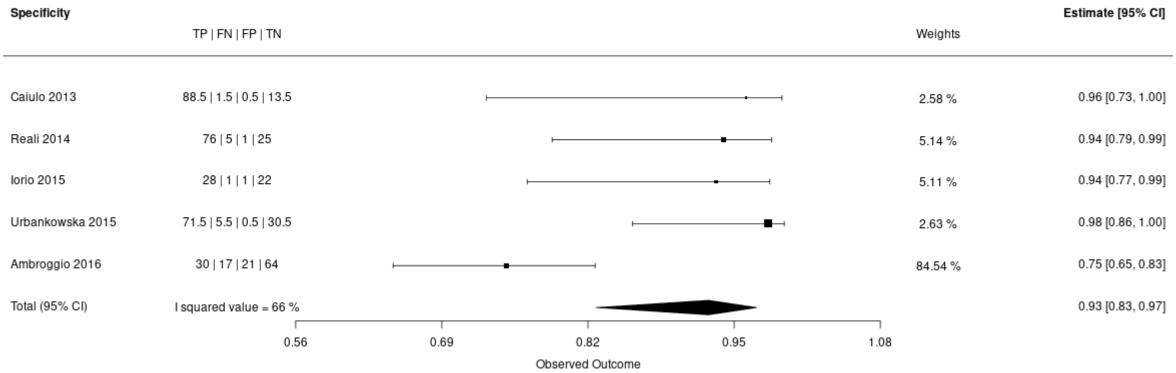


E.1.9 Subgroup by setting: Lung ultrasound on ward vs. chest x-ray

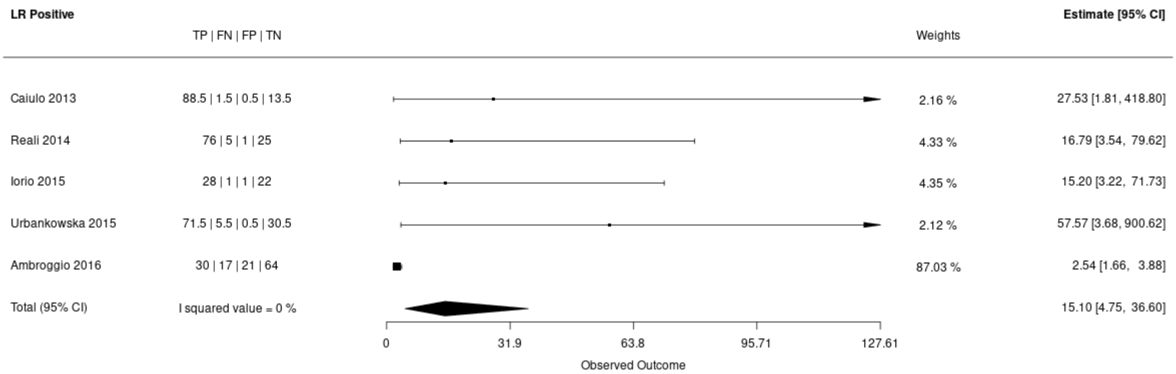
Sensitivity



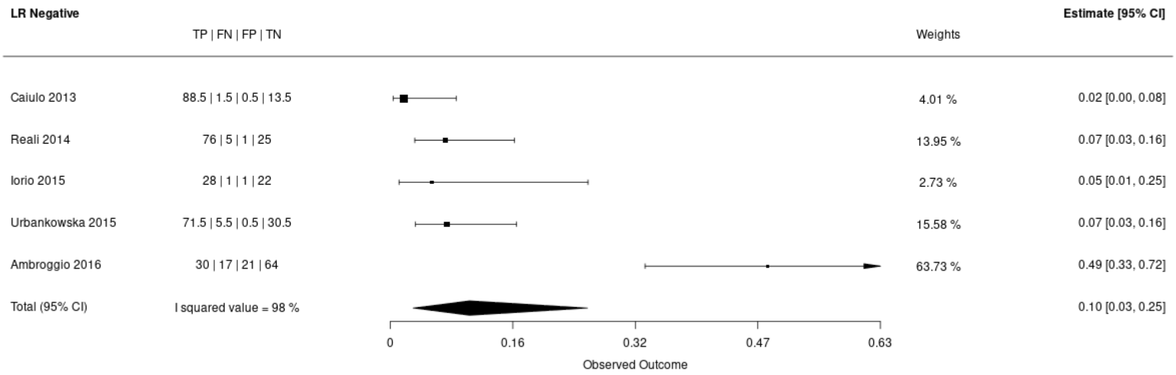
Specificity



Positive likelihood ratio



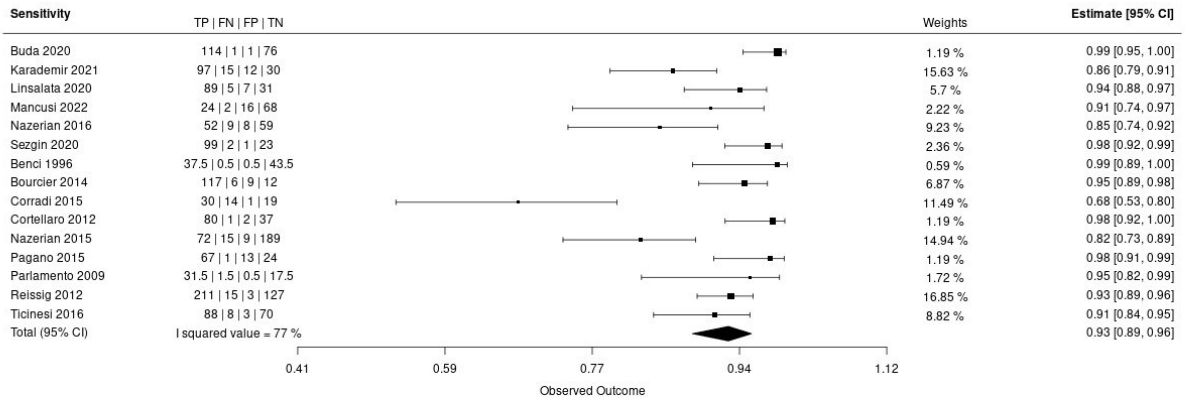
Negative likelihood ratio



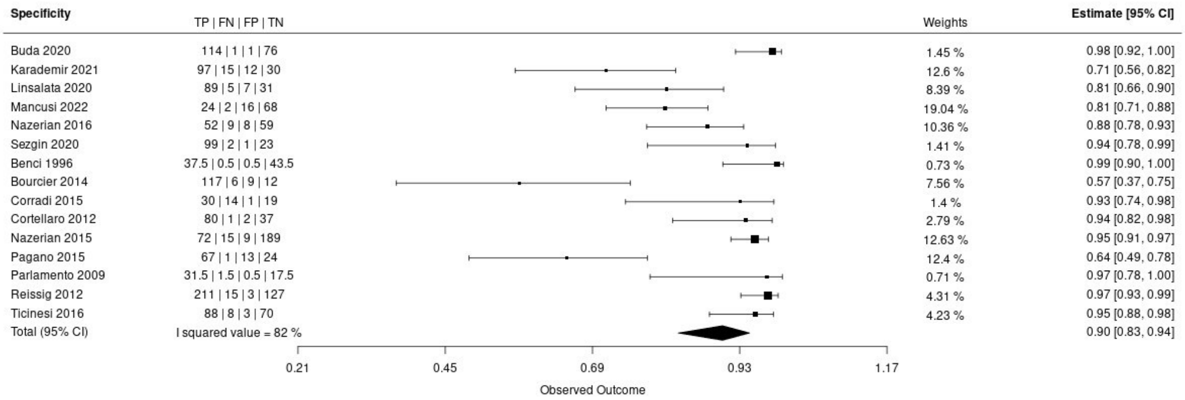
E.2. Forest plots for adults ≥18 years

E.2.1 Lung ultrasound vs. Standard care (all reference standards)

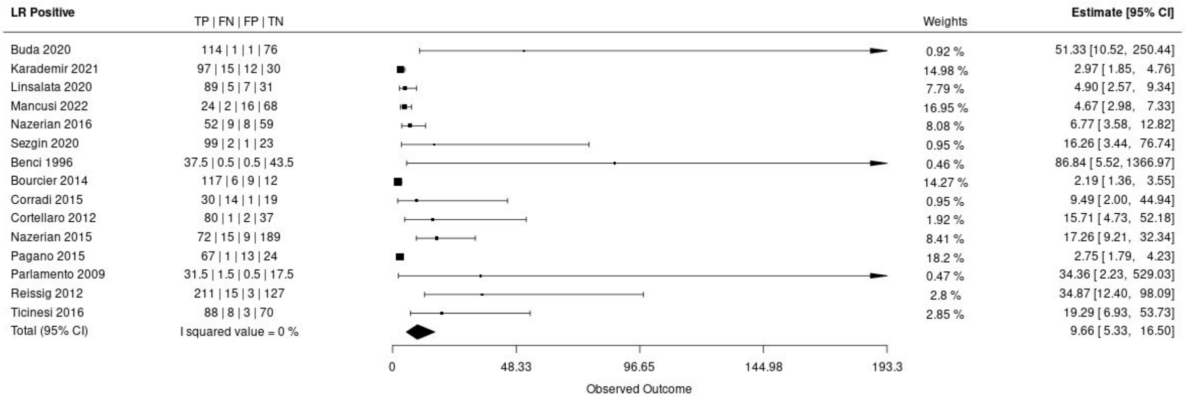
Sensitivity



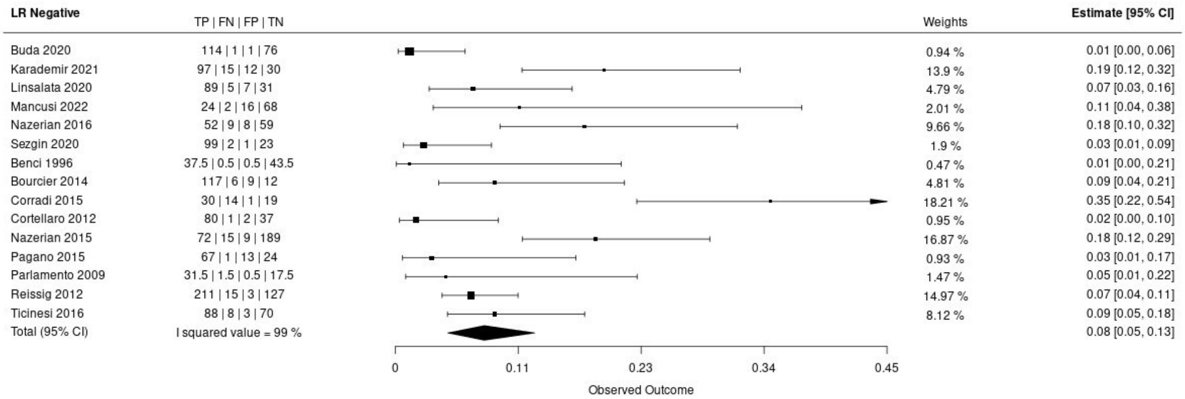
Specificity


Specificity
TP | FN | FP | TN
Weights
Estimate [95% CI]
Buda 2020
114 | 1 | 1 | 76
1.45 %
0.98 [0.92, 1.00]
Karademir 2021
97 | 15 | 12 | 30
12.6 %
0.71 [0.56, 0.82]
Linsalata 2020
89 | 5 | 7 | 31
8.39 %
0.81 [0.66, 0.90]
Mancusi 2022
24 | 2 | 16 | 68
19.04 %
0.81 [0.71, 0.88]
Nazerian 2016
52 | 9 | 8 | 59
10.36 %
0.88 [0.78, 0.93]
Sezgin 2020
99 | 2 | 1 | 23
1.41 %
0.94 [0.78, 0.99]
Benci 1996
37.5 | 0.5 | 0.5 | 43.5
0.73 %
0.99 [0.90, 1.00]
Bourcier 2014
117 | 6 | 9 | 12
7.56 %
0.57 [0.37, 0.75]
Corradi 2015
30 | 14 | 1 | 19
1.4 %
0.93 [0.74, 0.98]
Cortellaro 2012
80 | 1 | 2 | 37
2.79 %
0.94 [0.82, 0.98]
Nazerian 2015
72 | 15 | 9 | 189
12.63 %
0.95 [0.91, 0.97]
Pagano 2015
67 | 1 | 13 | 24
12.4 %
0.64 [0.49, 0.78]
Parlamento 2009
31.5 | 1.5 | 0.5 | 17.5
0.71 %
0.97 [0.78, 1.00]
Reissig 2012
211 | 15 | 3 | 127
4.31 %
0.97 [0.93, 0.99]
Ticinesi 2016
88 | 8 | 3 | 70
4.23 %
0.95 [0.88, 0.98]
Total (95% CI)
I squared value = 82 %
0.90 [0.83, 0.94]
0.21
0.45
0.69
0.93
1.17
Observed Outcome

