National Institute for Health and Care Excellence

Pneumonia: diagnosis and management (update)

[I] Evidence review for the effectiveness and cost-effectiveness of routine chest x-rays at 6-weeks post discharge for identifying underlying disease in people hospitalised with pneumonia

NICE guideline [number]

Evidence reviews underpinning recommendations 1.12.1 to 1.12.3 and a research recommendation in the NICE guideline

April 2025

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ISBN: xxx

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1 Follow-up chest X-rays

1.1 Review question

Is a routine chest X-ray at 6 weeks post discharge an effective and cost-effective strategy to identify underlying disease in people who have been treated for community- or hospital-acquired pneumonia in hospital?

1.1.1 Introduction

Currently, people who have been treated in hospital for community-acquired pneumonia (CAP) or hospital-acquired pneumonia (HAP) are offered a 6-week follow-up chest X-ray. These are done to check for resolution of the pneumonia and to find any underlying pathologies that may have contributed to the pneumonia or may have been missed due to consolidation. There is uncertainty about whether it is effective and cost-effective to offer this routinely to all people who have been hospitalised with pneumonia, or whether it should only be offered to specific groups, such as those with unresolved symptoms or other risk factors (such as age >50 years and smokers). The British Thoracic Society (BTS) recommends that a 6-week follow-up chest radiograph should be offered to patients who have a persistence of symptoms or physical signs, or who are at higher risk of underlying malignancy (especially smokers and those age >50 years), but these recommendations are not underpinned by clinical evidence. There is currently variation in the approach to follow-up chest radiographs, with some services offering it to all patients treated in hospital for CAP or HAP, and others offering it in line with the BTS recommendations.

This review aims to identify the number of malignancies, other non-malignant conditions, and congenital abnormalities detected through routine follow-up chest X-rays and to determine the most effective and cost-effective approach to follow-up screening.

1.1.2 Summary of the protocol

Table 1: PICOS inclusion criteria

Population	**Inclusion:** People diagnosed with community acquired pneumonia (CAP) or hospital acquired pneumonia (HAP) who received inpatient treatment and are 6 weeks post-discharge • CAP is defined as pneumonia that is acquired outside the hospital. • HAP is defined as pneumonia that occurs 48 hours or more after hospital admission and is not incubating at hospital admission. • Population includes adults (≥18 years) and babies (>28 days corrected gestational age and <1 year), children (up to 12 years) and young people (between 12 and 17 years). **Exclusion:** • Babies up to and including 28 days old (corrected gestational age) • People with COVID-19 pneumonia

	• People who acquire pneumonia while intubated (ventilator associated pneumonia) • People who are severely immunocompromised • People who already have a diagnosis of lung cancer See full protocol for list of all excluded groups.
Interventions	Repeat chest radiograph approximately 6 weeks post hospital discharge (included range 4-8 weeks)
Comparator	N/A
Outcomes	• Rate of detection of malignancies (e.g. lung cancer, other cancer) • Rate of detection of non-malignant conditions such as pulmonary empyema or other underlying disease (e.g. tuberculosis) • Rate of detection of congenital abnormalities
Study type	Cross-sectional studies, prospective and retrospective cohort studies

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.

No meta-analysis was undertaken for this review. A small number of single arm cohort studies (<5) reported radiographic resolution rates, and it was agreed that pooling this data would give no more information than presenting it in summary tables. For malignancy detection rates, the possibility of combining evidence into a weighted mean to estimate an overall rate of detection was explored, but the study populations and follow-up points were considered too heterogeneous. Results are therefore presented in tables and summarised narratively using evidence statements in section 1.1.11.

Due to the outcome data reported, particularly the lack of 95%CIs or other measures of variance, quality assessments using GRADE could not be conducted. Instead, risk of bias was assessed for each study and the individual study ratings were discussed with the committee, noting the reasons for downgrading and any other study limitations that may impact the quality of the evidence.

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

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 the diagnostic evidence were run on 23 November 2023. 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. Validated NICE filters were used in MEDLINE and Embase to remove references exclusively set in countries that are not OECD members.

The database searches were supplemented with additional search methods. Reference checking and forwards citation searching were conducted on Web of Science Core Collection on 22 November 2023 using seed references identified from the scoping searches and 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. The NICE OECD filters were used in MEDLINE and Embase.

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.

1.1.3.2 Protocol deviations

The protocol did not list radiographic resolution as an included outcome, largely because the purpose of the review was to identify the rate of malignancies and other non-malignant conditions that may be identified using follow-up chest radiography. However, radiographic resolution was reported in many of the included studies and conveyed important information about the progression and resolution of pneumonia over time. Furthermore, in the studies identified for children and young people under 18 years, radiographic resolution was the only outcome reported, predominantly because lung malignancies are rare in this population, so to maximise the evidence available for children and young people, a decision was made to revise the protocol to include radiographic resolution as an outcome of interest.

1.1.4 Diagnostic yield evidence

1.1.4.1 Included studies

A systematic search carried out to identify potentially relevant studies found 2199 references (see appendix B for the literature search strategy). These 2199 references were screened at title and abstract level against the review protocol, with 2183 excluded at this level. 10% of references were screened separately by two reviewers with 100% agreement.

The full texts of 16 papers were ordered for closer inspection. Ten of these studies (4 for children and young people and 6 for adults) met the criteria specified in the review protocol (appendix A) and 6 were excluded. For a summary of the 10 included studies see Table 2.

The clinical evidence study selection is presented as a PRISMA diagram 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 H.

1.1.5 Summary of studies included in the diagnostic yield evidence

Table 2. Summary of studies included in the diagnostic evidence

Study details	Study type	Population	Intervention	Outcomes	Comments
Studies of babies, children and young people (<18 years)					
Gibson 1993 UK	Prospective study	Children hospitalised with CAP Median age 4 years; range 2 months to 12 years N = 77	Chest radiograph 3-4 weeks after discharge from hospital	Radiological resolution at 3-4 week follow-up	
Grossman 1979 US	Prospective study evaluating the results of routine follow-up chest X-rays	Children diagnosed with acute onset of pneumonia Age range 6 weeks to 15 years. No mean or median age reported. N = 129	Chest radiograph 3-4 weeks after diagnosis of pneumonia	Radiological resolution at 3-4 week follow-up	Of 129 children enrolled in the study, 70 (54%) attended for follow-up chest radiograph. Unclear whether patients were hospitalised or treated as outpatients.

Study details	Study type	Population	Intervention	Outcomes	Comments
Heaton 1998 New Zealand	Retrospective analysis of patient records	Children hospitalised with CAP Mean age 3.5 years; range 5 months to 13 years. N = 65	Chest radiograph 4-6 weeks after discharge from hospital	Radiological resolution at 4-6 week follow-up	Follow-up arrangements were made by the admitting clinician, though some radiologists made specific recommendations in their reports. Of 65 initial chest radiographs, follow-up was requested in 54 cases, of whom 41 (76%) attended.
Virkki 2005 Finland	Prospective study	Children hospitalised with CAP Median age 2.4 years; range 0.1 to 15.6 years. Age ranges: <1 year (14%), 1-2 years (30%), 2-5 years (25%), 5+ years (25%). N = 196	Chest radiograph 3-7 weeks after admission	Radiological resolution at 3-7 week follow-up	
Studies of adults (≥18 years)					
Bruns 2007	Prospective study	Adults (≥18 years) hospitalised because of severe CAP	Chest radiograph on day 28 post-admission	Radiological resolution at day 28	Of 288 patients recruited at admission, 195 (67.7%) had chest radiographs on day 28. Paper

Study details	Study type	Population	Intervention	Outcomes	Comments
The Netherlands		Severe CAP defined as PSI score >90 Mean age 69.7 (SD: 13.9); range 20 to 95 years N = 195		Presence of unresolved abnormalities at day 28 (infiltrates; multilobar infiltrates; atelectasis; pleural fluid)	provides sample characteristics for full sample only.
Holmberg 1993 Sweden	Retrospective study of medical records	Adults (≥15 years) admitted to hospital with pneumonia Mean age 66 years; range 15 to 97 years. 76% > 55 years. N = 1011	Convalescent chest radiograph 1-2 months post-admission	Malignancy Important benign diagnosis	Of 1011 eligible patients, 678 (67%) were followed up with convalescent chest x-ray.
Little 2014 US	Retrospective study	Adults with presumed CAP. Mean age 63 years; range 20 to 98 years.	Follow-up chest radiograph; time frame not reported but mean time 78 days, median 41 days, 60% of patients within 90 days.	Malignancy Important benign diagnosis	Of 805 eligible patients for whom follow-up radiography was recommended, 618 (77%) underwent documented follow-up imaging. Patients with documented follow-up imaging were significantly more likely to have a history of

Study details	Study type	Population	Intervention	Outcomes	Comments
		27% had a history of cancer. 18% had COPD and 1.9% had known HIV. N = 805			known malignancy than those without follow-up imaging (27% vs 17%; $p = 0.005$) and more likely to have documented COPD (18% vs 7%; $p < 0.0001$). Index radiographs with findings that the interpreting radiologist thought were highly suspicious for cancer or recommended immediate chest CT were excluded from the study. Unclear from the study but appears that all patients were treated as outpatients. Follow-up radiography included CT in a small number of cases (53.6% had radiography only; 17.5% had radiography and CT; 5.6% had CT only). Outcome rates only presented as totals; cannot determine rates detected for radiography only group.
Macdonald 2015	Retrospective study	Adults (>50 years) admitted with a diagnosis of CAP and	Chest radiograph 6-12 weeks following admission	Malignancy	160/302 (53%) of patients received a follow-up chest x-ray within 6-12 weeks. 81% (130) of these were

Study details	Study type	Population	Intervention	Outcomes	Comments
New Zealand		presence of acute infiltrate on admission chest x-ray. Patients with HAP or aspiration pneumonia were excluded. Age ranges: 50-59 (14%), 60-69 (21%), 70-79 (25%), 80-89 (31%), >90 years (9%). 46% had prior lung disease, including COPD (33%), asthma (6%), previous pneumonia (6%) and pulmonary fibrosis (1%). N = 302			deemed intentional, based on the written information on the request from the ordering provider.
Mittl 1994	Prospective study	Adults (>18 years) meeting clinical and radiographic criteria	Serial chest radiographs obtained every 2 weeks after	Malignancy	37 were treated as inpatients, 44 were treated as outpatients.

Study details	Study type	Population	Intervention	Outcomes	Comments
US		for pneumonia diagnosis. Mean age 40.2 years (SD 16.4). 37% had a history of pulmonary or cardiopulmonary disease, including COPD, asthma, TB, prior pneumonia, and congestive heart failure. N = 81	initial diagnosis for first 8 weeks, then every 4 weeks up to 24 weeks. Of interest to this review are the 4-week and 6-week radiographs.	Radiographic resolution	
Tang 2011 Canada	Prospective population-based cohort study	Adults (>18 years) with a chest radiography-confirmed diagnosis of pneumonia. Mean age 57.9 years (SD 20.3). 61% ≥50 years.	Participants were followed-up for 5 years, including outcome assessments at 90-days, 1 year, 2 years, 3 years and 5 years. Of interest to this review is the 90-day follow-up.	Malignancy	665 (49%) were treated as inpatients. Paper does not report whether follow-up x-rays were requested by clinician / radiographer at diagnosis, but in the conclusion they refer to “follow-up radiographs ordered at the discretion of the treating physician.”

Study details	Study type	Population	Intervention	Outcomes	Comments
		20% had a history of COPD. N = 1354			

Notes: CAP: Community acquired pneumonia; COPD: chronic obstructive pulmonary disease; EDs: Emergency Departments; HAP: Hospital acquired pneumonia; PSI: Pneumonia Severity Index; TB: tuberculosis.

See appendix D for full evidence tables.

1.1.6 Summary of the diagnostic yield evidence

1.1.6.1 Evidence for babies, children and young people <18 years

1.1.6.1.1 Radiological resolution

Table 3: Rate of radiological resolution

Study	Follow-up duration	Radiological resolution	Risk of Bias
Gibson 1993	3-4 weeks	56 / 72 (77.8%)	Low
Grossman 1979	3-4 weeks	56 / 70 (80%)	Low
Heaton 1998	4-6 weeks	36 / 41 (88%)	Low
Virkki 2005	3-7 weeks	137 / 196 (70%)[a]	Low

[a] Example radiographic abnormalities seen in patients without radiological resolution: sole interstitial infiltrates (67%), atelectasis (47%), and enlarged lymph nodes (28%)

1.1.6.2 Evidence for adults

1.1.6.2.1 Radiological resolution

Table 4: Rate of radiological resolution

Study	Follow-up duration	Radiological resolution	Risk of Bias
Bruns 2007	28 days	103 / 195 (52.8%)[a]	Serious[1]
Mittl 1994	4 weeks	50 / 75 (66.7%)	Low
Mittl 1994	6 weeks	56 / 73 (76.7%)	Low

[a] Example radiographic abnormalities seen in patients without radiological resolution: infiltrates (37.9%), multilobar infiltrates (11.3%), atelectasis (6.7%) and pleural fluid (12.8%).

