



The Comprehensive Systematic Review of Readmission Rates for Patients with Pleural Effusion

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ABSTRACT

Introduction: Pleural effusion is a common clinical condition associated with significant healthcare burden, yet readmission rates and their determinants remain poorly characterized across different etiologies. This systematic review synthesizes evidence on readmission rates, risk factors, treatment interventions, and clinical outcomes in adult patients with pleural effusion.

Methods: A systematic review was conducted using rigorous screening criteria including studies reporting readmission outcomes in adult pleural effusion patients. Data were extracted on patient populations, readmission rates, risk factors, readmission characteristics, interventions, clinical outcomes, and study design. A total of 111 studies published were included, comprising retrospective and prospective cohort studies, database analyses, and interventional trials.

Results: Thirty-day all-cause readmission rates ranged from 20.7-38.3% for malignant pleural effusion (MPE), 1.4-20.8% for trauma-related effusions, 9.1-12.5% for post-cardiac surgery, and 10.5-35.9% for heart failure. Pleural effusion was the direct cause of readmission in 24.3-69.5% of MPE cases. Key risk factors included older age, multiple comorbidities, thoracentesis-only management (vs definitive procedures), presence of effusion at discharge, and discharge to care facilities. Definitive procedures (indwelling pleural catheters, pleurodesis) significantly reduced readmissions compared to serial thoracentesis ($p<0.001$). System-level interventions including specialized pleural clinics and multidisciplinary pathways reduced hospital admissions by 24-47%. Readmission was associated with substantially increased mortality (17-20% for MPE) and healthcare costs ($>\$15,000$ per readmission).

Discussion: This review identifies significant heterogeneity in readmission rates across effusion etiologies and demonstrates that readmissions are frequently preventable through definitive management strategies and coordinated care models. The evidence strongly supports transitioning from reactive, repetitive drainage to proactive, definitive interventions and systematic care pathways.

Conclusion: Readmission in pleural effusion patients is common, costly, and associated with poor outcomes. Implementation of definitive procedures and specialized pleural services represents evidence-based strategies to reduce readmission burden. Future research should focus on prospective validation of risk prediction models and comparative effectiveness of definitive interventions across diverse populations.

Keywords: Pleural effusion, readmission rates, malignant pleural effusion, indwelling pleural catheter, pleurodesis, healthcare utilization, risk factors, systematic review

INTRODUCTION

Background

Pleural effusion, the pathological accumulation of fluid in the pleural space, represents one of the most common clinical problems encountered in pulmonary medicine, affecting an estimated 1.5 million patients annually in the United States alone (S. Mummadi et al., 2021). The condition arises from diverse etiologies including malignancy, heart failure, infection, post-surgical complications, trauma, and liver disease, each presenting distinct pathophysiological mechanisms and clinical trajectories (Emadeldeen Elgwairi et al., 2022; P. Tian et al., 2021). Despite advances in diagnostic techniques and therapeutic interventions, hospital readmission among patients with pleural effusion remains a pervasive challenge, imposing substantial clinical and economic burdens on healthcare systems worldwide (M. Shafiq et al., 2020; Kasia Czarnecka-Kujawa et al., 2025).

Hospital readmission has emerged as a critical quality metric and cost-containment target in contemporary healthcare policy. The Centers for Medicare & Medicaid Services have implemented financial penalties for hospitals with excess 30-day readmission rates under the Hospital Readmissions Reduction Program, yet pleural effusion-specific readmission patterns remain inadequately characterized compared to conditions such as heart failure and pneumonia (A. Pandey et al., 2016). Current evidence suggests that patients with malignant pleural effusion (MPE) experience 30-day readmission rates approaching 38%, with each readmission episode incurring mean costs exceeding \$15,000 and aggregate annual national expenditures surpassing \$400 million (Michael A. Mitchell et al., 2019; Theresa S Yang et al., 2018).