Positive likelihood ratio

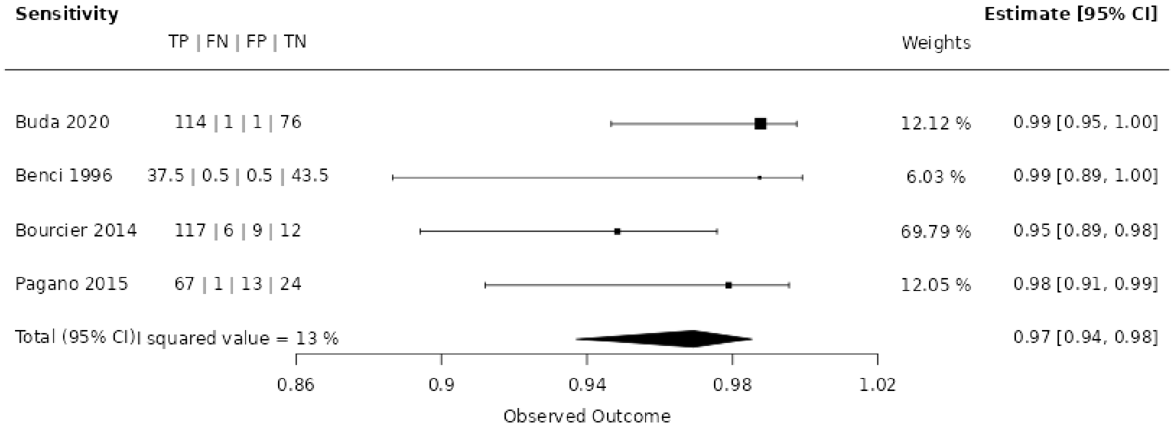


Negative likelihood ratio

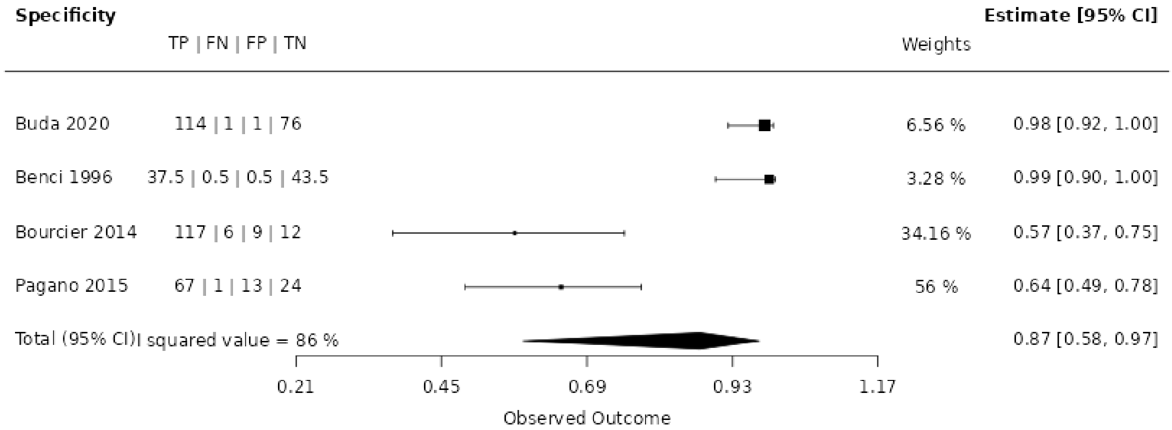


E.2.2 Lung ultrasound vs. Final clinical diagnosis + CXR

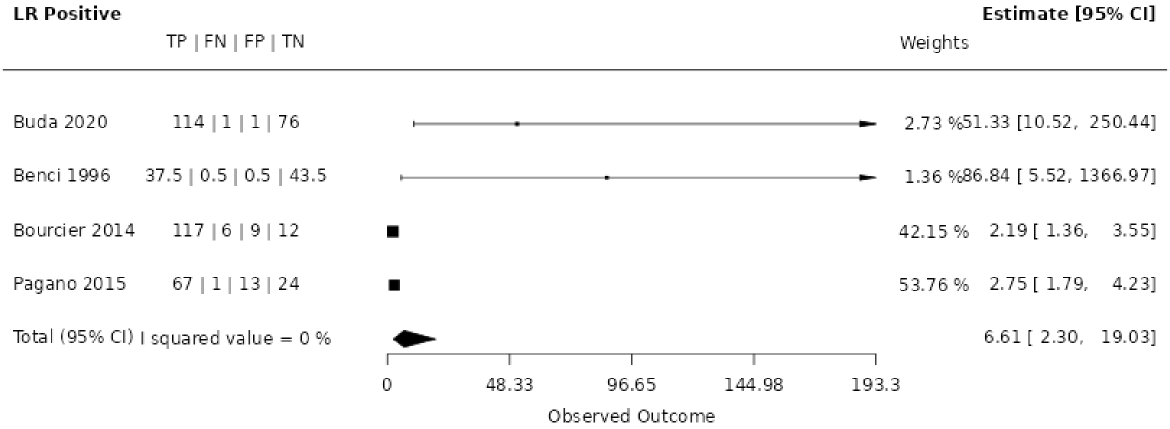
Sensitivity



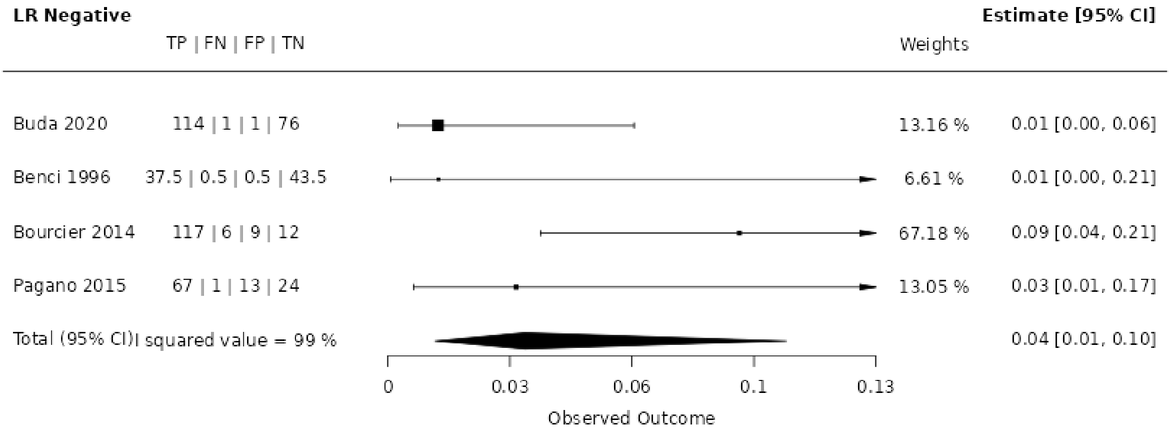
Specificity



Positive likelihood ratio

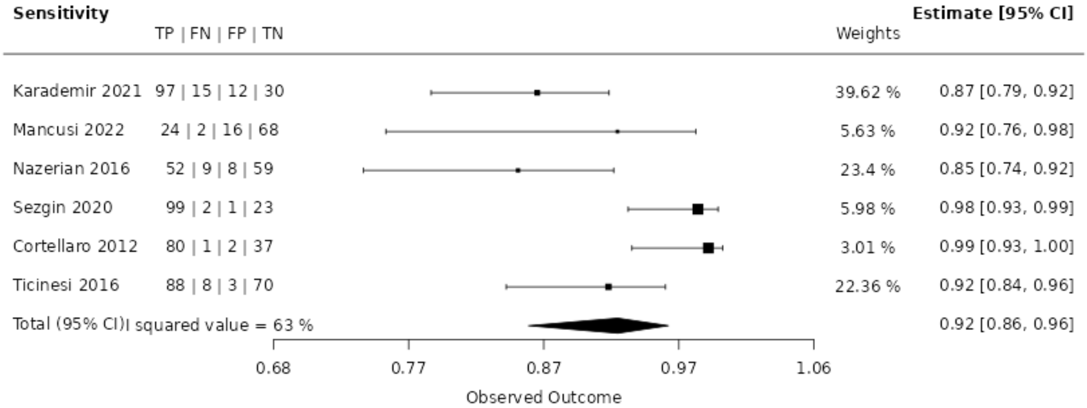


Negative likelihood ratio

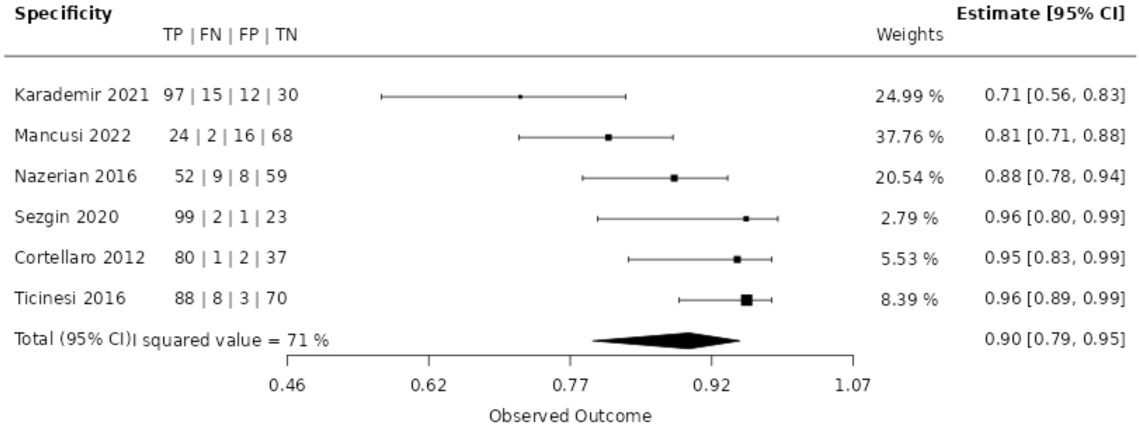


E.2.3 Lung ultrasound vs. Final clinical diagnosis + CXR & CT

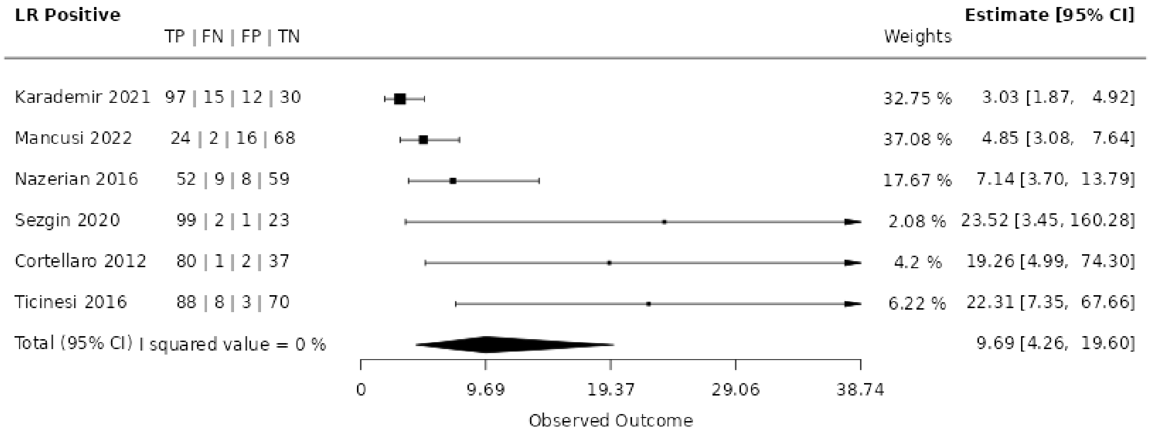
Sensitivity



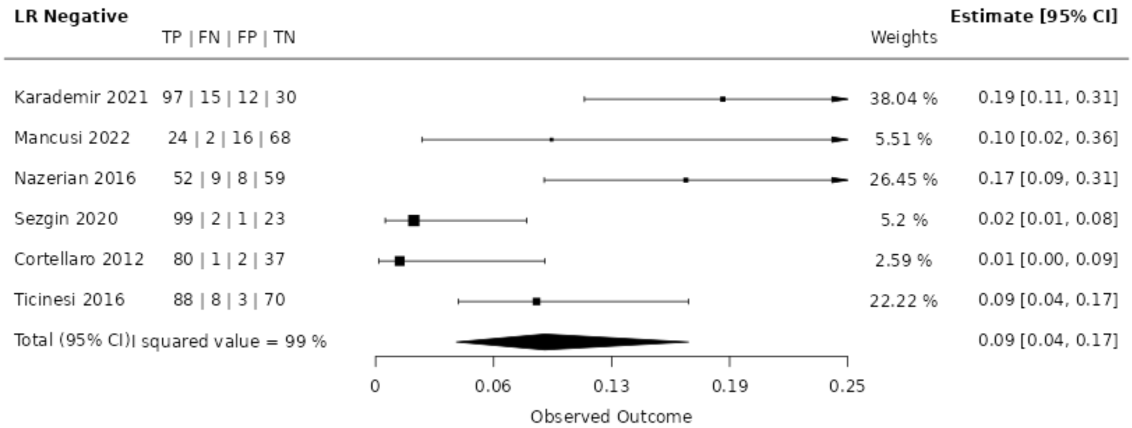
Specificity



Positive likelihood ratio

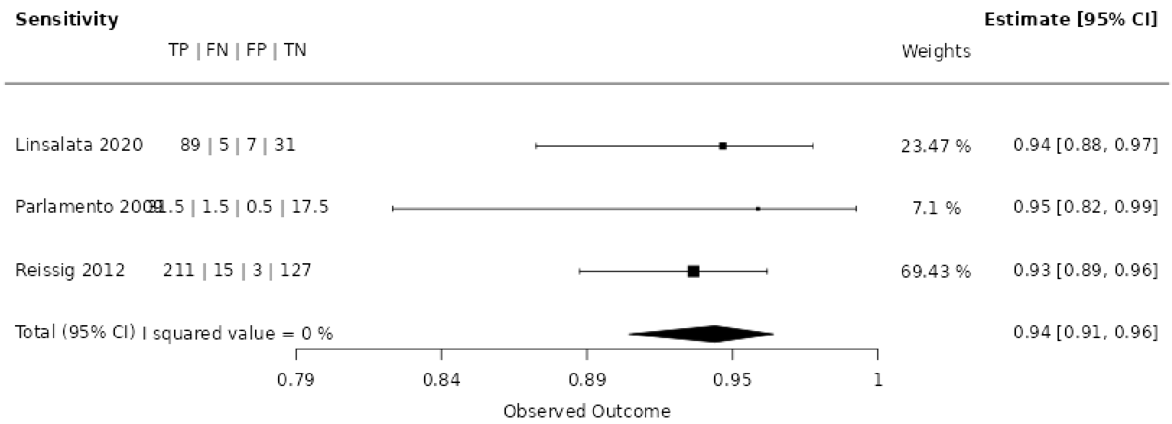


Negative likelihood ratio

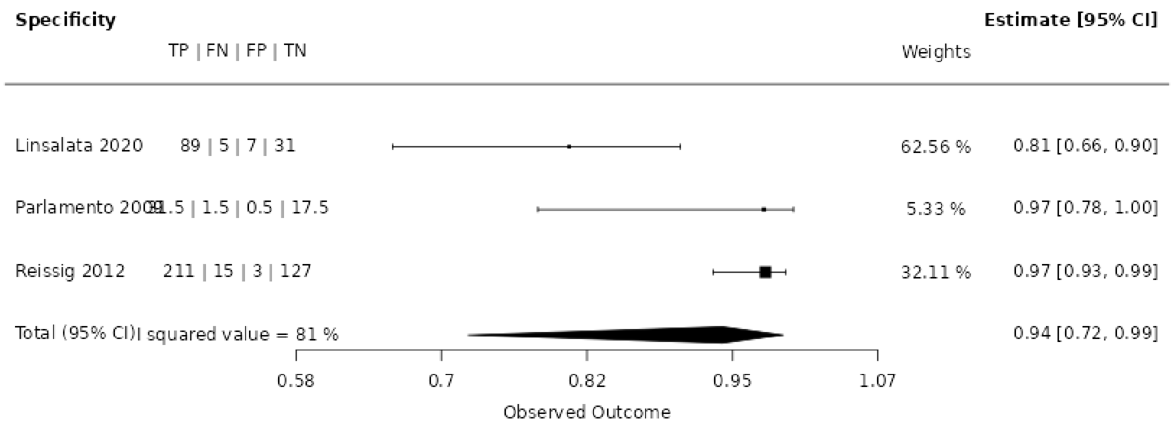


E.2.4 LUS vs. Chest imaging (CXR or CT)