[1] Patients that received a follow-up chest x-ray were different from patients who did not, on important characteristics that may have influenced the outcome (pneumonia severity, age, and history of heart disease), and these differences could not be controlled for in the analyses. The radiologists that interpreted the radiographs were provided with information on the patient's clinical condition, which could possibly have influenced their interpretation of radiographic resolution, but this is unlikely.

1.1.6.2.2 Detection of malignancies

Table 5: Detection rate for malignancies

Study	Follow-up duration	Malignacy	Diagnosis	Risk of Bias
Holmberg 1993	1-2 months	4 / 678 (0.58%)	Pulmonary carcinoma	Low
Little 2014	Mean time 78 days	15 / 618 (2.43%)	All new malignancies[a]	Serious[1]
	Median time 41 days	9 / 618 (1.5%)	Only malignancies that directly	

Study	Follow-up duration	Malignacy	Diagnosis	Risk of Bias
			corresponded with the index chest radiographic abnormality initially suspected to represent pneumonia (non-small cell lung cancer and large B cell lymphoma)	
Macdonald 2015	6-12 weeks	6 / 160 (3.75%)[b]	Pulmonary carcinoma	Serious[2]
Mittl 1994	Unclear; some time between 2 and 24 weeks[c]	1 / 81 (1.2%)	Pulmonary carcinoma	Low
Tang 2011	90 days	34 / 1354 (2.5%)	Pulmonary carcinoma	Moderate[3]

Notes.

[a] This includes all cases of any malignancy, including malignancies that corresponded with the abnormality on the initial radiograph (8 cases of non-small cell lung cancer and one case of large B cell lymphoma), and malignancies not correlating with the location on the index chest radiographic abnormality (which included a pancreatic neuroendocrine tumour without lung malignancy, other thoracic metastasis (lung, colon, chondrosarcoma, head and neck tumour), thoracic involvement by chronic lymphocytic leukaemia, and lymphangitic carcinomatosis (breast)).

[c] The paper only refers to 'follow-up radiograph' but does not specify the timepoint. Participants in this study were followed up at 2, 4, 6 and 8 weeks after initial pneumonia diagnosis, then every 4 weeks until 24 weeks.

[b] The paper reports a percentage yield of 2%, but this is for the total sample (n = 302). Only 160 (53%) of study participants received a follow-up chest X-ray within 6-12 weeks of admission, so yield reported in the table above is for the patients who received a follow-up X-ray only.

[1] Serious risk of bias because patients for whom follow-up radiography was recommended may differ from patients for whom it was not recommended in ways that could affect the outcome of interest. Unclear what criteria were used to recommend follow-up, Patients with documented follow-up imaging were more likely to have a history of malignancy or documented COPD than patients without follow-up imaging.

[2] Serious risk of bias because most patients receiving follow-up chest x-rays were at the request of the provider and patients for whom a follow-up chest x-ray was requested may differ from those for whom a follow-up was not requested, in ways that may influence the outcome.

[3] Moderate risk of bias because of concerns about potential confounding. Unclear whether follow-up x-rays were requested by clinician / radiographer at diagnosis. Patients for whom a chest x-ray is requested may differ from those for whom a chest x-ray is not requested, in ways that may impact the outcome.

Details of malignancies detected

Little 2014

- 9 of the 15 malignancies detected corresponded with the abnormality on the index radiograph. On chest radiography, only one of nine cases of malignancy was described as a nodule. The remaining eight cases were described as an opacity or consolidation.

- The mean age of these nine patients was 68.4 years (median, 73 years; range, 47–83 years). Five of the nine had a history of malignancy at the time of the index radiography, three had known COPD, and two were current smokers.

- Two patients (47 and 48 years old) with new diagnoses of non–small cell lung cancer corresponding with the original radiographic abnormality were under the age of 50 years, accounting for 22% of the new diagnoses of malignancies corresponding with the index radiographic abnormality.

Macdonald 2015

- Of the 6 / 160 patients diagnosed with lung cancer, four (66%) were aged 80-89 years and two (33%) were aged over 90 years.

- Of the 6 / 160 patients diagnosed with lung cancer, five (83%) had a history of smoking, and five (83%) had a previous diagnosis of COPD.

Mittl 1994

- One patient out of 81 was subsequently diagnosed with adenocarcinoma of the lung metastatic to the skin.

Tang 2011

- There were 57 lung cancers diagnosed within 1 year; 34 of these were diagnosed within 90-days. All 57 lung cancers would have been captured with universal follow-up requiring 3398 chest radiographs, for a yield of 1.7%. To maximize yield, our findings suggest restricting follow-up radiographs to patients 50 years or older. This strategy would have identified 56 of 57 (98%, 1 missed) lung cancers and required just 2010 chest radiographs for an estimated yield of 2.8%.

1.1.6.2.3 Detection of important benign diagnoses

Table 6: Detection rate for non-malignant conditions

Study	Follow-up duration	Important benign diagnosis	Risk of Bias
Holmberg 1993	1-2 months	0 / 678 (0%) cases of TB or other significant disease 1 / 678 (0.15%) case of anthracosis	Low
Little 2014	Mean time 78 days Median time 41 days	23 / 618 (3.72%)	Serious[1]

[1] In all cases, the interpreting radiologist recommended follow-up chest radiography to ensure resolution of radiographically suspected pneumonia. Patients for whom follow-up radiography is recommended may differ from patients for whom it is not recommended in ways that could affect the outcome of interest. It is unclear in the paper what criteria were used to recommend follow-up (e.g. all patients with pneumonia). In addition, patients with documented follow-up imaging were more likely to have a history of malignancy or documented COPD than patients without follow-up imaging.

Details of important benign conditions detected

Little 2014

- Important non-malignant diagnoses were: Tuberculosis or atypical mycobacterial infection (n = 6), fungal infection (n = 5), organising or eosinophilic pneumonia (n = 5), rounded atelectasis (n = 3), alveolar haemorrhage (n = 1), lung abscess (n = 1), *Pneumocystis jiroveci* (n = 1), and septic emboli (n = 1).

- The mean age of these 23 patients was 56 years (median, 58 years; range, 23–83 years).

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 E – Economic evidence study selection for the study selection process.

1.1.7.2 Excluded studies

See appendix H for a list of excluded studies, with reasons for exclusion.

1.1.8 Summary of included economic evidence

There are no included studies in this review question.

1.1.9 Economic model

No original economic modelling was completed for this review question.

1.1.10 Unit costs

No unit costs were supplied for this review question.

1.1.11 Evidence statements

- 4 cohort studies (3 directly applicable and 1 partially applicable) at low risk of bias containing data from 379 patients aged under 18 years who were hospitalised with CAP showed rates of radiological resolution between 77.8% and 80% at 3-4 weeks; 88% at 4-6 weeks; and 70% at 3-7 weeks.
- There was no evidence identified for rates of malignancy or other important benign diagnoses for children and young people aged under 18 years.
- 1 directly applicable cohort study at serious risk of bias, and 1 partially applicable cohort study at low risk of bias, containing data from 270 adult patients hospitalised with CAP showed rates of radiological resolution of 53% at 28 days, 67% at 4 weeks, and 77% at 6 weeks.
- 5 cohort studies (2 directly applicable and 3 partially applicable) at low (2 studies), moderate (1 study) and high (2 studies) risk of bias, containing data from 2,891 adult patients hospitalised with CAP showed rates of malignancy detection at 6 week follow-up between 0.58% and 3.75% (median 2.43%).
- 1 directly applicable cohort study at low risk of bias, and 1 partially applicable cohort study at serious risk of bias, containing data from 1,296 adult patients hospitalised with CAP showed rates of detection of important benign diagnoses at 1-2 month follow-up between 0.15% and 3.72%.

1.1.12 The committee's discussion and interpretation of the evidence

1.1.12.1. The outcomes that matter most

The committee agreed that the main purpose of offering people a chest x-ray 6 weeks after hospital discharge was to identify any malignancies or other areas of concern or abnormalities that may have been masked by the pneumonia consolidation on the persons admission x-ray. To a lesser extent the chest x-ray can be a confirmation of cure for pneumonia. Therefore, they agreed that the critical outcomes for repeat chest X-rays 6 weeks post hospital discharge were the rate of detection of malignancies (e.g., lung cancer, other cancer), rate of detection of non-malignant conditions or other underlying disease (e.g., TB, pulmonary empyema), and rate of detection of congenital abnormalities in children. The committee agreed to add the rate of radiographic resolution to the included outcomes in the protocol (appendix A) via a protocol deviation because many of the included studies reported this outcome and the committee agreed that it conveyed important information about the progression and resolution of pneumonia over time. Furthermore, this was the only outcome reported in studies of children and young people; no studies were identified that reported rates of detection of malignancies, non-malignant conditions, or congenital abnormalities in this population.

1.1.12.2 The quality of the evidence

The committee noted that there was no evidence identified for people with hospital-acquired pneumonia; all studies included patients with community-acquired pneumonia only. The committee reflected on this evidence gap and by consensus they agreed that the evidence from CAP could be extrapolated to HAP, since the indications, process measures and consequences of repeat chest x-rays are largely the same in both populations. Nevertheless, they acknowledged that the malignancy detection rate reported only applied to CAP and the malignancy detection rate for HAP was unknown. There was no evidence identified that reported on the detection of congenital abnormalities, and the studies of children and young people only reported outcome data for rate of radiological resolution – there was no evidence on detection of malignancies or other non-malignant conditions for this population, although the committee noted that rate of lung cancer in this population is very rare so that was expected. The committee also noted that all the included evidence was published before 2015 and while they were uncertain about why there was a lack of recent research in this area, they agreed that there had been no substantial changes in practice over time that would impact the relevance of the included evidence. It was noted that some of the papers that were published pre-2000 contained limited methodological information about the study design and data collection, which limited what could be extracted and assessed from those studies.

Quality assessments using GRADE could not be conducted because measures of variance were not reported for any outcomes. Study quality and directness was discussed with the committee when presenting the evidence. The risk of bias ratings ranged from low to high risk of bias: 3 studies were rated as high risk of bias, 1 at moderate risk of bias, and 6 at low risk of bias. The main reason for downgrading was because the follow-up chest x-rays

included in the study had been recommended or requested by the radiologist performing the initial diagnostic chest x-ray, but no information was provided about what criteria was used to recommend follow up (e.g., all patients with radiographic evidence of pneumonia; or only patients with certain risk factors present that would indicate a follow-up chest x-ray). It was therefore not possible to determine whether patients for whom follow-up radiography was recommended differed from patients for whom it was not recommended, and how these potential differences may have impacted the outcomes of interest. It was noted that the rate of malignancy detection in studies where the follow-up x-ray had been recommended during admission ranged from 2.43% to 3.75%, while the rate of malignancy detection in studies where all patients hospitalised with pneumonia received a follow-up x-ray ranged from 0.58% to 1.2%. The committee agreed that this made it seem more likely that some sort of clinical judgment had informed the referral.

The committee noted that in many studies the number of patients attending for follow-up chest x-rays was considerably lower than the number who were invited to attend: follow-up attendance rates ranged between 54% and 76% for children and young people, and between 53% and 77% for adults. Two studies of adults reported on the differences between these groups, which showed that patients with documented follow-up imaging were significantly more likely to have a known malignancy at baseline, more likely to have COPD, higher scores for pneumonia severity at baseline, were older, and were more likely to have a history of heart disease than patients who did not attend for follow-up imaging. The committee discussed these differences and agreed that patients who attend for follow-up may differ in other important ways from those who are eligible but do not attend, but they noted the difficulty in capturing and understanding both the reasons for and impact of non-attendance. For example, non-attenders may be those whose symptoms have resolved and who are feeling well but could also be those whose symptoms have worsened and who feel too unwell to attend. People who are seeking reassurance that their condition has fully resolved may be more likely to attend, while people with health anxiety or those who find medical tests distressing may be less likely to attend. The committee also noted that the wider literature on non-attendance indicates that sociodemographic characteristics and deprivation may have an influence.

Six studies were rated as directly applicable and 4 studies were rated as partially applicable because not all participants were hospitalised patients – in these 4 studies, either all or approximately half of the sample were treated as outpatients. The committee noted that it was not possible to tell from the included studies what stage the cancers were that were identified. This meant that it was not possible to judge whether people were identified earlier than they would otherwise be, and what impact this had on their prognosis and survival. They agreed these data would be helpful to more fully understand the usefulness of follow-up chest x-ray so they recommended that future research on follow-up chest x-rays should include consideration of the stage of cancer detected (appendix I).