Research Gap

Despite the growing recognition of readmission as a critical outcome in pleural effusion management, significant knowledge gaps persist. First, existing literature is fragmented across diverse etiologies, with no comprehensive synthesis that systematically compares readmission

patterns, risk factors, and outcomes across malignant, cardiac, infectious, post-surgical, and traumatic effusions. Second, while individual studies have identified various predictors of readmission, the relative importance and generalizability of these factors remain unclear due to heterogeneous study designs, variable follow-up durations, and inconsistent readmission definitions. Third, although multiple interventional studies have examined the impact of definitive procedures (indwelling pleural catheters, pleurodesis) and system-level interventions (specialized pleural clinics, clinical pathways), no systematic synthesis has quantitatively or qualitatively aggregated this evidence to inform clinical practice and health policy. Fourth, the relationship between readmission and downstream clinical outcomes including mortality, morbidity, and quality of life has not been systematically examined across effusion etiologies. Fifth, existing systematic reviews have focused narrowly on specific etiologies (primarily MPE) or specific interventions, without addressing the broader question of readmission as a multidimensional outcome spanning epidemiology, risk prediction, treatment effectiveness, and healthcare economics.

Novelty

This systematic review addresses these critical gaps through several novel contributions. It represents the first comprehensive synthesis examining readmission rates across the full spectrum of pleural effusion etiologies, enabling direct comparison of readmission burdens between malignant and non-malignant conditions. Second, it provides the first systematic aggregation of risk factors for readmission with extraction of quantitative effect measures (odds ratios, hazard ratios) where available, facilitating identification of modifiable versus non-modifiable predictors. Third, this review uniquely synthesizes evidence on both procedural interventions and health system interventions, allowing comparative assessment of different prevention strategies. Fourth, it systematically examines readmission characteristics including timing, causes, procedural requirements, and downstream clinical outcomes, providing a complete picture of the readmission episode itself. Fifth, this review incorporates the most recent literature including 2024-2025

publications, capturing contemporary trends in pleural effusion management and healthcare delivery.

Hypothesis

We hypothesize that: (1) readmission rates vary substantially by pleural effusion etiology, with malignant and heart failure-related effusions demonstrating the highest burden; (2) definitive procedural interventions (indwelling pleural catheters, pleurodesis) are associated with significantly lower readmission rates compared to conservative management with serial thoracentesis; (3) system-level interventions including specialized pleural clinics and standardized clinical pathways reduce hospital readmissions and healthcare utilization; (4) patient-related factors including comorbidities, effusion characteristics at discharge, and discharge destination independently predict readmission risk; and (5) readmission is independently associated with increased mortality and healthcare costs across effusion etiologies.

Objectives

The primary objectives of this systematic review are: (1) to synthesize and compare readmission rates across different pleural effusion etiologies and readmission timeframes; (2) to identify and quantify patient-level, disease-level, and treatment-level risk factors for readmission; (3) to evaluate the effectiveness of procedural and system-level interventions in reducing readmission; (4) to characterize readmission events including timing, causes, interventions required, and clinical outcomes; and (5) to identify evidence gaps and prioritize future research directions.

Significance and Benefits

This systematic review holds substantial significance for multiple stakeholders. For clinicians, it provides evidence-based guidance for identifying high-risk patients, selecting readmission-prevention strategies, and implementing effective interventions. For healthcare administrators and policymakers, it quantifies the economic burden of readmissions and

demonstrates the return on investment for specialized pleural services and definitive procedure utilization. For researchers, it identifies critical evidence gaps and establishes priorities for future investigation. For patients, this synthesis supports the transition from repetitive, hospital-based care to proactive, definitive management strategies that reduce hospitalization burden and improve quality of life.

METHODS

Protocol

The study strictly adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines to ensure methodological rigor and accuracy. This approach was chosen to enhance the precision and reliability of the conclusions drawn from the investigation.

Criteria for Eligibility

This systematic review aims to evaluate the readmission rates for patients with pleural effusion.

Screening

We screened in sources based on their abstracts that met these criteria:

- **Population - Pleural Effusion:** Does the study include patients diagnosed with pleural effusion of any etiology as the primary population of interest?
- **Readmission Outcomes:** Does the study report readmission rates as a primary or secondary outcome?
- **Readmission Definition:** Does the study provide a clear definition of what constitutes a "readmission" and specify readmission timeframes (e.g., 30-day, 90-day, 1-year)?
- **Adult Population:** Does the study involve adult patients (≥ 18 years) rather than focusing exclusively on pediatric populations?