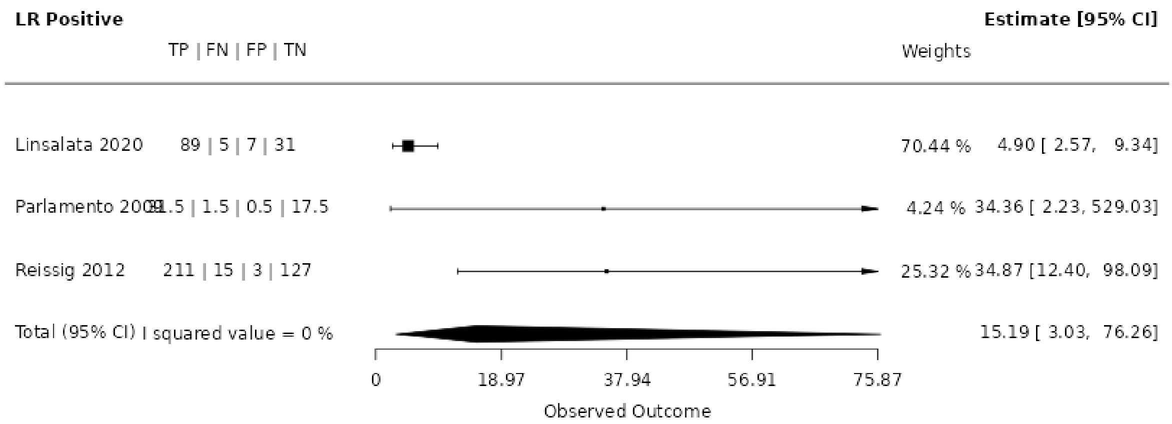
Sensitivity



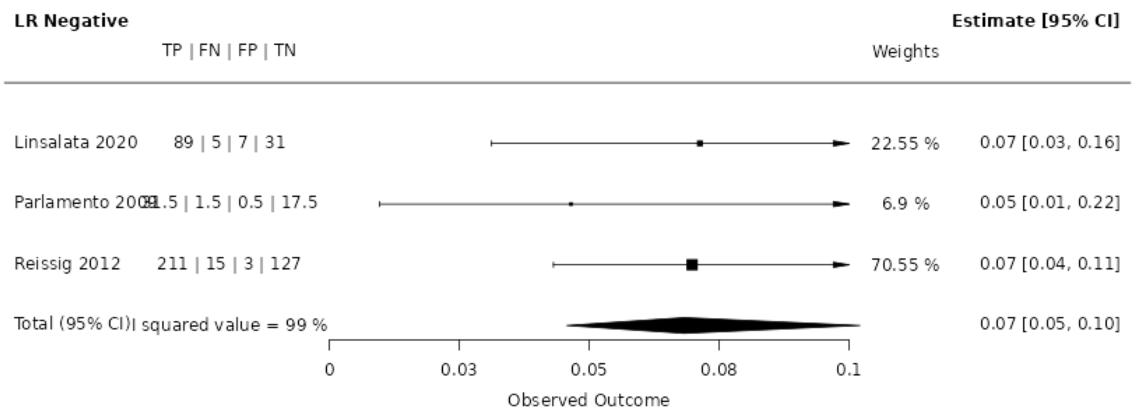
Specificity



Positive likelihood ratio

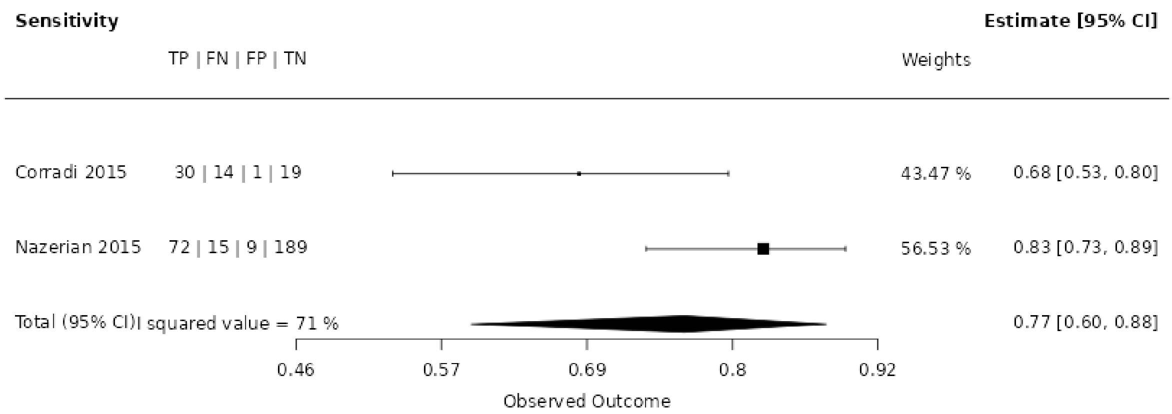


Negative likelihood ratio

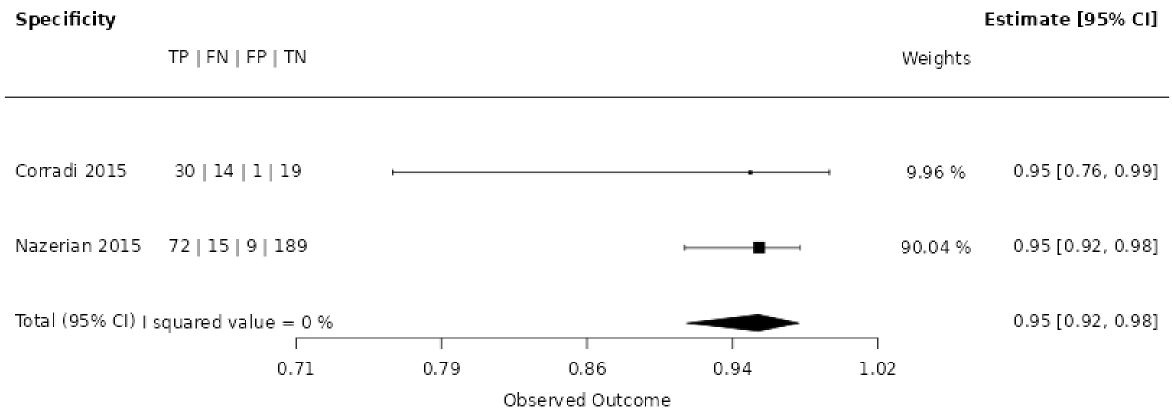


E.2.5 LUS vs. CT only

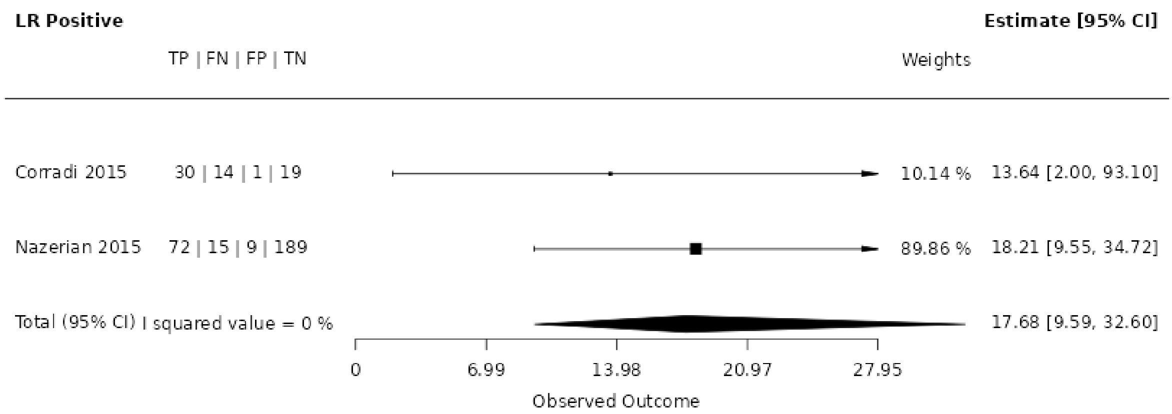
Sensitivity



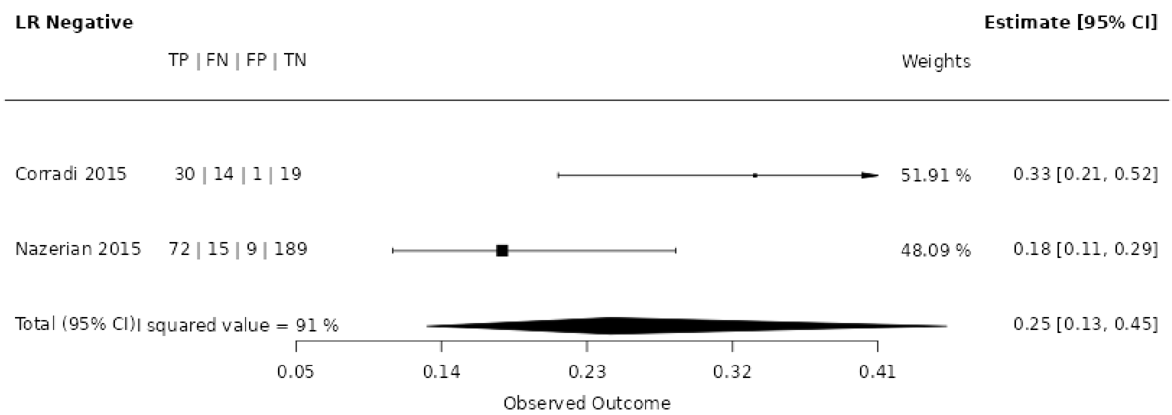
Specificity



Positive likelihood ratio

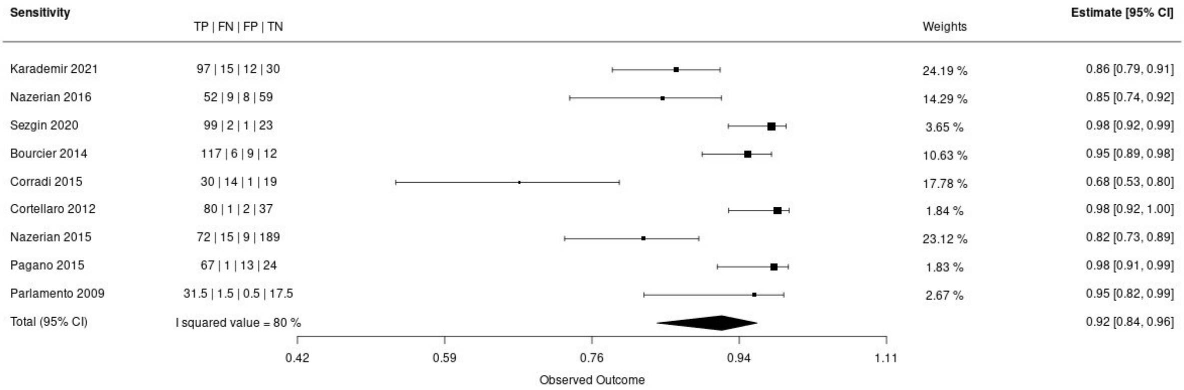


Negative likelihood ratio

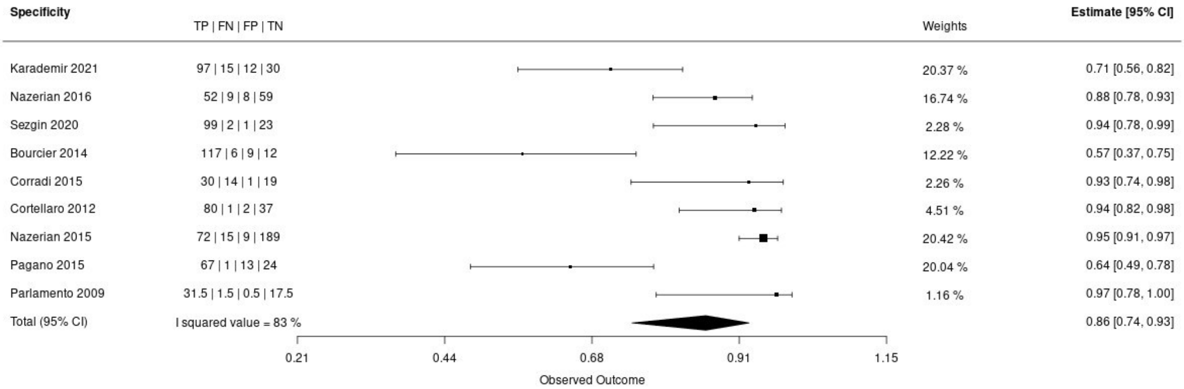


E.2.6 Lung ultrasound vs. Usual care: Emergency department subgroup

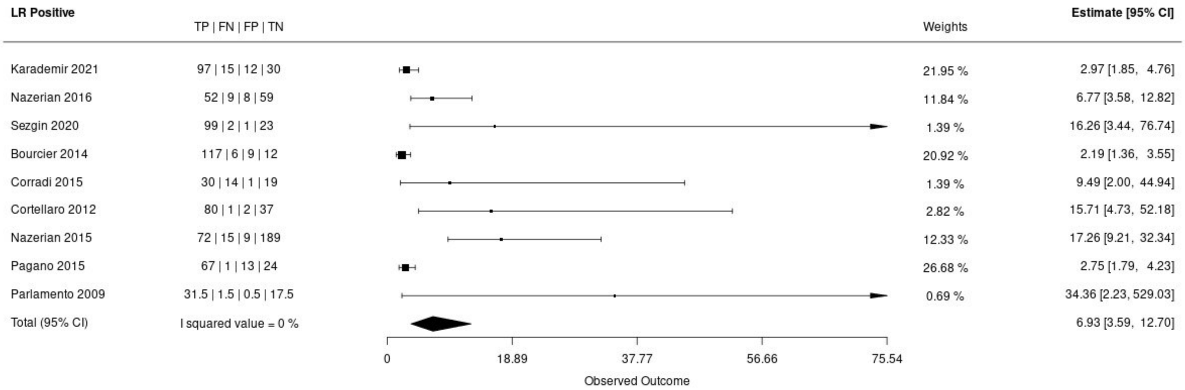
Sensitivity



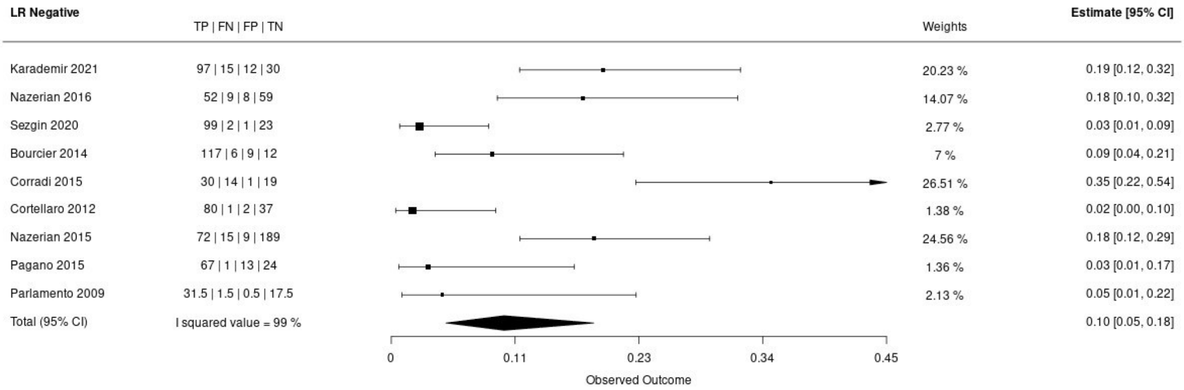
Specificity



Positive likelihood ratio

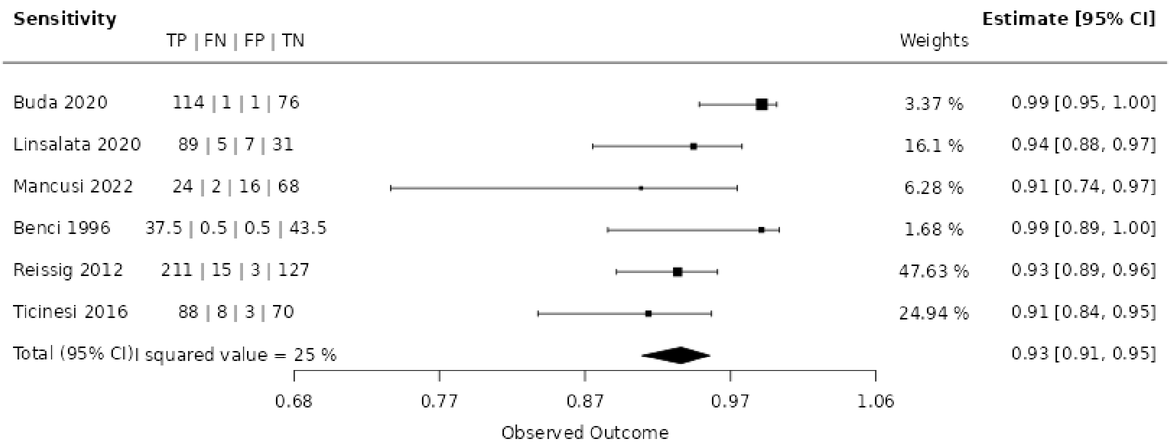