1.1.12.3 Benefits and harms

Babies, children and young people <18 years

The committee discussed evidence on the rate of radiological resolution at 3-7 weeks follow-up in babies, children and young people who had been hospitalised with CAP. The evidence showed radiological resolution rates of between 70% and 88% at follow-up. The committee noted findings from one study that showed that in cases where there were residual radiographic abnormalities, the follow-up imaging had been taken less than 4 weeks post-discharge. It was also noted from another study that when patients returned for a second follow-up chest x-ray between 6 weeks and 3 months after initial diagnosis, all showed complete resolution. The committee agreed that radiological changes seen on the diagnostic chest x-ray may persist beyond the clinical resolution of symptoms and do not necessarily indicate that further investigation or treatment is required. Similarly, authors from one study reported that the radiographic findings at the follow-up visit did not change the treatment for any patient. The committee agreed that given the very low likelihood of detecting malignancy, the high rate of radiological resolution, the absence of impact on treatment decisions, and the risks of radiation in children through repeated chest x-rays, 6-week follow-up chest x-rays for children who have been hospitalised with CAP are not clinically useful and should not be offered.

Adults ≥18 years

The committee discussed evidence for radiological resolution at 4–6-week follow-up, with evidence from 2 studies showing resolution rates of 53% and 77%. Unresolved abnormalities included infiltrates, atelectasis and pleural fluid. The committee agreed that, as with children, radiological changes may persist beyond the clinical resolution of symptoms, this does not necessarily indicate that further investigation or treatment is required.

The committee discussed the malignancy detection rates and noted that routine chest x-rays 6-weeks after inpatient treatment for CAP produces a diagnostic yield of around 2%. They considered whether this was clinically meaningful. They noted that none of the included studies provided information about the stage of cancer at the point of detection, the treatment provided for the cancers detected, or the long-term survival of those patients. The committee highlighted that this made it difficult to understand the clinical value of malignancy detection at 6-week follow-up. They also agreed that without data to compare the rate of malignancy detection in people who did not receive a follow-up chest x-ray at 6 weeks, it was not possible to understand the relative value of the diagnostic yield, or the likelihood that the cancers that were detected on the follow-up chest x-ray would have been detected otherwise. They were aware that there is a lack of evidence from comparative studies in this area, which is why they focused on cohort studies for this review, but they agreed that comparative studies are needed so they made a research recommendation (appendix I).

The committee considered the population characteristics of patients with a new malignancy. This was reported in 2 studies. Patients with a malignancy were older, had a history of malignancy, had known COPD, or had a history of smoking. The committee discussed these findings and considered the potential of recommending follow-up chest x-rays for higher risk populations only, particularly older people and people who smoke.

The committee reflected on existing guidance on repeat chest radiographs after pneumonia and noted that the British Thoracic Society (BTS) and the American Thoracic Society (ATS)

do not recommend routine chest radiographs in adults whose symptoms have resolved; and recommended that they are only required for patients with persistence of symptoms or patients who are at higher risk of underlying malignancy (for example, smokers and those aged >50 years). The committee concluded that the evidence did not support routine follow-up chest radiographs for all patients who had been treated in hospital for CAP. However, they agreed that follow-up imaging could be important in some circumstances, particularly for people with a higher risk of lung cancer or underlying respiratory disease such as smokers and people over 50. They also agreed that unresolved symptoms or unexplained weight loss could be indications of cancer or other underlying conditions, so people with these symptoms should also have a follow-up chest x-ray.

They discussed these higher risk groups while also considering the Targeted Lung Health Checks screening program for people aged between 55 and 74 years who are current or former smokers. The committee noted the overlap in eligible populations and expressed some concern that the groups they were recommending for follow-up chest imaging after pneumonia would also likely meet the criteria for other lung cancer screening programs. Nevertheless, they agreed that it was important to consider chest imaging for higher risk patients 6 weeks after being discharged from hospital following an episode of pneumonia as this was separate to the routine screening programme and patients may be more likely to attend.

The committee discussed hospital-acquired pneumonia and whether recommendations based on evidence for CAP would also apply to patients with HAP. They agreed that although the indications and processes involved in follow-up chest x-rays are largely the same for both conditions, they noted that patients with HAP are usually over 75, so the potential for malignancies may be higher in this group. The evidence did not report on the diagnostic yield of follow-up chest X-rays in patients with HAP, which may have been higher than the yield reported for CAP. However, they agreed that these patients would be captured by the recommendation to offer follow-up imaging to patients over 50 years so those at potentially higher risk of malignancy would receive appropriate follow-up. The committee also noted that patients with HAP may have had recent chest imaging during their prior admission for the non-pneumonia condition that resulted in their hospitalisation (during which they acquired HAP), so there may not be a requirement to perform further chest imaging in this group if previous (pre-pneumonia) imaging was normal. They therefore agreed that results of any previous imaging should be considered when deciding whether to request follow-up chest X-rays.

The committee considered the importance of shared decision making and acknowledged that some patients may not want to attend for further investigations, such as young and otherwise healthy people who feel fully recovered, or frail elderly patients where the results of further imaging would not change their treatment options or management. The committee discussed current practice and were concerned that in some areas follow-up chest X-rays were being automatically requested for all patients without consideration of clinical need and without discussion with patients. They noted the administrative burden of this. They felt that a recommendation stating that follow-up imaging is not necessary for all patients, and that

patients should be involved in decision making about follow-up care, would reduce unnecessary imaging

1.1.12.4 Cost effectiveness and resource use

No published health economic studies were identified for this review question. The committee noted that there is a lot of variation in practice around the country: there are some areas where a chest x-ray at 6 weeks is done for everyone and in other areas it is done in higher risk patients only. There is also variation in who is responsible for ensuring the chest x-ray is done: in some areas the general practitioner is responsible and in other areas the local hospital is responsible. So, the new recommendations are likely to reduce the overall number of chest x-rays that are performed, and the committee agreed that by targeting the high-risk groups, it is unlikely that those people who also have cancer will have a clinically meaningful delay in diagnosis. Therefore, the new recommendations are likely to be cost saving. There are also other benefits, such as reduced administrative burden and fewer people having to go back to the hospital for chest x-rays, so staff and equipment are freed up to do other procedures. This would also reduce costs to patients and carers in transport and time off work.

1.1.12.5 Other factors the committee took into account

The committee noted that the existing guideline recommends chest imaging for all people who are admitted with suspected pneumonia within 4 hours of admission and that this is routine practice in most places in the UK. They agreed that many abnormalities or pathologies would be noted by the reporting radiographer at this time, and if there was suspicion of an underlying pathology then this would be followed up during the person's stay in hospital or as an outpatient once they had been discharged.

The committee reflected on the overall uncertainty around follow-up imaging, both in terms of the evidence base and in terms of clinical practice, where there can be considerable variation in processes. They agreed that although the evidence had allowed them to make some recommendations about the higher risk groups who most need follow-up imaging, there remains uncertainty over the clinical and cost-effectiveness of this intervention and further research is needed. Therefore, the committee made a research recommendation.

1.1.14 References – included studies

1.1.14.1 Diagnostic yield

Bruns, Anke H W, Oosterheert, Jan Jelrik, Prokop, Mathias et al. (2007) Patterns of resolution of chest radiograph abnormalities in adults hospitalized with severe community-acquired pneumonia. Clinical infectious diseases: an official publication of the Infectious Diseases Society of America 45(8): 983-91

Gibson, N A; Hollman, A S; Paton, J Y (1993) Value of radiological follow up of childhood pneumonia. BMJ (Clinical research ed.) 307(6912): 1117

Grossman, L K, Wald, E R, Nair, P et al. (1979) Roentgenographic follow-up of acute pneumonia in children. Pediatrics 63(1): 30-1

Heaton, P and Arthur, K (1998) The utility of chest radiography in the follow-up of pneumonia. The New Zealand medical journal 111(1072): 315-7

Holmberg, H and Kragsbjerg, P (1993) Association of pneumonia and lung cancer: the value of convalescent chest radiography and follow-up. Scandinavian journal of infectious diseases 25(1): 93-100

Little, Brent P, Gilman, Matthew D, Humphrey, Kathryn L et al. (2014) Outcome of recommendations for radiographic follow-up of pneumonia on outpatient chest radiography. AJR. American journal of roentgenology 202(1): 54-9

Macdonald, C; Jayathissa, S; Leadbetter, M (2015) Is post-pneumonia chest X-ray for lung malignancy useful? Results of an audit of current practice. Internal medicine journal 45(3): 329-34

Mittl, R L Jr, Schwab, R J, Duchin, J S et al. (1994) Radiographic resolution of community-acquired pneumonia. American journal of respiratory and critical care medicine 149(3pt1): 630-5

Tang, Karen L, Eurich, Dean T, Minhas-Sandhu, Jasjeet K et al. (2011) Incidence, correlates, and chest radiographic yield of new lung cancer diagnosis in 3398 patients with pneumonia. Archives of internal medicine 171(13): 1193-8

Virkki, R, Juven, T, Mertsola, J et al. (2005) Radiographic follow-up of pneumonia in children. Pediatric pulmonology 40(3): 223-7

1.1.14.2 Economic

No studies were included.

Appendices

Appendix A – Review protocol

ID	Field	Content
1.	Review title	The impact of routine chest X-ray at 6 weeks post discharge to identify underlying disease in people who have been treated for CAP or HAP in hospital.
2.	Review question	Is a routine chest X-ray at 6 weeks post discharge an effective and cost-effective strategy to identify underlying disease in people who have been treated for community- or hospital-acquired pneumonia in hospital?
3.	Objective	To determine whether a routine chest X-ray at 6 weeks post hospital discharge is effective and cost-effective for identifying underlying disease in people treated for CAP or HAP.
4.	Searches	There will be separate searches for the effectiveness and cost effectiveness evidence. **Sources for effectiveness evidence**

		There will be a combined search for systematic reviews covering all review questions in this guideline. This 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. The following databases will be searched for the effectiveness evidence: • 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. The following sources will be applied as required to ensure relevant records are not missed: • The reference lists of potentially relevant systematic reviews will be checked.

		• The reference lists of any key potentially relevant publications will be checked where appropriate to the parameters set out in sections 6-10 below. • Later citations of any key trials or protocols identified in the search results could be checked where appropriate to the parameters set out in sections 6-10 below. • The guideline committee or other stakeholders could be asked if they are aware of any other relevant studies that could be considered. The searches for effectiveness evidence will not have any date limits applied. **Sources 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). **Managing search results** Database functionality will be used, where available, to exclude from all searches: • Animal studies • Editorials, letters, news items and commentaries • Conference abstracts and posters • Registry entries for ongoing clinical trials or those that contain no results • Theses and dissertations • Papers not published in the English language. 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]).

		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	Inclusion: People diagnosed with CAP or HAP who received inpatient treatment and are 6 weeks post discharge. • CAP is defined as pneumonia that is acquired outside hospital • HAP is defined as pneumonia that occurs 48 hours or more after hospital admission and is not incubating at hospital admission (inclusion criterion). • Population includes adults (≥18 years) and babies (1 year and under), children (up to 12 years) and young people (between 12 and 17 years).

		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. • People who already have a diagnosis of lung cancer

7.	Intervention/Exposure/Test	Repeat chest X-ray approximately 6 weeks post hospital discharge (range 4-8 weeks).
8.	Comparator	N/A
9.	Types of study to be included	• Cross-sectional studies • Prospective and retrospective cohort studies
10.	Other exclusion criteria	
11.	Context	Currently, people who have been treated in hospital for CAP or HAP are offered a 6-week follow-up chest X-ray. These are done to check for resolution of the pneumonia and also to find underlying pathologies that may have contributed to the pneumonia or may have been missed due to consolidation. There is uncertainty about whether it is effective and cost-effective to offer this routinely to all people who have been hospitalised with pneumonia, or whether it should only be offered to specific groups, such as those with unresolved symptoms, or other risk factors (such as age >50 years and smokers). This review aims to identify the number of malignancies, other non-malignant conditions, or congenital abnormalities detected

		through routine follow-up X-rays and to determine the most effective and cost-effective approach to follow-up screening.
12.	Primary outcomes (critical outcomes)	• Rate of detection of malignancies (e.g. lung cancer, other cancer) • Rate of detection of non-malignant conditions such as pulmonary empyema or other underlying disease (e.g. TB) • Rate of detection of congenital abnormalities
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 6.2). Study investigators may be contacted for missing data where time and resources allow.