Negative likelihood ratio

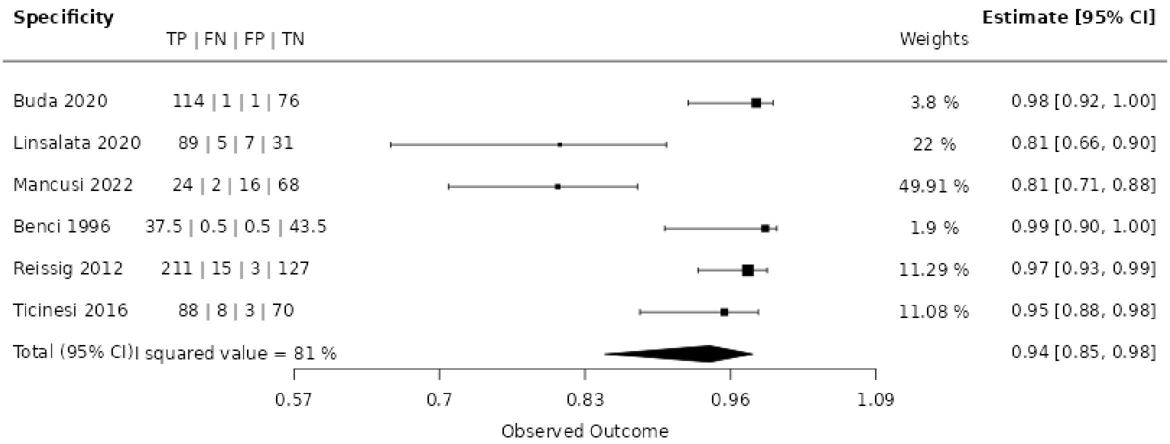


E.2.7 Lung ultrasound vs. Usual care: Hospital or ward settings subgroup

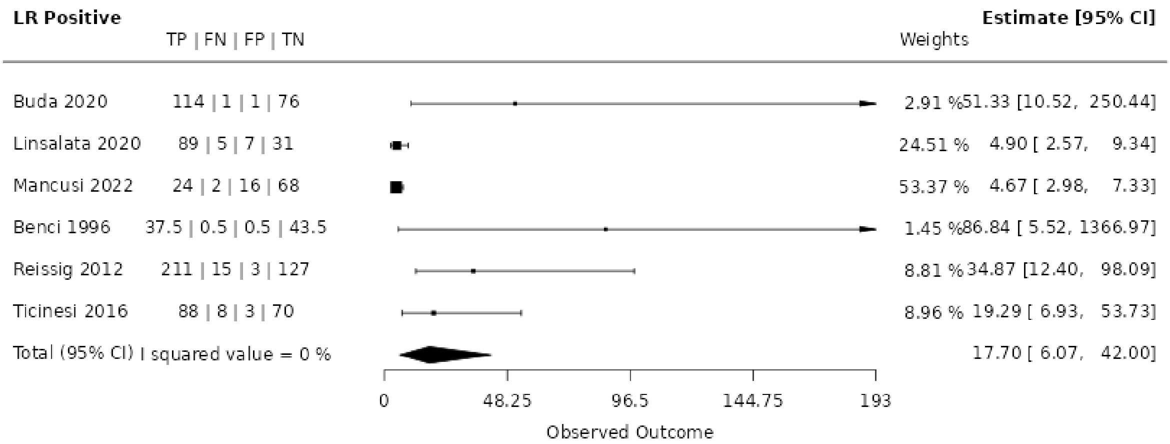
Sensitivity



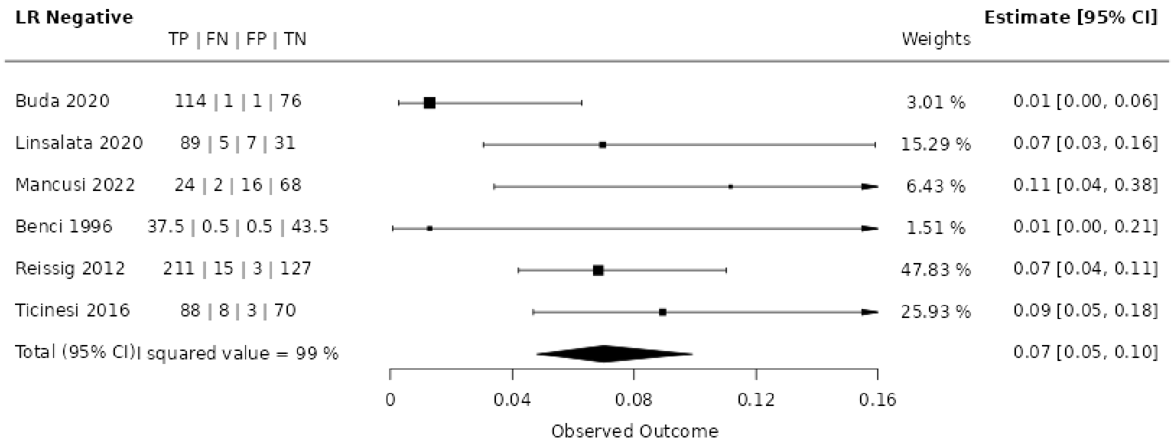
Specificity



Positive likelihood ratio



Negative likelihood ratio


LR Negative
TP | FN | FP | TN
Weights
Estimate [95% CI]
Buda 2020
114 | 1 | 1 | 76
3.01 %
0.01 [0.00, 0.06]
Linsalata 2020
89 | 5 | 7 | 31
15.29 %
0.07 [0.03, 0.16]
Mancusi 2022
24 | 2 | 16 | 68
6.43 %
0.11 [0.04, 0.38]
Benci 1996
37.5 | 0.5 | 0.5 | 43.5
1.51 %
0.01 [0.00, 0.21]
Reissig 2012
211 | 15 | 3 | 127
47.83 %
0.07 [0.04, 0.11]
Ticinesi 2016
88 | 8 | 3 | 70
25.93 %
0.09 [0.05, 0.18]
Total (95% CI)
I squared value = 99 %
0.07 [0.05, 0.10]
0
0.04
0.08
0.12
0.16
Observed Outcome