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 observational studies, the Cochrane ROBINS-I tool will be the preferred tool. The CASP cohort study checklist will be used if ROBINS-I is not appropriate.
16.	Strategy for data synthesis	Where possible, we will calculate a weighted mean and 95% confidence interval for each outcome and will perform a meta-analyses of these when the same outcome is reported by more than one study, with reference to the Cochrane Handbook for Systematic Reviews of Interventions. Where data can be disambiguated it will be separated into the subgroups identified in section 17 (below). Fixed- and random-effects models (der Simonian and Laird) will be fitted for all comparators, with the presented analysis dependent on the degree of heterogeneity in the assembled evidence. Fixed-effects models will be deemed to be inappropriate if one or both of the following conditions is met:

		• Significant between study heterogeneity in methodology, population, intervention or comparator was identified by the reviewer in advance of data analysis. • The presence of significant statistical heterogeneity in the meta-analysis, defined as $I^2 \geq 50\%$. 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. All outcomes in this review will be rated as high quality initially and downgraded from this point. 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. Minimally important differences (MIDs) will be discussed with the committee and if established MIDs are not identified, default MIDs will be used. These are 0.80 and

		1.25 for dichotomous outcomes, and 0.5 times the control group SD for continuous outcomes.
17.	Analysis of sub-groups	Where data is available, pre-planned analysis of subgroups will be conducted for: • CAP and HAP • Adults (≥18 years) and CYP (<18 years) • Age for under 18 year olds: <1 year, 1 to ≤5 years, >5 to ≤12 years, >12 to <18 years. • Presence of risk factors (over 50 years; smokers) • Ongoing symptoms vs symptom resolution • People with certain inclusion health characteristics, including homeless people, and injection drug users.
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 Adviser • Hannah Stockton, Technical Analyst • Steph Armstrong, Senior Health Economist • Eric Slade, Health Economic Adviser • 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, repeat chest X-ray, resolution of symptoms, lung malignancies, non-malignant respiratory conditions.
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

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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 potentially relevant results from this search were 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 23 November 2023.

- 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. All translated search strategies were peer reviewed by another SIS to ensure their accuracy. Both 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).

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

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 Effectiveness (Part 2) and 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) 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.

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) were not date limited as this was a new question that had not been covered in the earlier guidelines.

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) had no filters, as the protocol required systematic reviews, randomised clinical trials, RCTs, cross-sectional studies and cohort studies.

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.

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.

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

Part 2: Diagnostic evidence searches

The search was done in this structure:

Pneumonia AND X-rays AND (Post-discharge OR (Lung Conditions AND Diagnosis))

A more conventional arrangement was tested:

Pneumonia AND X-rays AND Post-discharge AND (Lung Conditions AND Diagnosis)

This approach was chosen as there was a risk of missing some of the test set with the conventional approach. This means the search is essentially looking for two different things: any post-discharge x-ray studies (including those testing whether pneumonia itself is relapsing, remitting or unresolved); and any x-ray studies that detect malignancy or other relevant conditions, whether that x-ray is done before or after treatment. The testing showed that both of these approaches were necessary, as not all the papers referred to both elements.

The base papers listed in the table for forwards citation searching and reference checking were used as a test set for the effectiveness search. Their MeSH terms were assessed with the Yale MeSH Analyzer.

The imaging terms were derived from a NICE QAed search written in July 2022 for externally commissioned work on imaging to detect ingested foreign bodies.

The list of related conditions that might be detected by a post-pneumonia x-ray (see lines 32-33 in MEDLINE) were derived from consulting with the technical team. The line was not intended to be a comprehensive list of conditions as the search also has the other component covering x-rays for any post-discharge outcomes. The terms were derived from discussions at the first committee meeting in November 2023 and from clinical advice during scoping (December 2022) that stated lower respiratory tract infections are illnesses that predominantly affect the respiratory tree below the larynx and where the infecting organism is relevant to the pneumonia scope.

The CENTRAL strategy is a direct translation of the MEDLINE strategy.

The Embase strategy had to be adapted to make it appropriate for the size of that database and the way it is indexed. The Emtree heading for X-rays and Follow Up were focussed, in order to reduce the total number of results from 2800 to 1700. A version without the focussed headings was run and none of the first 100 results that would be missed by running the more precise version were at all relevant. The more precise search still retrieved all five test papers in the test set.

Part 1: Systematic review searches

Database results

Databases	Date searched	Database platform	Database segment or version	No. of results downloaded
Cochrane Database of Systematic	20/11/2023	Wiley	Cochrane Database of Systematic Reviews Issue	177

Databases	Date searched	Database platform	Database segment or version	No. of results downloaded
Reviews (CDSR)			11 of 12, November 2023	
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
#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")

Searches
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))
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

Searches
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 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)	23/11/2023	Wiley	Cochrane Central Register of Controlled Trials, Issue 10 of 12, October 2023	50
Embase	23/11/2023	Ovid	Embase 1974 to 2023 November 22	1662
MEDLINE ALL	23/11/2023	Ovid	Ovid MEDLINE(R) ALL 1946 to November 22, 2023	1153

Additional search techniques

Databases	Date searched	Database platform	Database segment or version	No. of results downloaded
Forward citation searching	22/11/2023	Web of Science (WOS) Core Collection (1990-present)	Data updated 2023-11-19	74
Reference list checking	22/11/2023	Web of Science (WOS) Core Collection (1990-present)	Data updated 2023-11-19	41

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, 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
#3	#1 or #2 16754
#4	[mh ^X-Rays] 80

Searches
#5 [mh ^Radiography] 5253
#6 [mh ^"radiography, thoracic"] 390
#7 [mh ^"Radiographic Image Interpretation, Computer-Assisted"] 494
#8 ((x NEXT ray*) or xray* or (grenz NEXT ray*) or radiogra* or roent* or (x NEXT radiat*) or xradiat* or CXR):ti,ab 37344
#9 {or #4-#8} 40589
#10 #3 and #9 1292
#11 [mh ^"Patient Discharge"] 2291
#12 [mh ^"Aftercare"] 1060
#13 [mh ^"Patient Readmission"] 1393
#14 [mh ^"Convalescence"] 419
#15 [mh ^"Breakthrough Infections"] 4
#16 (postdischarge* or posthospital* or (post NEXT hospital*) or discharging* or convalescen* or aftercare* or (after NEXT care*)):ti,ab 6802
#17 ((hospital* or patient* or treatment* or therap* or care* or intervention*) NEAR/2 discharge*):ti,ab 17632
#18 (postpneumonia or postpneumonias or postbronchopneumon* or postpleuropneumon* or "post pneumonia" or "post pneumonias" or (post NEXT bronchopneumon*) or (post NEXT pleuropneumon*)):ti,ab 0
#19 (followup* or (follow NEXT up*)):ti 20236
#20 ((followup* or (follow NEXT up*)) NEAR/1 (patient* or treatment* or therap* or care* or intervention* or imaging* or diagnos* or assess* or scan* or (x NEXT ray*) or xray* or (grenz NEXT ray*) or radiogra* or roent* or (x NEXT radiat*) or xradiat* or CXR)):ab 17576
#21 ((after* or post* or follow* or subsequent*) NEAR/2 (clinical* or disease* or symptom* or condition*) NEAR/2 (cure* or resolution* or resolved*)):ti,ab 257
#22 {or #11-#21} 60123
#23 #10 and #22 162
#24 [mh ^"Early Detection of Cancer"] 2055
#25 [mh ^"Incidental Findings"] 45
#26 [mh "Diagnostic Errors"] 3462
#27 [mh ^"Delayed diagnosis"] 47
#28 [mh ^"diagnosis, differential"] 1712
#29 ((diagnos* or misdiagnos*) NEAR/2 (miss* or early* or delay* or late* or error* or mistake* or differentia* or value*)):ti,ab 6536
#30 (Incidental* NEAR/2 (discover* or finding* or diagnos* or detect* or misdiagnos* or identif*)):ti,ab 325
#31 {or #24-#30} 13410
#32 [mh "respiratory tract neoplasms"] or [mh ^"lymphoma, primary effusion"] or [mh ^"bronchiectasis"] or [mh ^"empyema, pleural"] or [mh ^"empyema, tuberculous"] or [mh ^"lung abscess"] or [mh ^"pleurisy"] or [mh ^"tuberculosis"] or [mh ^"tuberculosis, pulmonary"] or [mh "legionellosis"] or [mh "pleural effusion"] or [mh ^"pulmonary edema"] or [mh ^"respiratory tract fistula"] or [mh ^"respiratory tract infections"] or [mh bronchiolitis] or [mh ^"whooping cough"] 19272
#33 (neoplasm* or neoplasia* or cancer* or carcinoma* or adenocarcinoma* or carcinogenesis* or tumour* or tumor* or metast* or malignan* or adenoma* or lymphoma* or sarcoma* or abscess* or consolidation* or LRTI or Bronchiectasis* or Empyema* or Pleurisy* or Tuberculosis* or TB or Legionellosis* or Legionnaire* or effusion* or oedema*

Searches
or edema* or fistula* or bronchiolitis* or pertussis* or whooping* or ("lower respiratory tract" NEXT infection*)):ti 192626
#34 #32 or #33 198635
#35 #31 and #34 3668
#36 ((discover* or diagnos* or detect* or misdiagnos* or identif* or undiagnos*) and (neoplasm* or neoplasia* or cancer* or carcinoma* or adenocarcinoma* or carcinogenesis* or tumour* or tumor* or metast* or malignan* or adenoma* or lymphoma* or sarcoma* or abscess* or consolidation* or LRTI or Bronchiectasis* or Empyema* or Pleurisy* or Tuberculosis* or TB or Legionellosis* or Legionnaire* or effusion* or oedema* or edema* or fistula* or bronchiolitis* or pertussis* or whooping* or ("lower respiratory tract" NEXT infection*))):ti 6948
#37 ((discover* or diagnos* or detect* or misdiagnos* or identif* or undiagnos*) NEAR/5 (neoplasm* or neoplasia* or cancer* or carcinoma* or adenocarcinoma* or carcinogenesis* or tumour* or tumor* or metast* or malignan* or adenoma* or lymphoma* or sarcoma* or abscess* or consolidation* or LRTI or Bronchiectasis* or Empyema* or Pleurisy* or Tuberculosis* or TB or Legionellosis* or Legionnaire* or effusion* or oedema* or edema* or fistula* or bronchiolitis* or pertussis* or whooping* or ("lower respiratory tract" NEXT infection*))):ab 30127
#38 #35 or #36 or #37 34925
#39 #10 and #38 59
#40 #23 or #39 214
#41 #23 or #39 in Trials 207
#42 ((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 492331
#43 #41 not #42 65
#44 "conference":pt 226843
#45 #43 not #44 50

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 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/ 315066
2 (pneumonia or pneumonias or bronchopneumon* or pleuropneumon*).ti,ab. 232774
3 1 or 2 396131
4 *X ray/ 18237
5 *radiography/ 21252
6 *radiodiagnosis/ 9532

Searches
7 *thorax radiography/ 21163
8 *computer assisted radiography/627
9 (x ray* or xray* or grenz ray* or radiogra* or roent* or x radiat* or xradiat* or CXR).ti,ab. 807371
10 or/4-9 835938
11 3 and 10 27614
12 hospital discharge/ 188789
13 aftercare/ 8109
14 *follow up/ 58878
15 hospital readmission/ 101324
16 convalescence/ 58517
17 breakthrough infection/ 1708
18 (postdischarge* or posthospital* or "post hospital*" or discharging* or convalescen* or aftercare* or "after care*").ti,ab. 51925
19 ((hospital* or patient* or treatment* or therap* or care* or intervention*) adj2 discharge*).ti,ab. 168134
20 (postpneumonia or postpneumonias or postbronchopneumon* or postpleuropneumon* or "post pneumonia" or "post pneumonias" or "post bronchopneumon*" or "post pleuropneumon*").ti,ab. 88
21 (followup* or follow up*).ti. 163990
22 ((followup* or follow up*) adj1 (patient* or treatment* or therap* or care* or intervention* or imaging* or diagnos* or assess* or scan* or x ray* or xray* or grenz ray* or radiogra* or roent* or x radiat* or xradiat* or CXR)).ab. 100997
23 ((after* or post* or follow* or subsequent*) adj2 (clinical* or disease* or symptom* or condition*) adj2 (cure* or resolution* or resolved*)).ti,ab. 4765
24 or/12-23 702697
25 11 and 24 2213
26 early cancer diagnosis/ 14040
27 incidental finding/ 24165
28 diagnostic error/ or missed diagnosis/ 73031
29 delayed diagnosis/ 18506
30 differential diagnosis/ 375939
31 diagnostic value/ 221249
32 ((diagnos* or misdiagnos*) adj2 (miss* or early* or delay* or late* or error* or mistake* or differentia* or value*)).ti,ab. 541791
33 (Incidental* adj2 (discover* or finding* or diagnos* or detect* or misdiagnos* or identif*)).ti,ab. 42442
34 or/26-33 1054438
35 respiratory tract tumor/ or respiratory tract cancer/ or respiratory tract carcinoma/ or respiratory tract sarcoma/ or exp lung tumor/ or exp pleura tumor/ or primary effusion lymphoma/ or bronchiectasis/ or empyema/ or exp pleura empyema/ or lung abscess/ or exp pleurisy/ or lung tuberculosis/ or tuberculosis/ or legionellosis/ or legionnaire disease/ or pleura effusion/ or lung edema/ or respiratory tract fistula/ or bronchopleural fistula/ or bronchus fistula/ or lower respiratory tract infection/ or exp bronchiolitis/ or pertussis/ 885739
36 (neoplasm* or neoplasia* or cancer* or carcinoma* or adenocarcinoma* or carcinogenesis* or tumour* or tumor* or metast* or malignan* or adenoma* or lymphoma* or sarcoma* or abscess* or consolidation* or LRTI or Bronchiectasis* or Empyema* or