Appendix F – GRADE tables

Babies, children and young people

Lung ultrasound vs Standard care (all reference standards)

Quality assessment							No of patients	Effect estimate (95% CI)	Quality	Importance
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations				
Positive likelihood ratio										
21	Cohort	not serious	very serious[a]	not serious	not serious	none	2711	9.15 (6.18, 13.20)	Low	CRITICAL
Negative likelihood ratio										
21	Cohort	not serious	very serious[a]	not serious	not serious	none	2711	0.10 (0.06, 0.15)	Low	CRITICAL

CI: confidence interval
[a] $I^2 > 66.7\%$

Subgroup by reference standard: Lung ultrasound vs chest x-ray alone

Quality assessment							No of patients	Effect estimate (95% CI)	Quality	Importance
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations				
Positive likelihood ratio										
4	Cohort	Serious[a]	Not serious	not serious	not serious	none	430	6.48 (2.79, 15.06)	Moderate	CRITICAL

Negative likelihood ratio										
4	Cohort	Serious[a]	Very serious[b]	not serious	not serious	none	430	0.12 (0.07, 0.22)	Very low	CRITICAL

CI: confidence interval
[a] >33.3% of the weight in a meta-analysis came from studies at moderate or high risk of bias
[b] I^2 > 66.7%

Subgroup by reference standard: Lung ultrasound vs chest x-ray with other diagnostics

Quality assessment							No of patients	Effect estimate (95% CI)	Quality	Importance
No of studies	**Design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**				
Positive likelihood ratio										
17	Cohort	not serious	very serious[a]	not serious	not serious	none	2281	10.10 (6.52, 15.10)	Low	CRITICAL
Negative likelihood ratio										
17	Cohort	not serious	very serious[a]	not serious	not serious	none	2281	0.09 (0.05, 0.16)	Low	CRITICAL

CI: confidence interval
[a] I^2 > 66.7%

Subgroup by operator experience: Lung ultrasound by trained operator vs chest x-ray

Quality assessment							No of patients	Effect estimate (95% CI)	Quality	Importance
No of studies	**Design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**				
Positive likelihood ratio										
6	Cohort	Serious[a]	very serious[b]	not serious	not serious	none	924	9.24 (4.26, 18.10)	Very low	CRITICAL

Negative likelihood ratio										
6	Cohort	Serious[a]	very serious[b]	not serious	not serious	none	924	0.16 (0.05, 0.37)	Very low	CRITICAL

CI: confidence interval

[a] >33.3% of the weight in a meta-analysis came from studies at moderate or high risk of bias

[b] $I^2 > 66.7\%$

Subgroup by operator experience: Lung ultrasound by standard operator vs chest x-ray

Quality assessment							No of patients	Effect estimate (95% CI)	Quality	Importance
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations				
Positive likelihood ratio										
8	Cohort	Serious[a]	Serious[b]	not serious	not serious	none	1017	8.55 (4.75, 14.60)	Low	CRITICAL
Negative likelihood ratio										
8	Cohort	Serious[a]	Serious[b]	not serious	not serious	none	1017	0.06 (0.03, 0.10)	Low	CRITICAL

CI: confidence interval

[a] >33.3% of the weight in a meta-analysis came from studies at moderate or high risk of bias

[b] I^2 between 33.3% and 66.7%

Subgroup by operator experience: Lung ultrasound by specialist operator vs chest x-ray

Quality assessment							No of patients	Effect estimate (95% CI)	Quality	Importance
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations				
Positive likelihood ratio										
6	Cohort	not serious	very serious[a]	not serious	not serious	none	570	9.70 (4.61, 18.10)	Low	CRITICAL

Negative likelihood ratio										
6	Cohort	not serious	very serious[a]	not serious	not serious	none	570	0.10 (0.04, 0.23)	Low	CRITICAL

CI: confidence interval

[a] I^2 > 66.7%

Subgroup by setting: Lung ultrasound in emergency department vs chest x-ray

Quality assessment							No of patients	Effect estimate (95% CI)	Quality	Importance
No of studies	**Design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**				
Positive likelihood ratio										
14	Cohort	not serious	Serious[e]	not serious	not serious	none	1684	7.39 (4.90, 10.90)	Moderate	CRITICAL
Negative likelihood ratio										
14	Cohort	not serious	very serious[a]	not serious	not serious	none	1684	0.10 (0.05, 0.18)	Low	CRITICAL

CI: confidence interval

[a] I^2 between 33.3% and 66.7%

[b] I^2 > 66.7%

Subgroup by setting: Lung ultrasound on ward vs chest x-ray

Quality assessment							No of patients	Effect estimate (95% CI)	Quality	Importance
No of studies	**Design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**				
Positive likelihood ratio										
5	Cohort	not serious	very serious[a]	not serious	not serious	none	503	15.10 (4.75, 36.60)	Low	CRITICAL
Negative likelihood ratio										

5	Cohort	not serious	very serious[a]	not serious	not serious	none	503	0.10 (0.03, 0.25)	Low	CRITICAL

CI: confidence interval
[a] $I^2 > 66.7\%$

Adults

LUS vs Standard care (all reference standards)

Quality assessment							No of patients	Effect estimate (95% CI)	Quality	Importance
No of studies	**Design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**				
Positive likelihood ratio										
15	Prospective	very serious[1]	not serious	serious[2]	not serious	none	2217	**9.67** (5.33 – 16.50)	⊕◯◯◯ Very low	CRITICAL
Negative likelihood ratio										
15	Prospective	very serious[1]	very serious[3]	serious[2]	not serious	none	2217	**0.08** (0.05 – 0.13)	⊕◯◯◯ Very low	CRITICAL

CI: confidence interval; LUS: lung ultrasound
[1] >33.3% of the weight in a meta-analysis came from studies at high risk of bias
[2] >33.3% of the weight in a meta-analysis came from partially direct or indirect studies
[3] $I^2 > 66.7\%$

Subgroup by reference standard: LUS vs. Final clinical diagnosis + CXR

Quality assessment	No of patients	Effect estimate (95% CI)	Quality	Importance

No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations				
Positive likelihood ratio										
4	Prospective	very serious[1]	not serious	serious[2]	not serious	none	523	**6.61** (2.30 – 19.03)	⊕◯◯◯ Very low	CRITICAL
Negative likelihood ratio										
4	Prospective	very serious[1]	very serious[3]	serious[2]	not serious	none	523	**0.04** (0.01 – 0.10)	⊕◯◯◯ Very low	CRITICAL

CI: confidence interval; CXR: chest X-ray; LUS: lung ultrasound

[1] >33.3% of the weight in a meta-analysis came from studies at high risk of bias

[2] >33.3% of the weight in a meta-analysis came from partially direct or indirect studies

[3] I^2 > 66.7%

Subgroup by reference standard: LUS vs. Final clinical diagnosis + CXR & CT

Quality assessment							No of patients	Effect estimate (95% CI)	Quality	Importance
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations				
Positive likelihood ratio										
6	Prospective	serious[1]	not serious	serious[2]	not serious	none	806	**9.69** (4.26 – 19.60)	⊕⊕◯◯ Low	CRITICAL
Negative likelihood ratio										
6	Prospective	serious[1]	very serious[3]	serious[2]	not serious	none	806	**0.09** (0.04 – 0.17)	⊕◯◯◯ Very low	CRITICAL

CI: confidence interval; CT: computed tomography; CXR: chest X-ray; LUS: lung ultrasound

[1] >33.3% of the weight in a meta-analysis came from studies at moderate or high risk of bias

[2] >33.3% of the weight in a meta-analysis came from partially direct or indirect studies

[3] I^2 > 66.7%

Subgroup by reference standard: LUS vs. Chest imaging (CXR / CT)

Quality assessment							No of patients	Effect estimate (95% CI)	Quality	Importance
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations				
Positive likelihood ratio										
3	Prospective	serious[1]	not serious	serious[2]	not serious	none	539	**15.19** (3.03 – 76.26)	⊕⊕◯◯ Low	CRITICAL
Negative likelihood ratio										
3	Prospective	serious[1]	very serious[3]	serious[2]	not serious	none	539	**0.07** (0.05 – 0.10)	⊕◯◯◯ Very low	CRITICAL

CI: confidence interval; CT: computed tomography; CXR: chest X-ray; LUS: lung ultrasound

[1] >33.3% of the weight in a meta-analysis came from studies at moderate or high risk of bias

[2] >33.3% of the weight in a meta-analysis came from partially direct studies

[3] I^2 > 66.7%

Subgroup by reference standard: LUS vs. CT only

Quality assessment							No of patients	Effect estimate (95% CI)	Quality	Importance
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations				
Positive likelihood ratio										
2	Prospective	very serious[1]	not serious	very serious[2]	not serious	none	349	**17.68** (9.59 – 32.60)	⊕◯◯◯ Very low	CRITICAL
Negative likelihood ratio										
2	Prospective	very serious[1]	very serious[3]	very serious[2]	not serious	none	349	**0.25** (0.13 – 0.45)	⊕◯◯◯ Very low	CRITICAL

CI: confidence interval; CT: computed tomography; LUS: lung ultrasound

[1] >33.3% of the weight in a meta-analysis came from studies at high risk of bias

[2] >33.3% of the weight in a meta-analysis came from indirect studies

[3] I^2 > 66.7%

Subgroup by setting: Emergency departments

Quality assessment							No of patients	Effect estimate (95% CI)	Quality	Importance
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations				
Positive likelihood ratio										
9	Prospective	very serious[1]	not serious	not serious	not serious	none	1,176	**6.93** (3.59 – 12.70)	⊕⊕◯◯ Low	CRITICAL
Negative likelihood ratio										
9	Prospective	very serious[1]	very serious[2]	very serious[3]	not serious	none	1,176	**0.10** (0.05 – 0.18)	⊕◯◯◯ Very low	CRITICAL

CI: confidence interval

[1] >33.3% of the weight in a meta-analysis came from studies at high risk of bias

[2] I^2 > 66.7%

[3] >33.3% of the weight in a meta-analysis came from indirect studies

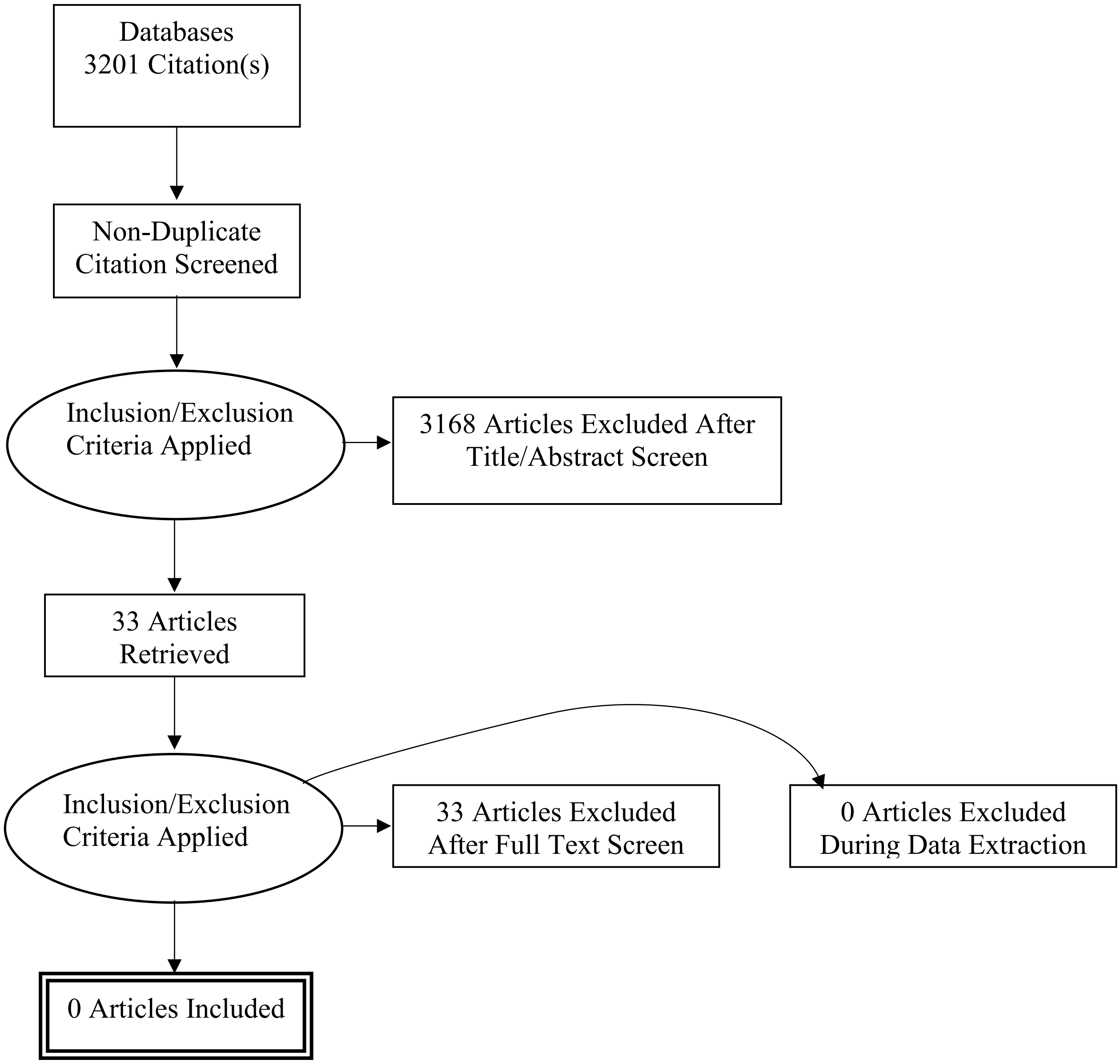
Subgroup by setting: Hospitals / wards

Quality assessment							No of patients	Effect estimate (95% CI)	Quality	Importance
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations				
Positive likelihood ratio										
6	Prospective	very serious[1]	no serious	serious[2]	not serious	none	1,041	**17.70** (6.07 – 42.00)	⊕◯◯◯ Very low	CRITICAL
Negative likelihood ratio										
6	Prospective	very serious[1]	very serious[3]	serious[2]	not serious	none	1,041	**0.07** (0.05 – 0.10)	⊕◯◯◯ Very low	CRITICAL

CI: confidence interval

[1] >33.3% of the weight in a meta-analysis came from studies at high risk of bias
[2] >33.3% of the weight in a meta-analysis came from partially direct or indirect studies
[3] $I^2 > 66.7\%$

Appendix G – Economic evidence study selection



Appendix H – Economic evidence tables

No studies were included in this review question.

Appendix I – Health economic model

No original health economic modelling was done for this review question.

Appendix J – Excluded studies

Clinical

Babies, children and young people

Study	Code [Reason]
Ahmad, T., Farooq, M.A., Ashraf, S. et al. (2019) Diagnostic accuracy of lung ultrasound in diagnosis of pediatric pneumonia. Medical Forum Monthly 30(9): 20-23	- Non-OECD country *Pakistan*
Amatya, Yogendra, Russell, Frances M, Rijal, Suraj et al. (2023) Bedside lung ultrasound for the diagnosis of pneumonia in children presenting to an emergency department in a resource-limited setting. International journal of emergency medicine 16(1): 2	- Non-OECD country
Balk, Daniel S, Lee, Christine, Schafer, Jesse et al. (2018) Lung ultrasound compared to chest X-ray for diagnosis of pediatric pneumonia: A meta-analysis. Pediatric pulmonology 53(8): 1130-1139	- SR not selected for use *Published in 2018 and more recent SRs available with more up to date includes*
Bloise, Silvia, La Regina, Domenico Paolo, Pepino, Daniela et al. (2021) Lung ultrasound compared to chest X-ray for the diagnosis of CAP in children. Pediatrics international : official journal of the Japan Pediatric Society 63(4): 448-453	- Not a relevant study design *case-control study*
Buz Yasar, Aysenur, Tarhan, Merve, Atalay, Basak et al. (2023) Investigation of Childhood Pneumonia With Thoracic Ultrasound: A Comparison Between X-ray and Ultrasound. Ultrasound quarterly 39(4): 216-222	- Not possible to calculate a contingency table from the data specified in the protocol *Only confirmed pneumonia cases included, so cannot calculate sensitivity or specificity*
Ciuca, Ioana Mihaiela, Dediu, Mihaela, Marc, Monica Steluta et al. (2021) Lung Ultrasound Is More Sensitive for Hospitalized Consolidated Pneumonia Diagnosis Compared to CXR in Children. Children (Basel, Switzerland) 8(8)	- Non-OECD country *Romania*
Daniel, E. and Ramachandran, A. (2023) Accuracy of Lung Ultrasonography versus Chest Radiography for the Diagnosis of Community Acquired Pneumonia in Children: A Cross-sectional Study. Journal of Clinical and Diagnostic Research 17(3): tc19-tc22	- Non-OECD country *India*
DeSanti, Ryan L, Al-Subu, Awni M, Cowan, Eileen A et al. (2021) Point-of-Care Lung Ultrasound to Diagnose the Etiology of Acute Respiratory Failure at Admission to the PICU. Pediatric critical care medicine : a journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies 22(8): 722-732	- Reference standard in study does not match that specified in protocol *Clinical diagnosis, no chest x-ray*

Study	Code [Reason]
Dimkpa, JN Robinson, ED Aitafo, JE Ugboma, EW Nwankwo, NC (2022) Diagnostic value of lung ultrasonography compared with chest radiography among children with pneumonia in Rivers State University Teaching Hospital, Port Harcourt. WEST AFRICAN JOURNAL OF RADIOLOGY 29(2): 101 - 111	- Non-OECD country *Nigeria*
Don, Massimiliano, Fiotti, Nicola, Bizjak, Ruben et al. (2022) Multicentre study supports the use of lung ultrasound in diagnosing paediatric community-acquired pneumonia. Acta paediatrica (Oslo, Norway : 1992) 111(2): 401-402	- Commentary article
Ginsburg, Amy Sarah, Lenahan, Jennifer L, Jehan, Fyezah et al. (2021) Performance of lung ultrasound in the diagnosis of pediatric pneumonia in Mozambique and Pakistan. Pediatric pulmonology 56(2): 551-560	- Non-OECD country *Mozambique and Pakistan*
Guitart, Carmina, Rodriguez-Fanjul, Javier, Bobillo-Perez, Sara et al. (2022) An algorithm combining procalcitonin and lung ultrasound improves the diagnosis of bacterial pneumonia in critically ill children: The PROLUSP study, a randomized clinical trial. Pediatric pulmonology 57(3): 711-723	- Not a relevant study design *RCT*
Hajalioghli, P., Nemati, M., Saleh, L.D. et al. (2016) Can chest computed tomography be replaced by lung ultrasonography with or without plain chest radiography in pediatric pneumonia?. Journal of Thoracic Imaging 31(4): 247-252	- Non-OECD country *Iran*
Hegazy, Laila M, Rezk, Ahmed R, Sakr, Hossam M et al. (2020) Comparison of Efficacy of LUS and CXR in the Diagnosis of Children Presenting with Respiratory Distress to Emergency Department. Indian journal of critical care medicine : peer-reviewed, official publication of Indian Society of Critical Care Medicine 24(6): 459-464	- Non-OECD country *Egypt*
Ho, Meng-Chieh, Ker, Chin-Ru, Hsu, Jong-Hau et al. (2015) Usefulness of lung ultrasound in the diagnosis of community-acquired pneumonia in children. Pediatrics and neonatology 56(1): 40-5	- Non-OECD country *Taiwan*
Iorio, G., Capasso, M., Prisco, S. et al. (2018) Lung Ultrasound Findings Undetectable by Chest Radiography in Children with Community-Acquired Pneumonia. Ultrasound in Medicine and Biology 44(8): 1687-1693	- Not possible to calculate a contingency table from the data specified in the protocol *Only confirmed pneumonia cases included, so cannot calculate sensitivity or specificity*

Study	Code [Reason]
Jones, Brittany Pardue, Tay, Ee Tein, Elikashvili, Inna et al. (2016) Feasibility and Safety of Substituting Lung Ultrasonography for Chest Radiography When Diagnosing Pneumonia in Children: A Randomized Controlled Trial. Chest 150(1): 131-8	- Not a relevant study design *RCT*
Kurian, J., Levin, T.L., Han, B.K. et al. (2009) Comparison of ultrasound and CT in the evaluation of pneumonia complicated by parapneumonic effusion in children. American Journal of Roentgenology 193(6): 1648-1654	- Not possible to calculate a contingency table from the data specified in the protocol *Only confirmed pneumonia cases included, so cannot calculate sensitivity or specificity*
Lemine, ATM Salim, HAM Abdelmeged, KMS Bayoumi, SS (2022) Evaluation of Pneumonia using Lung Ultrasound in children with Acute Bronchiolitis. INTERNATIONAL JOURNAL OF EARLY CHILDHOOD SPECIAL EDUCATION 14(3): 5832 - 5839	- Non-OECD country *Egypt*
Liao, H Zhu, XJ Niu, YD (2021) The Diagnostic Value of Lung Ultrasonography in Children Community-Acquired Pneumonia. INDIAN JOURNAL OF PHARMACEUTICAL SCIENCES 83: 255 - 261	- Non-OECD country *China*
Lovrenski, Jovan, Petrovic, Slobodanka, Balj-Barbir, Svetlana et al. (2016) Stethoscope vs. ultrasound probe - which is more reliable in children with suspected pneumonia?. Acta medica academica 45(1): 39-50	- Non-OECD country *Serbia*
Lu, Xiaoxue, Jin, Yanping, Li, Ying et al. (2022) Diagnostic accuracy of lung ultrasonography in childhood pneumonia: a meta-analysis. European journal of emergency medicine : official journal of the European Society for Emergency Medicine 29(2): 105-117	- SR not selected for use *Search date 2020; more recent reviews available*
Man, Sorin Claudiu, Fufezan, Otilia, Sas, Valentina et al. (2017) Performance of lung ultrasonography for the diagnosis of communityacquired pneumonia in hospitalized children. Medical ultrasonography 19(3): 276-281	- Non-OECD country *Romania*
Mohamed, S.A., Bazaraa, H.M., Ishak, S.K. et al. (2023) The reliability of POCUS in the diagnosis of community-acquired pneumonia in critically ill pediatric patients: a cross-sectional study. Egyptian Pediatric Association Gazette 71(1): 83	- Non-OECD country *Egypt*
Najgrodzka, Paulina, Buda, Natalia, Zamojska, Anna et al. (2019) Lung Ultrasonography in the Diagnosis of Pneumonia in Children-A Metaanalysis and a	- SR not selected for use *More recent and comprehensive reviews available*

Study	Code [Reason]
Review of Pediatric Lung Imaging. Ultrasound quarterly 35(2): 157-163	
Omran, Ahmed, Eesai, Samah, Ibrahim, Mostafa et al. (2018) Lung ultrasound in diagnosis and follow up of community acquired pneumonia in infants younger than 1-year old. The clinical respiratory journal 12(7): 2204-2211	- Non-OECD country *Egypt*
Orso, Daniele; Ban, Alessio; Guglielmo, Nicola (2018) Lung ultrasound in diagnosing pneumonia in childhood: a systematic review and meta-analysis. Journal of ultrasound 21(3): 183-195	- SR not selected for use *More recent and comprehensive reviews available*
Osman, A.M., Sarhan, A.A., Abd-Elrahman, A.M. et al. (2020) Lung ultrasound for the diagnosis of community-acquired pneumonia in infants and children. Egyptian Journal of Chest Diseases and Tuberculosis 69(1): 227-234	- Non-OECD country *Egypt*
Rahmati, M B, Ahmadi, M, Malekmohamadi et al. (2015) The significance of chest ultrasound and chest X-ray in the diagnosis of children clinically suspected of pneumonia. Journal of medicine and life 8(speciss3): 50-53	- Non-OECD country *Iran*
Ru, Qi; Liu, LanLan; Dong, Xiaoyun (2023) Diagnosis of asthmatic pneumonia in children by lung ultrasound vs. chest X-ray: an updated systematic review and meta-analysis. Postepy dermatologii i alergologii 40(1): 28-34	- SR not selected for use *Only 9 included studies and all overlapped with more comprehensive reviews*
Saraya, S. and El Bakry, R. (2017) Ultrasound: Can it replace CT in the evaluation of pneumonia in pediatric age group?. Egyptian Journal of Radiology and Nuclear Medicine 48(3): 687-694	- Non-OECD country *Egypt*
Sharif, Mudassar, Saeed, Tariq, Saheel, Khalid et al. (2021) Comparison of chest X-ray with lung ultrasound in the diagnosis of pneumonia in children aged 02 months to 12 years. Journal of Rawalpindi Medical College 25(1): 87-90	- Non-OECD country *Pakistan*
Talwar, Neetu; Manik, Lucky; Chugh, Krishan (2022) Pediatric Lung Ultrasound (PLUS) in the diagnosis of Community-Acquired Pneumonia (CAP) requiring hospitalization. Lung India : official organ of Indian Chest Society 39(3): 267-273	- Non-OECD country *India*
Thareeb, M.K.; Zghair, M.A.A.; Hassan, Q.A. (2022) Diagnostic Ability of Chest Ultrasound in Selective Paediatric Pneumonia Alternative to CT scan: A single-center Comparative Observational Study. Journal of Nepal Paediatric Society 42(3): 17-23	- Non-OECD country *Iraq*