Searches
Pleurisy* or Tuberculosis* or TB or Legionellosis* or Legionnaire* or effusion* or oedema* or edema* or fistula* or "lower respiratory tract infection*" or bronchiolitis* or pertussis* or whooping*).ti. 3827785
37 or/35-36 4171904
38 34 and 37 256379
39 ((discover* or diagnos* or detect* or misdiagnos* or identif* or undiagnos*) and (neoplasm* or neoplasia* or cancer* or carcinoma* or adenocarcinoma* or carcinogenesis* or tumour* or tumor* or metast* or malignan* or adenoma* or lymphoma* or sarcoma* or abscess* or consolidation* or LRTI or Bronchiectasis* or Empyema* or Pleurisy* or Tuberculosis* or TB or Legionellosis* or Legionnaire* or effusion* or oedema* or edema* or fistula* or "lower respiratory tract infection*" or bronchiolitis* or pertussis* or whooping*)).ti. 289356
40 ((discover* or diagnos* or detect* or misdiagnos* or identif* or undiagnos*) adj5 (neoplasm* or neoplasia* or cancer* or carcinoma* or adenocarcinoma* or carcinogenesis* or tumour* or tumor* or metast* or malignan* or adenoma* or lymphoma* or sarcoma* or abscess* or consolidation* or LRTI or Bronchiectasis* or Empyema* or Pleurisy* or Tuberculosis* or TB or Legionellosis* or Legionnaire* or effusion* or oedema* or edema* or fistula* or "lower respiratory tract infection*" or bronchiolitis* or pertussis* or whooping*)).ab. 954960
41 or/38-40 1213724
42 11 and 41 4476
43 25 or 42 6350
44 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 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/ 1717716
45 exp "organisation for economic co-operation and development"/ 2776
46 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/

Searches		
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/		3803208
47	european union/	31510
48	developed country/	35737
49	or/45-48	3836988
50	44 not 49	1563528
51	43 not 50	5972
52	limit 51 to english language	5279
53	(letter or editorial).pt.	2083575
54	52 not 53	5251
55	Case report/	2940832
56	54 not 55	3017
57	nonhuman/ not human/	5329071
58	56 not 57	2954
59	(conference abstract* or conference review or conference paper or conference proceeding).db,pt,su.	5746571
60	58 not 59	1662

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/	125256
2	(pneumonia or pneumonias or bronchopneumon* or pleuropneumon*).ti,ab.	159602
3	or/1-2	229588
4	X-Rays/	32075
5	Radiography/	328061
6	radiography, thoracic/	33547
7	Radiographic Image Interpretation, Computer-Assisted/	16023
8	(x ray* or xray* or grenz ray* or radiogra* or roent* or x radiat* or xradiat* or CXR).ti,ab.	703670
9	or/4-8	981304
10	3 and 9	17796
11	Patient Discharge/	40452
12	Aftercare/	13382
13	Patient Readmission/	23138
14	Convalescence/	3983
15	Breakthrough Infections/	228

Searches
16 (postdischarge* or posthospital* or "post hospital*" or discharging* or convalescen* or aftercare* or "after care*").ti,ab. 41106
17 ((hospital* or patient* or treatment* or therap* or care* or intervention*) adj2 discharge*).ti,ab. 94851
18 (postpneumonia or postpneumonias or postbronchopneumon* or postpleuropneumon* or "post pneumonia" or "post pneumonias" or "post bronchopneumon*" or "post pleuropneumon*").ti,ab. 53
19 (followup* or follow up*).ti. 120575
20 ((followup* or follow up*) adj1 (patient* or treatment* or therap* or care* or intervention* or imaging* or diagnos* or assess* or scan* or x ray* or xray* or grenz ray* or radiogra* or roent* or x radiat* or xradiat* or CXR)).ab. 61206
21 ((after* or post* or follow* or subsequent*) adj2 (clinical* or disease* or symptom* or condition*) adj2 (cure* or resolution* or resolved*)).ti,ab. 3047
22 or/11-21 351443
23 10 and 22 696
24 Early Detection of Cancer/ 38718
25 Incidental Findings/ 11811
26 exp Diagnostic Errors/ 122779
27 Delayed diagnosis/ 8470
28 diagnosis, differential/ 468793
29 ((diagnos* or misdiagnos*) adj2 (miss* or early* or delay* or late* or error* or mistake* or differentia* or value*)).ti,ab. 387052
30 (Incidental* adj2 (discover* or finding* or diagnos* or detect* or misdiagnos* or identif*)).ti,ab. 27894
31 or/24-30 939749
32 exp respiratory tract neoplasms/ or lymphoma, primary effusion/ or bronchiectasis/ or empyema, pleural/ or empyema, tuberculous/ or lung abscess/ or pleurisy/ or tuberculosis/ or tuberculosis, pulmonary/ or exp legionellosis/ or exp pleural effusion/ or pulmonary edema/ or respiratory tract fistula/ or respiratory tract infections/ or exp bronchiolitis/ or whooping cough/ 616298
33 (neoplasm* or neoplasia* or cancer* or carcinoma* or adenocarcinoma* or carcinogenesis* or tumour* or tumor* or metast* or malignan* or adenoma* or lymphoma* or sarcoma* or abscess* or consolidation* or LRTI or Bronchiectasis* or Empyema* or Pleurisy* or Tuberculosis* or TB or Legionellosis* or Legionnaire* or effusion* or oedema* or edema* or fistula* or "lower respiratory tract infection*" or bronchiolitis* or pertussis* or whooping*).ti. 3070029
34 or/32-33 3279600
35 31 and 34 226818
36 ((discover* or diagnos* or detect* or misdiagnos* or identif* or undiagnos*) and (neoplasm* or neoplasia* or cancer* or carcinoma* or adenocarcinoma* or carcinogenesis* or tumour* or tumor* or metast* or malignan* or adenoma* or lymphoma* or sarcoma* or abscess* or consolidation* or LRTI or Bronchiectasis* or Empyema* or Pleurisy* or Tuberculosis* or TB or Legionellosis* or Legionnaire* or effusion* or oedema* or edema* or fistula* or "lower respiratory tract infection*" or bronchiolitis* or pertussis* or whooping*)).ti. 228547
37 ((discover* or diagnos* or detect* or misdiagnos* or identif* or undiagnos*) adj5 (neoplasm* or neoplasia* or cancer* or carcinoma* or adenocarcinoma* or carcinogenesis* or tumour* or tumor* or metast* or malignan* or adenoma* or lymphoma* or sarcoma* or abscess* or consolidation* or LRTI or Bronchiectasis* or Empyema* or Pleurisy* or Tuberculosis* or TB or Legionellosis* or Legionnaire* or effusion* or oedema* or edema* or

Searches		
fistula* or "lower respiratory tract infection*" or bronchiolitis* or pertussis* or whooping*)).ab.		629820
38	35 or 36 or 37	873480
39	10 and 38	2263
40	23 or 39	2883
41	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 "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/		1314562
42	"organisation for economic co-operation and development"/	568
43	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/		3517005
44	european union/	17819
45	developed countries/	21445
46	or/42-45	3533112
47	41 not 46	1224433
48	40 not 47	2703
49	limit 48 to english language	1933
50	limit 49 to (letter or historical article or comment or editorial or news or case reports)	754
51	49 not 50	1179
52	Animals/ not (Animals/ and Humans/)	5139672
53	51 not 52	1153

Additional search techniques

Forward citation searching and reference list checking

Date of search	22 November 2023
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	Cao was identified from the search for Systematic Reviews (Part 1). Heaton was identified in the December 2022 scoping searches. The other papers were identified by the technical team after the first committee meeting.
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 (2015-present)
Date of last update	19 November 2023
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	Reviewed on screen in WOS for potential relevance after excluding methods guides, background info and epidemiology. Only included pneumonia i.e. excluded COVID-19 and other conditions listed in the protocol as out of scope. Only included OECD countries.
List of seed papers used	Cao AM et al. (2013) Chest radiographs for acute lower respiratory tract infections. *Cochrane Database of Systematic Reviews*, 2013(12), CD009119. Heaton P & Arthur K (1998) The utility of chest radiography in the follow-up of pneumonia. New Zealand Medical Journal, 111(1072), 315-7.

	Holmberg H & Kragsbjerg P. (1993) Association of pneumonia and lung cancer: the value of convalescent chest radiography and follow-up. *Scandinavian Journal of Infectious Diseases*, *25*(1), 93–100. Little BP et al. (2014) Outcome of recommendations for radiographic follow-up of pneumonia on outpatient chest radiography. *AJR. American Journal of Roentgenology*, *202*(1), 54–59. Macdonald C et al. (2015) Is post-pneumonia chest X-ray for lung malignancy useful? Results of an audit of current practice. *Internal Medicine Journal*, *45*(3), 329–334. Tang KL et al. (2011) Incidence, correlates, and chest radiographic yield of new lung cancer diagnosis in 3398 patients with pneumonia. *Archives of Internal Medicine*, 171(13), 1193–1198.
No. of forward citation searching results	74
No. of reference list checking results	41

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
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 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

Searches
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 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

Searches
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
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

Searches
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 "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/

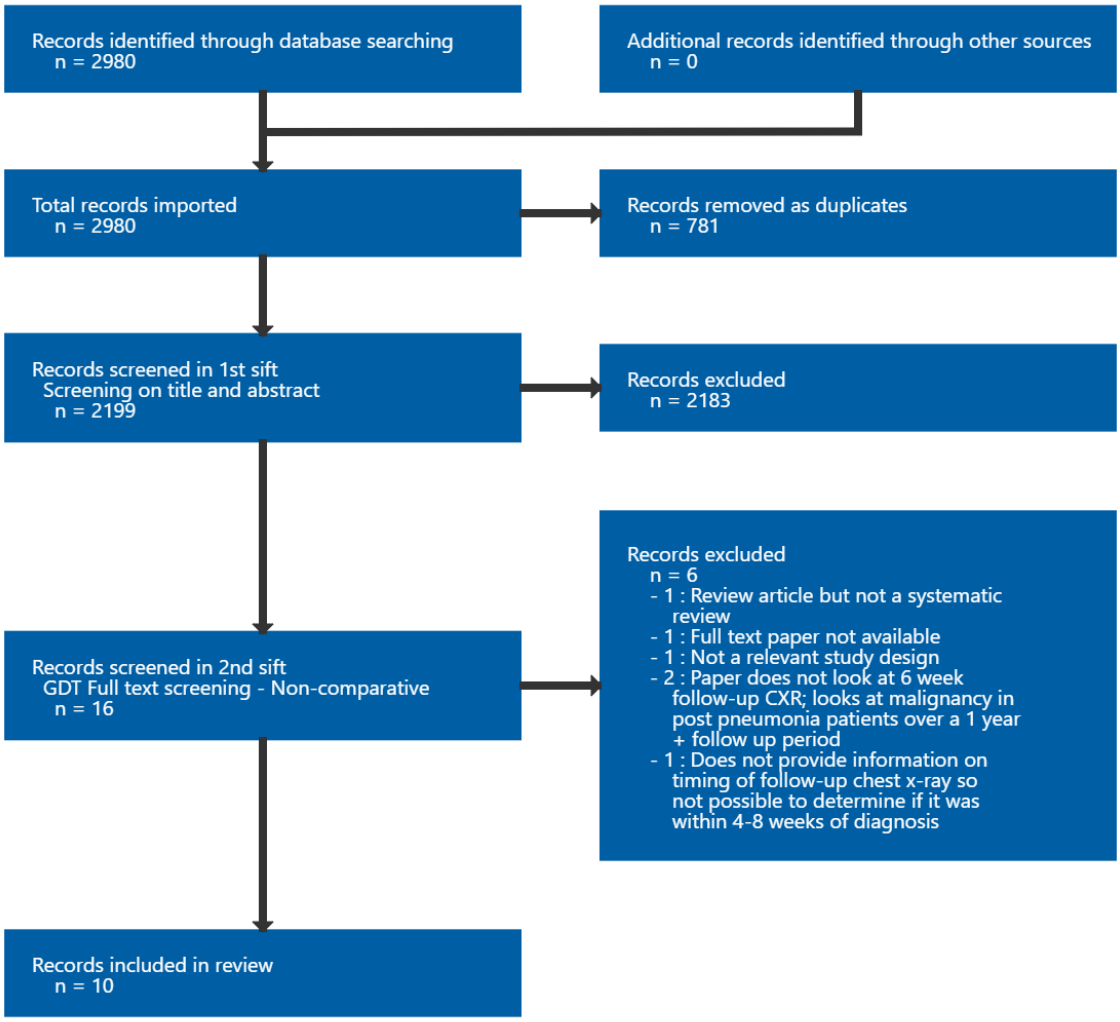
Searches
or suriname/ or syria/ or taiwan/ or tajikistan/ or tanzania/ or thailand/ or timor-leste/ or togo/ or tonga/ or "trinidad and tobago"/ or tunisia/ or turkmenistan/ or uganda/ or ukraine/ or united arab emirates/ or uruguay/ or uzbekistan/ or vanuatu/ or venezuela/ or vietnam/ or west indies/ 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

Searches
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 yield evidence study selection



Appendix D – Diagnostic yield evidence

Bruns, 2007

Bibliographic Reference	Bruns, Anke H W; Oosterheert, Jan Jelrik; Prokop, Mathias; Lammers, Jan-Willem J; Hak, Eelko; Hoepelman, Andy I M; Patterns of resolution of chest radiograph abnormalities in adults hospitalized with severe community-acquired pneumonia.; Clinical infectious diseases : an official publication of the Infectious Diseases Society of America; 2007; vol. 45 (no. 8); 983-91

Study Characteristics

Study type	Prospective cohort study Patients hospitalised because of severe CAP were followed up for 28 days in a prospective multicentre study. Chest radiographs were obtained at hospital admission and at days 7 and 28, in order to study the time to resolution of pulmonary infiltrates and other chest radiograph abnormalities caused by pneumonia.
Study details	Study location: The Netherlands Study setting: University Medical Centre Study dates: July 2000 to June 2003 Sources of funding: Not reported
Inclusion criteria	Adult patients (≥18 years) admitted to hospital for severe CAP (severe CAP defined as PSI score >90 or according to the American Thoracic society definition).
Exclusion criteria	Patients who were subsequently diagnosed with a condition other than CAP; patients with interstitial pneumonia.
Length of follow-up	28 days
Loss to follow-up	Of 288 patients recruited at admission, chest radiographs were obtained for 195 (67.7%) on day 28.
Outcome (s)	Radiological resolution

Population characteristics

Study-level characteristics

Characteristic	Study (N = 288)
Male No of events	n = 190 ; % = 66

Characteristic	Study (N = 288)
Female No of events	n = 98 ; % = 34
Age range Range	20 to 95
Mean age (SD) Mean (SD)	69.7 (13.9)
PSI score Range	33 to 217
PSI score Mean (SD)	112.8 (39.2)
PSI score >90 No of events	n = 248 ; % = 86.1
Comorbidity No of events	n = 154 ; % = 53.5
Chronic heart failure No of events	n = 34 ; % = 11.8
Neoplasm No of events	n = 65 ; % = 22.6
Cerebrovascular disease No of events	n = 25 ; % = 8.7
Renal disease No of events	n = 27 ; % = 9.4

Critical appraisal - ROBINS-I: a tool for non-randomised studies of interventions

Section	Question	Answer
Overall bias	Risk of bias judgement	Serious *Patients that received a follow-up chest x-ray were different from patients who did not, on important characteristics that may have influenced the outcome (pneumonia severity, age, and history of heart disease), and these differences could not*

Section	Question	Answer
		be controlled for in the analyses. The radiologists that interpreted the radiographs were provided with information on the patient's clinical condition, which could possibly have influenced their interpretation of radiographic resolution, but this is unlikely.
Overall bias	Directness	Directly applicable *Study sample and setting matches those defined in the protocol*

Gibson, 1993

Bibliographic Reference	Gibson, N A; Hollman, A S; Paton, J Y; Value of radiological follow up of childhood pneumonia.; BMJ (Clinical research ed.); 1993; vol. 307 (no. 6912); 1117

Study Characteristics

Study type	Patient records audit
Study details	Study location: Not reported, but all authors were from Royal Hospital for Sick Children, Glasgow. Study setting: Children's hospital Study dates: Not reported Sources of funding: Not reported
Inclusion criteria	Children with chest radiographs showing opacification consistent with pneumonic consolidation and repeat radiographs 3-4 weeks after discharge from hospital
Exclusion criteria	Children with asthmatic attacks, compromised immunity, or pre-existing disease
Length of follow-up	3 to 4 weeks
Loss to follow-up	5 of 77 (6.5%) children defaulted from follow-up
Outcome (s)	Radiological resolution 56 / 72 children showed complete radiological resolution

Population characteristics

Study-level characteristics

Characteristic	Study (N = 77)
Median age	4 years

Characteristic	Study (N = 77)
Age range Range	2 months to 12 years
Intravenous antibiotic (usually co-amoxiclav) No of events	n = 52 ; % = 67.5
Oral antibiotic (mostly erythromycin or co-amoxiclav) No of events	n = 25 ; % = 32.5

Critical appraisal - ROBINS-I: a tool for non-randomised studies of interventions

Section	Question	Answer
Overall bias	Risk of bias judgement	Low
Overall bias	Directness	Directly applicable *Study sample and setting matches those defined in the protocol*

Grossman, 1979

Bibliographic Reference	Grossman, L K; Wald, E R; Nair, P; Papiez, J; Roentgenographic follow-up of acute pneumonia in children.; Pediatrics; 1979; vol. 63 (no. 1); 30-1

Study Characteristics

Study type	Patient records audit Prospective study evaluating the results of routine follow-up chest X-rays 3-4 weeks after initial diagnosis of acute pneumonia in children
Study details	Study location: US Study setting: Children's hospital Study dates: December 1975 to April 1977 Sources of funding: Not reported
Inclusion criteria	Patients aged 6 weeks to 15 years with acute onset of pneumonia, diagnosed based on the presence of infiltration on posteroanterior and lateral chest films.
Exclusion criteria	Patients with known chronic pulmonary diseases such as asthma and cystic fibrosis; patients with sickle cell anaemia, known

	immunodeficiency syndromes, or history of recurrent or persistent pneumonia
Length of follow-up	3 to 4 weeks after diagnosis
Loss to follow-up	129 children were enrolled in the study; 70 (54%) attended for follow-up chest x-ray within a 3 to 4 week period after diagnosis.
Outcome (s)	Radiological resolution

Population characteristics

Study-level characteristics

Characteristic	Study (N = 129)
Age Range	6 weeks to 15 years

Critical appraisal - ROBINS-I: a tool for non-randomised studies of interventions

Section	Question	Answer
Overall bias	Risk of bias judgement	Low
Overall bias	Directness	Partially Applicable *Unclear whether patients were hospitalised or treated as outpatients.*

Heaton, 1998

Bibliographic Reference	Heaton, P; Arthur, K; The utility of chest radiography in the follow-up of pneumonia.; The New Zealand medical journal; 1998; vol. 111 (no. 1072); 315-7

Study Characteristics

Study type	Patient records audit Examined case records of all paediatric admissions for pneumonia over one year
Study details	Study location: New Zealand Study setting: District general hospital Study dates: January 1996 to December 196

	Sources of funding: Not reported
Inclusion criteria	Children aged between 6 weeks and 15 years, diagnosed with CAP, without underlying immune deficiency, cardiac disease or bronchopulmonary dysplasia
Length of follow-up	In 31/41 cases follow-up was between 4 and 6 weeks after discharge; in 5/41 cases follow-up was less than 4 weeks; and in 5 cases follow-up was more than 6 weeks.
Loss to follow-up	Of 65 initial chest radiographs, follow-up was requested in 54 cases, of whom 41 (76%) attended - 10 did not attend and 3 attended a different medical facility.
Outcome (s)	Radiological resolution

Population characteristics

Study-level characteristics

Characteristic	**Study (N = 65)**
Male No of events	n = 38 ; % = 58
Female No of events	n = 27 ; % = 42
Age range Range	5 years to 13 years
Mean age (SD) (years) Mean (SD)	3.5 (not reported)
History of asthma No of events	n = 22 ; % = 34
Length of hospital stay (days) Range	1 to 11
Length of hospital stay (days) Mean (SD)	2.6 (not reported)
Intravenous antibiotics No of events	n = 46
Oral antibiotics No of events	n = 15

Critical appraisal - ROBINS-I: a tool for non-randomised studies of interventions

Section	Question	Answer
Overall bias	Risk of bias judgement	Low
Overall bias	Directness	Directly applicable *Study sample and setting matches those defined in the protocol*

Holmberg, 1993

Bibliographic Reference	Holmberg, H; Kragsbjerg, P; Association of pneumonia and lung cancer: the value of convalescent chest radiography and follow-up.; Scandinavian journal of infectious diseases; 1993; vol. 25 (no. 1); 93-100

Study Characteristics

Study type	Patient records audit Retrospectively studied all medical records from patients with pneumonia admitted to the hospital during 1981-1985.
Study details	Study location: Sweden Study setting: Hospital Study dates: 1981 to 1985 Sources of funding: Not reported
Inclusion criteria	Adult patients diagnosed with pneumonia, x-rayed on admission, and receiving convalescent chest x-ray at 1-2 month follow-up
Exclusion criteria	Severe chronic debilitating disease resulting in multiple episodes of pneumonia (e.g. multiple sclerosis, muscular dystrophy); age <15 years
Length of follow-up	1-2 months after hospital admission for pneumonia
Loss to follow-up	During the eligible study period, there were 1201 admissions with a diagnosis of pneumonia. Medical records of 24 of these patients were not found. Another 138 admissions were excluded for not meeting inclusion criteria, including incorrect diagnosis (n=59), no x-ray was performed (n=15), or age <15 years (n=19). The remaining study group consisted of 1011 admissions. Convalescent chest X-ray was not performed in 333/1011 patients for the following reasons: death during hospitalization (n = 73), X-ray

	during hospitalisation showed regression of infiltrates (n = 24), follow-up at another hospital department was planned (n = 146), only a clinical follow-up was planned (n = 21), and 9 patients declined any follow-up. In 60 patients no reason for omission of follow-up was given in the medical records. Therefore, of 1011 patients, 678 were followed-up with convalescent chest x-ray 1-2 months after admission.
Outcome (s)	Malignancy 13 new cases of pulmonary carcinoma were found among the 1011 patients with pneumonia - 8 of these were detected at the acute x-ray (at admission) and one was detected during autopsy in a patient who died 9 days after admission. 4 cases were detected at convalescent x-ray. So of 678 patients who underwent follow-up chest radiography 1-2 months after acute onset of pneumonia, 4 (0.58%) had pulmonary carcinoma indicated by the findings of convalescent chest x-ray. Important benign diagnosis No tuberculous infection or other significant disease, except 1 case of anthracosis, was found on any of the 678 convalescent X-rays.

Population characteristics

Study-level characteristics

Characteristic	Study (N = 1011)
Male No of events	n = 544
Female No of events	n = 467
Age range	15 years to 97 years
Mean age (SD) Mean (SD)	66 (not reported)
Number of patients > 55 years No of events	% = 76

Critical appraisal - ROBINS-I: a tool for non-randomised studies of interventions

Section	Question	Answer
Overall bias	Risk of bias judgement	Low
Overall bias	Directness	Directly applicable *Study sample and setting matches those defined in the protocol*

Little, 2014

Bibliographic Reference	Little, Brent P; Gilman, Matthew D; Humphrey, Kathryn L; Alkasab, Tarik K; Gibbons, Fiona K; Shepard, Jo-Anne O; Wu, Carol C; Outcome of recommendations for radiographic follow-up of pneumonia on outpatient chest radiography.; AJR. American journal of roentgenology; 2014; vol. 202 (no. 1); 54-9

Study Characteristics

Study type	Patient records audit Retrospective review of all chest radiography examinations performed during a 1 year study period to identify cases where the interpreting radiologist recommended follow-up chest radiography to ensure resolution of radiographically suspected pneumonia.
Study details	Study location: US Study setting: Academic medical centre Study dates: Data collected from 2008 records Sources of funding: Not reported
Inclusion criteria	Follow-up chest radiography to ensure resolution of radiographically suspected pneumonia.
Exclusion criteria	Index radiography examinations with findings that the interpreting radiologist thought were highly suspicious for cancer or recommended immediate investigation
Length of follow-up	Reports of all chest radiography and all chest CT examinations performed during the follow-up period (January 2008–January 2010) were reviewed. Follow-up time frame not reported but mean time 78 days, median 41 days, 60% of patients within 90 days.
Loss to follow-up	618 of 805 (77%) patients for whom follow-up radiography was recommended underwent follow-up imaging .