Study	Code [Reason]
Tsou, Po-Yang, Chen, Kenneth P, Wang, Yu-Hsun et al. (2019) Diagnostic Accuracy of Lung Ultrasound Performed by Novice Versus Advanced Sonographers for Pneumonia in Children: A Systematic Review and Meta-analysis. Academic emergency medicine : official journal of the Society for Academic Emergency Medicine 26(9): 1074-1088	- SR not selected for use *Comprehensive review (n=25 includes) but 2019 search and more recent reviews available. Non-overlapping studies checked and all would be excludes (e.g. studies of neonates; primary care settings)*
Venkatakrishna, Shyam Sunder B, Stadler, Jacob A M, Kilborn, Tracy et al. (2024) Evaluation of the diagnostic performance of physician lung ultrasound versus chest radiography for pneumonia diagnosis in a peri-urban South African cohort. Pediatric radiology 54(3): 413-424	- Non-OECD country *South Africa*
Wang, Liang, Song, Wei, Wang, Yong et al. (2019) Lung ultrasonography versus chest radiography for the diagnosis of pediatric community acquired pneumonia in emergency department: a meta-analysis. Journal of thoracic disease 11(12): 5107-5114	- SR not selected for use *Only 6 includes; all contained in other more comprehensive SRs*
Xin, Hua; Li, Jie; Hu, Hai-Yang (2018) Is Lung Ultrasound Useful for Diagnosing Pneumonia in Children?: A Meta-Analysis and Systematic Review. Ultrasound quarterly 34(1): 3-10	- SR not selected for use *More recent SRs available*
Yadav, Krishna Kumar; Awasthi, Shally; Parihar, Anit (2017) Lung Ultrasound is Comparable with Chest Roentgenogram for Diagnosis of Community-Acquired Pneumonia in Hospitalised Children. Indian journal of pediatrics 84(7): 499-504	- Non-OECD country *India*
Yan, Cui, Hui, Ren, Lijuan, Zhang et al. (2020) Lung ultrasound vs. chest X-ray in children with suspected pneumonia confirmed by chest computed tomography: A retrospective cohort study. Experimental and therapeutic medicine 19(2): 1363-1369	- Non-OECD country *China*
Yan, Jun-Hong, Yu, Na, Wang, Yue-Heng et al. (2020) Lung ultrasound vs chest radiography in the diagnosis of children pneumonia: Systematic evidence. Medicine 99(50): e23671	- Non-OECD country *China*
Yang, Yalong; Wu, Yuexuan; Zhao, Wen (2024) Comparison of lung ultrasound and chest radiography for detecting pneumonia in children: a systematic review and meta-analysis. Italian journal of pediatrics 50(1): 12	- SR not selected for use *Included studies overlap with another included SR*

OECD: organisation for economic co-operation and development; RCT: randomised controlled trial; SR: systematic review

Adults

Study	Code [Reason]
Abdel Kader, M. and Osman, N.M.M. (2016) Implementation of chest ultrasound with color Doppler in diagnosis of pneumonia in adults. Egyptian Journal of Radiology and Nuclear Medicine 47(3): 771-781	- Non-OECD country *Egypt*
Abid, Iqra, Qureshi, Nadia, Lategan, Nicola et al. (2024) Point-of-care lung ultrasound in detecting pneumonia: A systematic review. Canadian journal of respiratory therapy : CJRT = Revue canadienne de la therapie respiratoire : RCTR 60: 37-48	- SR not selected for use *Adults and children combined; only 12 studies*
Alawaji, OM Yones, DK Almalki, MA Babiker, RA Awadallah, MF (2019) VALUE OF LUNG ULTRASONOGRAPHY FOR THE DIAGNOSIS OF ACUTE PNEUMONIA IN EMERGENCY DEPARTMENT, MULTICENTER STUDY IN MEDINA, SAUDI ARABIA. INDO AMERICAN JOURNAL OF PHARMACEUTICAL SCIENCES 6(1): 1441 - 1450	- Non-OECD country *Saudi Arabia*
Alkhayat, K.F. and Alam-Eldeen, M.H. (2014) Value of chest ultrasound in diagnosis of community acquired pneumonia. Egyptian Journal of Chest Diseases and Tuberculosis 63(4): 1047-1051	- Non-OECD country *Egypt*
Alzahrani, Saeed Ali, Al-Salamah, Majid Abdulatief, Al-Madani, Wedad Hussain et al. (2017) Systematic review and meta-analysis for the use of ultrasound versus radiology in diagnosing of pneumonia. Critical ultrasound journal 9(1): 6	- SR not selected for use *Adults and children combined; studies of adults all overlap with other selected SR*
Amatya, Yogendra, Rupp, Jordan, Russell, Frances M et al. (2018) Diagnostic use of lung ultrasound compared to chest radiograph for suspected pneumonia in a resource-limited setting. International journal of emergency medicine 11(1): 8	- Non-OECD country *Nepal*
Asmara, Oke Dimas, Pitoyo, Ceva Wicaksono, Wulani, Vally et al. (2022) Accuracy of Bedside Lung Ultrasound in Emergency (BLUE) Protocol to Diagnose the Cause of Acute Respiratory Distress Syndrome (ARDS): A Meta-Analysis. Acta medica Indonesiana 54(2): 266-282	- SR not selected for use *Only 5 included studies; more comprehensive SR selected for use*
Bitar, Zouheir Ibrahim, Maadarani, Ossama Sajeh, El-Shably, AlAsmar Mohammed et al. (2019) Diagnostic accuracy of chest ultrasound in patients with pneumonia in the intensive care unit: A single-hospital study. Health science reports 2(1): e102	- Non-OECD country *Kuwait*

Study	Code [Reason]
Chavez, Miguel A, Shams, Navid, Ellington, Laura E et al. (2014) Lung ultrasound for the diagnosis of pneumonia in adults: a systematic review and meta-analysis. Respiratory research 15: 50	- SR not selected for use *Included studies overlap with another included SR*
Desai, Dev, Shah, Abhijay B, Dela, Joseph Rem C et al. (2024) Lung Ultrasonography Accuracy for Diagnosis of Adult Pneumonia: Systematic Review and Meta-Analysis. Advances in respiratory medicine 92(3): 241-253	- SR not selected for use *Review inclusion criteria do not match those listed in protocol - include studies of patients with VAP and other respiratory conditions that aren't CAP or HAP - respiratory failure, acute dyspnoea, chest pain or severe thoracic disease, H1N1 infection*
Dexheimer Neto, Felippe Leopoldo, Andrade, Juliana Mara Stormovski de, Raupp, Ana Carolina Tabajara et al. (2015) Diagnostic accuracy of the Bedside Lung Ultrasound in Emergency protocol for the diagnosis of acute respiratory failure in spontaneously breathing patients. Jornal brasileiro de pneumologia : publicacao oficial da Sociedade Brasileira de Pneumologia e Tisilogia 41(1): 58-64	- Non-OECD country *Brazil*
Dhawan, Jonny and Singh, Gurpreet (2022) Bedside Lung Ultrasound as an Independent Tool to Diagnose Pneumonia in Comparison to Chest X-ray: An Observational Prospective Study from Intensive Care Units. Indian journal of critical care medicine : peer-reviewed, official publication of Indian Society of Critical Care Medicine 26(8): 920-929	- Non-OECD country *India*
El Sheikh, H. and Abd Rabboh, M.M. (2014) Chest ultrasound in the evaluation of complicated pneumonia in the ICU patients: Can be viable alternative to CT?. Egyptian Journal of Radiology and Nuclear Medicine 45(2): 325-331	- Non-OECD country *Egypt*
Elatroush, H.H., Essawy, T.S., Kenawy, M.M. et al. (2023) The Assessment of the Diagnostic Accuracy of Bedside Lung Ultrasound in Critically Ill Respiratory Failure Patients. Biomedical and Pharmacology Journal 16(1): 525-532	- Non-OECD country *Egypt*
Elsayed, M., Hesham, M.A., Kamel, K.M. et al. (2022) Diagnostic Accuracy of Lung Ultrasound in Patients with Community-Acquired Pneumonia: A Single Center Observational Study. Open Access Macedonian Journal of Medical Sciences 10: 2405-2410	- Non-OECD country *Egypt*
Fares, Auf and Naglah, Ahmed (2015) Role of Transthoracic Ultrasound in Detection of Pneumonia in	- Non-OECD country *Egypt*

Study	Code [Reason]
ICU Patients. Medical Journal of Cairo University 83(1): 307-314	
Haggag, Youssef Ibrahim, Mashhour, Karim, Ahmed, Kamal et al. (2019) Effectiveness of Lung Ultrasound in Comparison with Chest X-Ray in Diagnosis of Lung Consolidation. Open access Macedonian journal of medical sciences 7(15): 2457-2461	- Non-OECD country *Egypt*
Hu, Qian-Jing, Shen, Yong-Chun, Jia, Liu-Qun et al. (2014) Diagnostic performance of lung ultrasound in the diagnosis of pneumonia: a bivariate meta-analysis. International journal of clinical and experimental medicine 7(1): 115-21	- SR not selected for use *Mixed review of adults and children, only 4 studies of adults and all overlap with those included in another selected review*
Liu, Xiao-lei, Lian, Rui, Tao, Yong-kang et al. (2015) Lung ultrasonography: an effective way to diagnose community-acquired pneumonia. Emergency medicine journal : EMJ 32(6): 433-8	- Non-OECD country *China*
Llamas-Alvarez, Ana M; Tenza-Lozano, Eva M; Latour-Perez, Jaime (2017) Accuracy of Lung Ultrasonography in the Diagnosis of Pneumonia in Adults: Systematic Review and Meta-Analysis. Chest 151(2): 374-382	- SR not selected for use *Search conducted in 2017, more recent SRs available*
Mehrabi, S.; Rahmanian, J.; Jalli, R. (2023) The Accuracy of Lung Ultrasonography Diagnosis of Community-Acquired Pneumonia, in an Adult Cohort. Journal of Diagnostic Medical Sonography 39(1): 43-48	- Non-OECD country *Iran*
Nafae, R., Eman, S.R., Mohamad, N.A. et al. (2013) Adjuvant role of lung ultrasound in the diagnosis of pneumonia in intensive care unit-patients. Egyptian Journal of Chest Diseases and Tuberculosis 62(2): 281-285	- Non-OECD country *Egypt*
Orso, Daniele; Guglielmo, Nicola; Copetti, Roberto (2018) Lung ultrasound in diagnosing pneumonia in the emergency department: a systematic review and meta-analysis. European journal of emergency medicine : official journal of the European Society for Emergency Medicine 25(5): 312-321	- SR not selected for use *Included studies overlap with another included SR*
Sistani, S.S. and Parooie, F. (2021) Diagnostic Performance of Ultrasonography in Patients With Pneumonia: An Updated Comparative Systematic Review and Meta-analysis. Journal of Diagnostic Medical Sonography 37(4): 371-381	- SR not selected for use *Included studies overlap with another included SR*
Staub, Leonardo Jonck, Mazzali Biscaro, Roberta Rodolfo, Kaszubowski, Erikson et al. (2019) Lung Ultrasound for the Emergency Diagnosis of Pneumonia, Acute Heart Failure, and Exacerbations of Chronic	- SR not selected for use *Use of LUS not exclusive to pneumonia. Subsample*