	Patients without follow-up imaging were younger (mean, 54 years; median, 55 years) than patients with follow-up imaging (mean, 63 years; median, 64 years p < 0.0001). Patients with follow-up imaging (27%) were more likely to have a history of known malignancy than those without follow up imaging (17% p = 0.005) and were more likely to have chronic obstructive pulmonary disease (COPD) (18%) than those without follow-up (7% p < 0.0001).
Outcome (s)	Malignancy In total, 15 cases of previously undiagnosed cancer or previously unknown recurrent malignancy were found in the study group during follow-up imaging. Important benign diagnosis 23 patients had important non-malignant diagnoses made on follow-up imaging. Tuberculosis or atypical mycobacterial infection (n = 6), fungal infection (n = 5), organizing or eosinophilic pneumonia (n = 5), rounded atelectasis (n = 3), alveolar hemorrhage (n = 1), lung abscess (n = 1), Pneumocystis jiroveci (n = 1), and septic emboli (n = 1) were among the diagnoses made that corresponded with the original chest radiographic abnormality. The mean age of these 23 patients was 56 years (median, 58 years; range, 23–83 years).

Population characteristics

Study-level characteristics

Characteristic	Study (N = 805)
Number of participants Sample size	n = 618 ; % = 77
Male Sample size	n = 381 ; % = 47
Female Sample size	n = 424 ; % = 53
Mean age (SD) Mean (SD)	61 (NR)
Median age (IQR)	62 (NR to NR)
Current smoker Sample size	n = 126 ; % = 16

Characteristic	Study (N = 805)
Known COPD Sample size	n = 127 ; % = 16
Diabetes Sample size	n = 108 ; % = 13
History of cancer Sample size	n = 201 ; % = 25
Undergoing chemotherapy Sample size	n = 25 ; % = 3
Known HIV Sample size	n = 14 ; % = 2
Perioperative examination Sample size	n = 36 ; % = 4

Critical appraisal - ROBINS-I: a tool for non-randomised studies of interventions

Section	Question	Answer
Overall bias	Risk of bias judgement	Serious *In all cases, the interpreting radiologist recommended follow-up chest radiography to ensure resolution of radiographically suspected pneumonia. Patients for whom follow-up radiography is recommended may differ from patients for whom it is not recommended in ways that could affect the outcome of interest. It is unclear in the paper what criteria were used to recommend follow-up (e.g. all patients with pneumonia). Of 805 eligible patients for whom follow-up radiography was recommended, 618 (77%) underwent documented follow-up imaging. Patients with documented follow-up imaging were significantly more likely to have a history of known malignancy than those without follow-up imaging (27% vs 17%; p = 0.005) and more likely to have documented COPD (18% vs 7%; p < 0.0001).*
Overall bias	Directness	Partially Applicable *All patients were treated as outpatients*

Macdonald, 2015

Bibliographic Reference	Macdonald, C; Jayathissa, S; Leadbetter, M; Is post-pneumonia chest X-ray for lung malignancy useful? Results of an audit of current practice.; Internal medicine journal; 2015; vol. 45 (no. 3); 329-34

Study Characteristics

Study type	Patient records audit
Study details	Study location: New Zealand Study setting: Hospital Study dates: Data was extracted for patients admitted to hospital between January 2010 and January 2012 Sources of funding: Paper reports: None
Inclusion criteria	Adult patients aged over 50 years admitted with a diagnosis of CAP. Patients had to have received a chest x-ray on admission and it had to confirm the presence of an acute infiltrate.
Exclusion criteria	Excluded patients who were less than 50 years, had HAP or aspiration pneumonia, had previously diagnosed lung cancer or metastatic disease, or where there was no infiltrate on the admission x-ray.
Length of follow-up	6-12 weeks following admission
Loss to follow-up	312 patients over the age of 50 years were admitted with radiologically confirmed CAP between January 2010 and January 2012. Ten patients were excluded from data collection, as these subjects had moved out of the region, giving a total sample size of 302 patients. Within 6–12 weeks following admission with pneumonia, 53% (160) of study subjects received a follow-up chest X-ray.
Outcome (s)	Malignancy 6 patients were diagnosed with lung cancer, giving a percentage yield of 2%

Population characteristics

Study-level characteristics

Characteristic	Study (N = 302)
Male No of events	n = 145 ; % = 48
Female No of events	n = 157 ; % = 52

Characteristic	Study (N = 302)
50–59 years No of events	n = 42 ; % = 14
60-69 years No of events	n = 63 ; % = 21
70-79 years No of events	n = 76 ; % = 25
80-89 years No of events	n = 94 ; % = 31
>90 years No of events	n = 27 ; % = 9
Never smoked No of events	n = 121 ; % = 40
Smoker No of events	n = 181 ; % = 60
No lung disease No of events	n = 163 ; % = 54
COPD No of events	n = 100 ; % = 33
Asthma No of events	n = 18 ; % = 6
Previous pneumonia No of events	n = 18 ; % = 6
Pulmonary fibrosis No of events	n = 3 ; % = 1

Critical appraisal - ROBINS-I: a tool for non-randomised studies of interventions

Section	Question	Answer
Overall bias	Risk of bias judgement	Serious *160/302 (53%) of patients received a follow-up chest x-ray within 6-12 weeks. 81% (130) of these were deemed intentional, based on the written information on the request from the ordering provider. Patients for whom a follow-up chest x-ray was requested may differ from those for whom a follow-up was not requested, in ways that may influence the outcome.*
Overall bias	Directness	Directly applicable *Study sample and setting matches those defined in the protocol*

Mittl, 1994

Bibliographic Reference	Mittl, R L Jr; Schwab, R J; Duchin, J S; Goin, J E; Albeida, S M; Miller, W T; Radiographic resolution of community-acquired pneumonia.; American journal of respiratory and critical care medicine; 1994; vol. 149 (no. 3pt1); 630-5

Study Characteristics

Study type	Patient records audit Prospectively assessed radiographic resolution of pneumonia by obtaining serial chest radiographs every 2 weeks for an initial period of 8 weeks, then every 4 weeks until 24 weeks had passed or all radiographic abnormalities had cleared.
Study details	Study location: US Study setting: Hospital Study dates: January 1990 to December 1990 Sources of funding: Supported in part by Grant No. 5-M01-RROOO40 from the Clinical Research Center at the University of Pennsylvania School of Medicine.
Inclusion criteria	Patients aged 18 years and older, presenting with an acute febrile illness and lower-respiratory symptoms compatible with pneumonia. Radiographic criteria for inclusion consisted of focal or diffuse airspace consolidation or focal diffuse interstitial disease
Exclusion criteria	Immunocompromised patients; patients hospitalised within 4 weeks prior to pneumonia diagnosis; patients receiving antibiotics prior to diagnosis; pregnant patients; patients in whom TB was identified;

	patients unable to give consent; patients who died within 1 week of diagnosis.
Length of follow-up	Serial posteroanterior and lateral chest radiographs were obtained every 2 weeks after initial diagnosis for an initial period of 8 weeks, and then every 4 weeks up to a maximum of 24 weeks after diagnosis or until radiographic abnormalities had resolved
Loss to follow-up	One hundred sixty-three patients were identified for this study, 29(18%) could not be contacted for recruitment, 29 (18%) refused to participate, and 24 (15%) did not return for their initial follow-up chest radiographs resulting in 81 patients being recruited, including 37 treated as inpatients and 44 treated as outpatients. No statistically significant differences between included patients (n=81) and patients who were eligible but did not enrol (n=82) were found
Outcome (s)	Malignancy Radiological resolution 50/75 (66.7%) patients demonstrated complete resolution at 4 week chest x-ray. 11/75 (14.7%) of patients demonstrated residual consolidation at 4 weeks. 56/73 (76.7%) patients demonstrated complete resolution at 6 week chest x-ray. 6/73 (8.2%) of patients demonstrated residual consolidation at 6 weeks.

Population characteristics

Study-level characteristics

Characteristic	Study (N = 81)
Mean age (SD) Mean (SD)	40.2 (16.4)
Inpatients: mean age (SD) Mean (SD)	45.3 (16.5)
Outpatients: mean age (SD) Mean (SD)	35.9 (15.3)
Smokers Data on smoking only available	n = 40 ; % = 54

Characteristic	Study (N = 81)
for 74 of the 81 study participants No of events	
Inpatients: smokers No of events	n = 24 ; % = 65
Outpatients: smokers No of events	n = 16 ; % = 43
Moderate to heavy alcohol use (>2 drinks per day) Data on alcohol use only available for 72 of the 81 study participants No of events	n = 10 ; % = 14
Inpatients: alcohol use No of events	n = 7 ; % = 19
Outpatients: alcohol use No of events	n = 3 ; % = 9
White blood cell count Data on WBC only available for 59 of the 81 study participants; specifically only 24 of 44 outpatient participants Mean	14700
Inpatients: WBC count Mean	12500
Outpatients: WBC count Mean	16300
History of pulmonary or cardiopulmonary disease No of events	n = 30 ; % = 37
COPD No of events	n = 6

Characteristic	Study (N = 81)
Asthma No of events	n = 10
TB No of events	n = 1
Prior pneumonia No of events	n = 8
Spontaneous pneumothorax No of events	n = 1
Prior lobectomy for lung carcinoma No of events	n = 1
Pulmonary embolism No of events	n = 1
Congestive heart failure No of events	n = 5

Critical appraisal - ROBINS-I: a tool for non-randomised studies of interventions

Section	Question	Answer
Overall bias	Risk of bias judgement	Low
Overall bias	Directness	Partially Applicable *37 were treated as inpatients, 44 were treated as outpatients.*

Tang, 2011

Bibliographic Reference	Tang, Karen L; Eurich, Dean T; Minhas-Sandhu, Jasjeet K; Marrie, Thomas J; Majumdar, Sumit R; Incidence, correlates, and chest radiographic yield of new lung cancer diagnosis in 3398 patients with pneumonia.; Archives of internal medicine; 2011; vol. 171 (no. 13); 1193-8

Study Characteristics

Study type	Patient records audit

	Population-based cohort study of patients with chest-radiography confirmed pneumonia, discharged alive from hospital or ED care
Study details	Study location: Canada Study setting: Hospitals Study dates: 2000 to 2002 Sources of funding: Canadian Institutes of Health Research and operating grants from Alberta Heritage Foundation for Medical Research (AHFMR), grants-in-aid from Capital Health, and unrestricted grants from Abbott-Canada, Pfizer-Canada, and Jannsen-Ortho Canada.
Inclusion criteria	All adult patients who attended any of the eligible EDs or hospitals during the study period and who received a chest radiography-confirmed diagnosis of pneumonia
Exclusion criteria	People with TB, cystic fibrosis, immunocompromised patients, people who were pregnant, people who had died in hospital, people with documented cancer at the time of presentation; and people who could not be linked to appropriate databases for identifying longer-term outcomes
Length of follow-up	Participants were followed-up for up to 5 years, including outcome assessment at 90-days, 1 year, 2 years, 3 years and 5 years.
Loss to follow-up	There were 4261 patients potentially eligible for inclusion in this study. After excluding those with a documented history of any cancer at presentation (n=472), who died in hospital (n=189), or who could not be linked to provincial databases for outcomes ascertainment (n=202), the final study cohort consisted of 3398 patients. Of those, 1354 (40%) received a follow-up chest radiograph within 90 days of pneumonia diagnosis.
Outcome (s)	Malignancy Within 90 days of presenting with pneumonia, 36 of 3398 patients were diagnosed as having a new lung cancer, for an incidence of 1.1% The yield of follow-up radiographs when ordered at the discretion of the treating physicians in our region was 2.5%. To maximize yield, our findings suggest restricting follow-up radiographs to patients 50 years or older. This strategy would have identified 56 of 57 (98%, 1 missed) lung cancers and required just 2010 chest radiographs for an estimated yield of 2.8%.