Study	Code [Reason]
Obstructive Pulmonary Disease/Asthma in Adults: A Systematic Review and Meta-analysis. The Journal of emergency medicine 56(1): 53-69	*reported for pneumonia only, but not comprehensive*
Taghizadieh, Ali, Ala, Alireza, Rahmani, Farzad et al. (2015) Diagnostic Accuracy of Chest x-Ray and Ultrasonography in Detection of Community Acquired Pneumonia; a Brief Report. Emergency (Tehran, Iran) 3(3): 114-6	- Non-OECD country *East Azerbaijan and Iran*
Unluer, E.E., Karagoz, A., Senturk, G.O. et al. (2013) Bedside lung ultrasonography for diagnosis of pneumonia. Hong Kong Journal of Emergency Medicine 20(2): 98-104	- Non-OECD country *China*
Vafaei, SJE, Mohammadi, S, Zamanimehr, N et al. (2019) Comparison the diagnostic accuracy of conventional radiography with ultrasound for the diagnosis of pneumonia. Healthy Aging Research 9(1): 1-5	- Non-OECD country *Iran*
Xia, Yang, Ying, Yinghua, Wang, Shaobin et al. (2016) Effectiveness of lung ultrasonography for diagnosis of pneumonia in adults: a systematic review and meta-analysis. Journal of thoracic disease 8(10): 2822-2831	- SR not selected for use *Included studies overlap with another included SR*
Ye, Xiong, Xiao, Hui, Chen, Bo et al. (2015) Accuracy of Lung Ultrasonography versus Chest Radiography for the Diagnosis of Adult Community-Acquired Pneumonia: Review of the Literature and Meta-Analysis. PloS one 10(6): e0130066	- SR not selected for use *Only 5 included studies, more comprehensive SR selected for use*
Zare, M.A., Mizani, M., Sameti, A. et al. (2021) Emergency Physicians Performing Point-of-Care Lung Sonography to Diagnose Pneumonia: A Prospective Multicenter Study. Journal of Diagnostic Medical Sonography 37(3): 261-267	- Non-OECD country *Iran*
Zhao, Xue, Zhang, Mao, Wang, Yi et al. (2020) Diagnostic value of lung ultrasound for pregnant women with community-acquired pneumonia. JPMA. The Journal of the Pakistan Medical Association 70specialissue(9): 57-63	- Non-OECD country *China*

CAP: community-acquired pneumonia; HAP; hospital acquired pneumonia; OECD: organisation for economic co-operation and development; RCT: randomised controlled trial; SR: systematic review; VAP: ventilator-associated pneumonia

Economic

Study	Code [Reason]
Akyil, Fatma Tokgoz, Hazar, Armagan, Erdem, Ipek et al. (2015) Hospital Treatment Costs and Factors	- Study does not contain a relevant intervention

Study	Code [Reason]
Affecting These Costs in Community-Acquired Pneumonia. Turkish thoracic journal 16(3): 107-113	*Costing study, does not compare interventions*
Andrews, Annie Lintzenich, Simpson, Annie N, Heine, Daniel et al. (2015) A Cost-Effectiveness Analysis of Obtaining Blood Cultures in Children Hospitalized for Community-Acquired Pneumonia. The Journal of pediatrics 167(6): 1280-6	- US study
Antunes, C, Pereira, M, Rodrigues, L et al. (2020) Hospitalization direct cost of adults with community-acquired pneumonia in Portugal from 2000 to 2009. Pulmonology 26(5): 264-267	- Study does not contain a relevant intervention *Costing study, does not compare interventions*
Asti, L, Bartsch, S M, Umscheid, C A et al. (2019) The potential economic value of sputum culture use in patients with community-acquired pneumonia and healthcare-associated pneumonia. Clinical microbiology and infection : the official publication of the European Society of Clinical Microbiology and Infectious Diseases 25(8): 1038e1-1038e9	- US study
Buendia, Jefferson A and Patino, Diana Guerrero (2023) Corticosteroids for the treatment of respiratory infection by Mycoplasma pneumoniae in children: A cost-utility analysis. Pediatric pulmonology 58(10): 2809-2814	- Non OECD country *Columbia*
Cammarota, Gianmaria; Vetrugno, Luigi; Longhini, Federico (2023) Lung ultrasound monitoring: impact on economics and outcomes. Current opinion in anaesthesiology 36(2): 234-239	- Does not contain a population of people with only pneumonia, includes people with acute respiratory failure *Unclear if the patients are intubated* - US study *Unclear if the study is US or Europe* -Abstract only
Ceyhan, Mehmet, Ozsurekci, Yasemin, Aykac, Kubra et al. (2018) Economic burden of pneumococcal infections in children under 5 years of age. Human vaccines & immunotherapeutics 14(1): 106-110	- Study does not contain a relevant intervention *Non-comparative costing analysis*
Cisco, Giulio, Meier, Armando N, Senn, Nicolas et al. (2024) Cost-effectiveness analysis of procalcitonin and lung ultrasonography guided antibiotic prescriptions in primary care. The European journal of health economics : HEPAC : health economics in prevention and care	- setting in primary care whereas the review was in secondary care

Study	Code [Reason]
Costa, Nadege, Hoogendijk, Emiel O, Mounie, Michael et al. (2017) Additional Cost Because of Pneumonia in Nursing Home Residents: Results From the Incidence of Pneumonia and Related Consequences in Nursing Home Resident Study. Journal of the American Medical Directors Association 18(5): 453e7-453e12	- Study does not contain a relevant intervention *Non-comparative costing analysis*
Hyams, Catherine; Williams, O Martin; Williams, Philip (2020) Urinary antigen testing for pneumococcal pneumonia: is there evidence to make its use uncommon in clinical practice?. ERJ open research 6(1)	- Review article but not a systematic review, all primary studies were check for relevance
Ito, Akihiro, Ishida, Tadashi, Tokumasu, Hironobu et al. (2017) Impact of procalcitonin-guided therapy for hospitalized community-acquired pneumonia on reducing antibiotic consumption and costs in Japan. Journal of infection and chemotherapy : official journal of the Japan Society of Chemotherapy 23(3): 142-147	- Not a relevant study design *Costing study not a cost utility study*
Javanbakht, Mehdi, Moradi-Lakeh, Maziar, Mashayekhi, Atefeh et al. (2022) Continuous Monitoring of Respiratory Rate with Wearable Sensor in Patients Admitted to Hospital with Pneumonia Compared with Intermittent Nurse-Led Monitoring in the United Kingdom: A Cost-Utility Analysis. PharmacoEconomics - open 6(1): 73-83	- Study does not contain a relevant intervention *Continuous monitoring versus intermittent monitoring, NEWS used in both arms*
Khole, Aalok V, Dionne, Emily, Zitek-Morrison, Emily et al. (2023) Cefepime extended infusion versus intermittent infusion: Clinical and cost evaluation. Antimicrobial stewardship & healthcare epidemiology : ASHE 3(1): e119	- US study
Latif, Marina, Guo, Ning, Tereshchenko, Larisa G et al. (2023) Association of hospital spending with care patterns and mortality in patients hospitalized with community-acquired pneumonia. Journal of hospital medicine 18(11): 986-993	- Study does not contain a relevant intervention *US costing study with no comparative interventions*
Leem, Ah Young, Jung, Won Jai, Kang, Young Ae et al. (2014) Comparison of methicillin-resistant Staphylococcus aureus community-acquired and healthcare-associated pneumonia. Yonsei medical journal 55(4): 967-74	- Not a relevant study design *Not a health economic study*
Macaya, M.C.; Ridulfo, A.H.; Ramirez-Santana, M. (2015) Comparison of costs and health outcomes of users with community-acquired pneumonia treated at home or in traditional hospitalization: An exploratory study of 40 cases. Value in Health Regional Issues 8: 112-115	- Study not reported in English *Reported in Spanish*

Study	Code [Reason]
McKinnell, James A, Corman, Shelby, Patel, Dipen et al. (2018) Effective Antimicrobial Stewardship Strategies for Cost-effective Utilization of Telavancin for the Treatment of Patients With Hospital-acquired Bacterial Pneumonia Caused by Staphylococcus aureus. Clinical therapeutics 40(3): 406-414e2	- Study does not contain a relevant intervention *US study that compares different antibiotics rather than length of treatments*
Meacock, Rachel, Sutton, Matt, Kristensen, Soren Rud et al. (2017) Using Survival Analysis to Improve Estimates of Life Year Gains in Policy Evaluations. Medical decision making : an international journal of the Society for Medical Decision Making 37(4): 415-426	- Study does not contain a relevant intervention *Modelling survival not cost effectiveness of treatment*
Miners, Lisa, Huntington, Susie, Lee, Nathaniel et al. (2023) An economic evaluation of two PCR-based respiratory panel assays for patients admitted to hospital with community-acquired pneumonia (CAP) in the UK, France and Spain. BMC pulmonary medicine 23(1): 220	- Not a relevant study design *Cost consequence study*
Patel, Archana B, Bang, Akash, Singh, Meenu et al. (2015) A randomized controlled trial of hospital versus home based therapy with oral amoxicillin for severe pneumonia in children aged 3 - 59 months: The IndiaCLEN Severe Pneumonia Oral Therapy (ISPOT) Study. BMC pediatrics 15: 186	- Non OECD country *India*
Pliakos, Elina Eleftheria, Andreatos, Nikolaos, Tansarli, Giannoula S et al. (2019) The Cost-Effectiveness of Corticosteroids for the Treatment of Community-Acquired Pneumonia. Chest 155(4): 787-794	- US study
Prasath, T.M., Ramachandran, V., Geetha, S. et al. (2019) Hidden Markov model-based cough sound analysis for classification of asthma and pneumonia in pediatric. Drug Invention Today 11(7): 1692-1695	- Full text paper not available
Przybilla, Jens, Ahnert, Peter, Bogatsch, Holger et al. (2020) Markov State Modelling of Disease Courses and Mortality Risks of Patients with Community-Acquired Pneumonia. Journal of clinical medicine 9(2)	- Study does not contain a relevant intervention *Does not include costs*
Reynolds, Courtney A, Finkelstein, Jonathan A, Ray, G Thomas et al. (2014) Attributable healthcare utilization and cost of pneumonia due to drug-resistant streptococcus pneumonia: a cost analysis. Antimicrobial resistance and infection control 3: 16	- Study does not contain a relevant intervention *Looking at different antibiotics not the length of the courses*
Rozenbaum, Mark H, Mangen, Marie-Josee J, Huijts, Susanne M et al. (2015) Incidence, direct costs and duration of hospitalization of patients hospitalized	- Study does not contain a relevant intervention

Study	Code [Reason]
with community acquired pneumonia: A nationwide retrospective claims database analysis. Vaccine 33(28): 3193-9	*Costing analysis without comparators*
Shi, Honghao, Guo, Wanjie, Zhu, He et al. (2019) Cost-Effectiveness Analysis of Xiyanping Injection (Andrographolide Sulfonate) for Treatment of Adult Community Acquired Pneumonia: A Retrospective, Propensity Score-Matched Cohort Study. Evidence-based complementary and alternative medicine : eCAM 2019: 4510591	- Study does not contain a relevant intervention *Andrographolide Sulfonate injection*
Shiri, Tinevimbo, Khan, Kamran, Keaney, Katherine et al. (2019) Pneumococcal Disease: A Systematic Review of Health Utilities, Resource Use, Costs, and Economic Evaluations of Interventions. Value in health : the journal of the International Society for Pharmacoeconomics and Outcomes Research 22(11): 1329-1344	- Study does not contain a relevant intervention *Vaccines and antibiotics (not length of treatment)*
Sultana, Marufa, Sarker, Abdur Razzaque, Ali, Nausad et al. (2019) Economic evaluation of community acquired pneumonia management strategies: A systematic review of literature. PloS one 14(10): e0224170	- Study does not contain a relevant intervention *Different antibiotics in adults and bubble continuous positive airway pressure in newborns*
Tesfaye, Solomon H, Loha, Eskindir, Johansson, Kjell Arne et al. (2022) Cost-effectiveness of pulse oximetry and integrated management of childhood illness for diagnosing severe pneumonia. PLOS global public health 2(7): e0000757	- Non OECD country *Ethiopia*
Torres, Antoni, Bassetti, Matteo, Welte, Tobias et al. (2020) Economic analysis of ceftaroline fosamil for treating community-acquired pneumonia in Spain. Journal of medical economics 23(2): 148-155	- Study does not contain a relevant intervention *Different antibiotics not different durations*
Wagner, A P, Enne, V I, Livermore, D M et al. (2020) Review of health economic models exploring and evaluating treatment and management of hospital-acquired pneumonia and ventilator-associated pneumonia. The Journal of hospital infection 106(4): 745-756	- Study does not contain a relevant intervention *Different antibiotics not different durations*
Xie, Xuanqian; Sinclair, Alison; Dendukuri, Nandini (2017) Evaluating the accuracy and economic value of a new test in the absence of a perfect reference test. Research synthesis methods 8(3): 321-332	Included in review question 4.2
Zhang, Shanshan, Sammon, Peter M, King, Isobel et al. (2016) Cost of management of severe pneumonia in young children: systematic analysis. Journal of global health 6(1): 010408	- Study does not contain a relevant intervention *Costing study with no outcomes*

NEWS: National Early Warning Score; OECD: organisation for economic co-operation and development