Population characteristics

Study-level characteristics

Characteristic	Study (N = 1354)
Male No of events	n = 723 ; % = 53
Female No of events	n = 631 ; % = 47
Mean age (SD) Mean (SD)	57.9 (20.3)
Age <50 years No of events	n = 830 ; % = 61
Inpatient No of events	n = 665 ; % = 49
Current smoker No of events	n = 258 ; % = 19
COPD No of events	n = 272 ; % = 20
Diabetes No of events	n = 154 ; % = 11
PSI score: I or II No of events	n = 639 ; % = 47
PSI score: III No of events	n = 238 ; % = 18
PSI score: IV No of events	n = 350 ; % = 26
PSI score: V No of events	n = 127 ; % = 9

Critical appraisal - ROBINS-I: a tool for non-randomised studies of interventions

Section	Question	Answer
Overall bias	Risk of bias judgement	Moderate *Some concerns about potential confounding as paper is unclear: it does not report whether follow-up x-rays were requested by clinician / radiographer at diagnosis, but in the conclusion they refer to "follow-up radiographs ordered at the discretion of the treating physician." Patients for whom a chest x-ray is requested may differ from those for whom a chest x-ray is not requested, in ways that may impact the outcome.*
Overall bias	Directness	Partially Applicable *49% of patients were treated as inpatients; 51% were outpatients. No separate analyses reported for these two groups.*

Virkki, 2005

Bibliographic Reference	Virkki, R; Juven, T; Mertsola, J; Ruuskanen, O; Radiographic follow-up of pneumonia in children.; Pediatric pulmonology; 2005; vol. 40 (no. 3); 223-7

Study Characteristics

Study type	Patient records audit 3-year prospective study of the etiology and clinical profile of childhood CAP
Study details	Study location: Finland Study setting: Not reported Study dates: Enrolment between 01/01/1993 and 31/12/1995 Sources of funding: Not reported
Inclusion criteria	Follow-up chest radiography to ensure resolution of radiographically suspected pneumonia.
Exclusion criteria	Unavailability of follow up x-ray Unavailability of convalescent serum for viral and bacterial studies
Length of follow-up	8-10 years. Chest radiographs were taken on admission and 3-7 weeks later.
Loss to follow-up	NA
Outcome (s)	Radiological resolution

	On follow-up, 59/196 (30%) patients had radiographic abnormalities. Sole interstitial infiltrates (67%), atelectasis (47%), and enlarged lymph nodes (28%) were the most frequent findings. In 20% of patients, new radiographic changes developed after the original chest radiograph: most commonly, small atelectasis (in 24 cases), enlarged lymph nodes, and interstitial infiltrates.

Population characteristics

Study-level characteristics

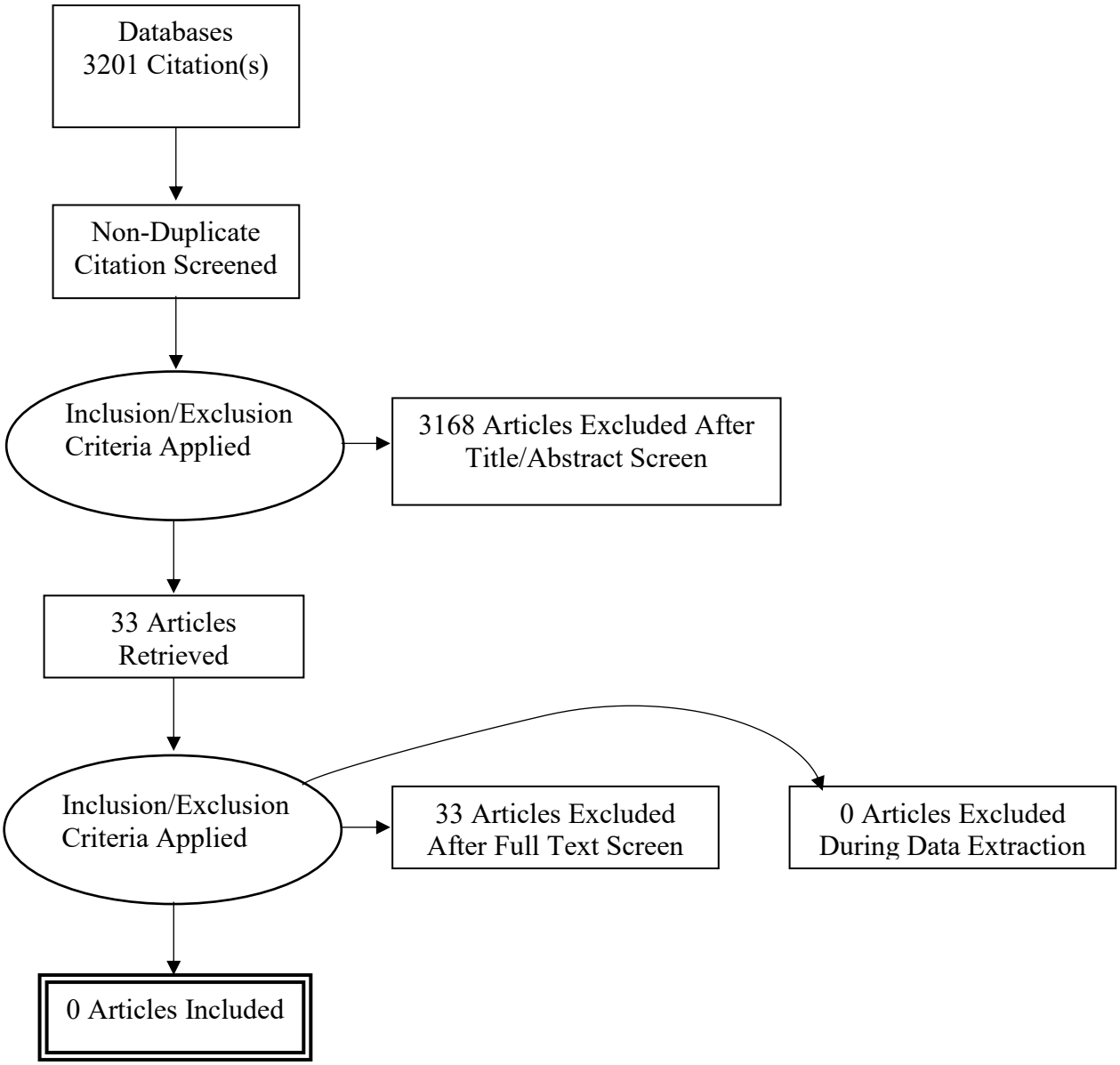
Characteristic	Study (N = 196)
Male Sample size	n = 104 ; % = 53
Female Sample size	n = 92 ; % = 47
Age range (years) Range	0.1 to 15.6
Mean age (SD) (years) Mean (SD)	2.4 (NR)
<1 year No of events	n = 27 ; % = 14
1-2 years No of events	n = 59 ; % = 30
2-5 years No of events	n = 60 ; % = 31
5+ years No of events	n = 50 ; % = 25
Bacterial infection No of events	n = 40 ; % = 20
Viral infection No of events	n = 65 ; % = 33
Mixed viral-bacterial	n = 60 ; % = 31

Characteristic	Study (N = 196)
No of events	
No etiologic agent found No of events	n = 31 ; % = 16
Penicillin G No of events	n = 153 ; % = 78
Cefuroxime No of events	n = 17 ; % = 9
Erythromycin No of events	n = 14 ; % = 7

Critical appraisal - ROBINS-I: a tool for non-randomised studies of interventions

Section	Question	Answer
Overall bias	Risk of bias judgement	Low
Overall bias	Directness	Directly applicable *Study sample and setting matches those defined in the protocol*

Appendix E – Economic evidence study selection



Appendix F – Economic evidence tables

No studies were included in this review question.

Appendix G – Health economic model

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

Appendix H – Excluded studies

Diagnostic

Study	Reason
Anonymous (2006) I recently recovered from pneumonia. I'm feeling much better, but my doctor still wants me to get a chest X-ray in a few weeks. Why is this necessary?. Mayo Clinic health letter (English ed.) 24(9): 8	- Full text paper not available
Mahmood, Dhia, Vartzelis, George, McQueen, Paula et al. (2007) Radiological follow-up of pediatric pneumonia: principle and practice. Clinical pediatrics 46(2): 160-2	- Not a relevant study design *Survey of clinicians to ask about current practice - no data on patients or outcomes collected*
Mortensen, Eric M, Copeland, Laurel A, Pugh, Mary Jo et al. (2010) Diagnosis of pulmonary malignancy after hospitalization for pneumonia. The American journal of medicine 123(1): 66-71	- Paper does not look at 6 week follow-up CXR; looks at malignancy in post pneumonia patients over a 1 year + follow up period
Shepshelovich, D Barda, N Goldvaser, H Dagan, N Zer, A Diker-Cohen, T Balicer, R Gafter-Gvili, A (2022) Incidence of lung cancer following pneumonia in smokers: a population-based study. QJM-AN INTERNATIONAL JOURNAL OF MEDICINE 115(5): 287 - 291	- Paper does not look at 6 week follow-up CXR; looks at malignancy in post pneumonia patients over a 1 year + follow up period
Suren, Pal, Try, Kirsti, Eriksson, Jan et al. (2008) Radiographic follow-up of community-acquired pneumonia in children. Acta paediatrica (Oslo, Norway : 1992) 97(1): 46-50	- Does not provide information on timing of follow-up chest x-ray so not possible to determine if it was within 4-8 weeks of diagnosis
Wacogne, Ian and Negrine, Robert J S (2003) Are follow up chest x ray examinations helpful in the management of children recovering from pneumonia?. Archives of disease in childhood 88(5): 457-8	- Review article but not a systematic review *Review article containing only 3 studies and all 3 studies have been identified in the search and included at full text*

CXR = chest x-ray

Economic

Study	Code [Reason]
Akyil, Fatma Tokgoz, Hazar, Armagan, Erdem, Ipek et al. (2015) Hospital Treatment Costs and Factors Affecting These Costs in Community-Acquired Pneumonia. Turkish thoracic journal 16(3): 107-113	- Study does not contain a relevant intervention *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*

Study	Code [Reason]
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
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*

Study	Code [Reason]
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*
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	- US study

Study	Code [Reason]
Community-Acquired Pneumonia. Chest 155(4): 787-794	
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 with community acquired pneumonia: A nationwide retrospective claims database analysis. Vaccine 33(28): 3193-9	- Study does not contain a relevant intervention *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)*

Study	Code [Reason]
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*

Appendix I – Research recommendations – full details

I1.1 Research recommendation

What is the clinical and cost-effectiveness of follow-up chest imaging (chest X-ray)for adults discharged from hospital after treatment for pneumonia? Which patients should be offered follow-up chest imaging and when should it be done?

I1.1.1 Why this is important

The evidence is unclear about whether malignancies and pathologies identified by a follow up chest image are identified at an earlier stage than they would otherwise be, and therefore it is unclear what benefit is attached to the chest imaging. For example, if a person who has lung cancer is discharged from hospital after an episode of pneumonia, and does not have 6-week routine chest imaging, how long would it be before the cancer is diagnosed via another route? It was also agreed that the 6-week follow-up was not based on evidence, so there is uncertainty about the optimal time frame for conducting chest imaging. Similarly, further research is needed to more clearly determine which patients should be offered follow-up chest imaging.

I1.1.2 Rationale for research recommendation

Importance to 'patients' or the population	Little is known about the impact of routine chest imaging on the diagnosis of underlying pathology (including malignancy). It is also important to determine who does not require follow-up imaging to avoid unnecessary investigations and minimise people's exposure to unnecessary radiation.
Relevance to NICE guidance	The guideline recommends not doing routine chest imaging at 6 weeks post discharge for people who have had pneumonia unless there is a good clinical reason to do so.
Relevance to the NHS	This may reduce the burden on NHS radiography departments and associated follow up appointments.
National priorities	High – early identification of cancer is a national priority
Current evidence base	Minimal long-term data.
Equality considerations	People from lower socioeconomic groups are disproportionately affected by pneumonia and are more likely to have some risk factors for lung cancer, for example smoking.

I1.1.3 Modified PICO table

Population	Adults diagnosed with pneumonia (CAP or HAP) and discharged from hospital.

Intervention	Chest x-ray performed after hospital discharge (timeframe to be determined).
Comparator	Standard care (this may be routine imaging for all patients, or targeted to higher risk patients, or no imaging post-discharge).
Outcome	• Detection of pathology (including cancer) and abnormalities on chest x-ray. • If cancer, stage of cancer detected. • Subsequent health service resource use (hospitalisation, treatment). • Improvement in clinical symptoms. • Overall patient well-being/QoL. • Cost-effectiveness
Study design	Test and treat RCT
Timeframe	Long term
Additional information	None