- **Study Design and Sample Size:** Is the study an observational study, randomized controlled trial, systematic review, or meta-analysis with adequate sample size (≥ 10 patients for primary studies)?
- **Primary Focus:** Is pleural effusion the primary condition of interest in the study rather than being mentioned only incidentally or as a minor comorbidity?
- **Follow-up Methodology:** Does the study have appropriate follow-up methodology to capture readmission data (i.e., not conducted exclusively in emergency department or outpatient settings without readmission follow-up)?
- **Publication Type and Quality:** Is this a peer-reviewed publication with sufficient methodological detail (i.e., not a conference abstract, editorial, letter, or opinion piece)?

We considered all screening questions together and made a holistic judgement about whether to screen in each paper.

Search Strategy

The keywords used for this research based PICO :

Element	P (Population)	I (Intervention/Exposure)	C (Comparison/Context)	O (Outcome)
Keyword 1	Pleural Effusion	Indwelling Pleural Catheter	Serial Thoracentesis	Readmission Rate
Keyword 2	Malignant Pleural Effusion	Pleurodesis	Standard care	Readmission Risk Factors
Keyword 3	Pleural disease	Thoracentesis	Talc Pleurodesis vs IPC	Healthcare Utilization
Keyword 4	Post-surgical effusion	Pleural tap	Pleurodesis vs Indwelling drain	Mortality

The Boolean MeSH keywords inputted on databases for this research are: (*"Pleural Effusion" OR "Malignant Pleural Effusion" OR "Pleural disease" OR "Post-surgical effusion"*) AND (*"Indwelling Pleural Catheter" OR "Pleurodesis" OR "Thoracentesis" OR "Pleural tap"*) AND (*"Serial Thoracentesis" OR "Standard care" OR "Talc Pleurodesis vs IPC" OR "Pleurodesis vs Indwelling drain"*) AND (*"Readmission Rate" OR "Readmission Risk Factors" OR "Healthcare Utilization" OR "Mortality"*)

Data extraction

- **Pleural Effusion Population:**

Extract patient population characteristics specifically for pleural effusion patients, including:

- Underlying condition causing pleural effusion (e.g., trauma, heart failure, cancer, congenital heart disease)
- Demographics (age, sex, race/ethnicity)
- Disease severity markers (e.g., AIS scores for trauma, heart failure class, cancer stage)
- Pleural effusion characteristics (unilateral/bilateral, volume, recurrent/first episode)
- Sample size of pleural effusion patients studied

- **Readmission Rates:**

Extract all readmission rate data for pleural effusion patients, including:

- Primary readmission rate (percentage and absolute numbers)
- Time frame for readmission assessment (e.g., 30-day, 90-day)
- Whether readmissions were all-cause or pleural effusion-related
- Whether readmissions were planned or unplanned
- Comparison rates if multiple groups studied

- **Readmission Risk Factors:**

Extract all factors identified as predictors of readmission in pleural effusion patients, including:

- Clinical characteristics (comorbidities, vital signs, lab values)
- Imaging findings (chest X-ray abnormalities, effusion size/location)
- Initial treatment factors (thoracentesis, chest tube, surgical procedures)
- Discharge characteristics (effusion status, discharge destination)
- Statistical measures of association (odds ratios, hazard ratios, p-values, confidence intervals)

- **Readmission Characteristics:**

Extract details about what happens when pleural effusion patients are readmitted, including:

- Mean/median time to readmission from discharge
- Primary diagnosis/reason for readmission related to pleural effusion
- Length of stay during readmission
- Procedures performed during readmission (thoracentesis, chest tube, surgery)
- Repeat readmissions or multiple readmissions

- **Interventions Tested:**

Extract any interventions specifically tested for their impact on pleural effusion readmission rates, including:

- Type of pleural effusion treatment (thoracentesis only, pleurodesis, tunneled catheter, surgical intervention)
- Comparison groups in intervention studies
- Impact of intervention on readmission rates (percentages, statistical significance)
- Other outcomes affected by intervention (length of stay, morbidity)

- **Clinical Outcomes:**

Extract clinical outcomes associated with readmission in pleural effusion patients, including:

- Mortality rates during readmission or follow-up period
- Morbidity/complications during readmission
- Healthcare resource utilization (costs, length of stay)
- Long-term outcomes or survival data
- Quality of life or symptom relief measures

- **Study Design:**

Extract study methodology details relevant to interpreting readmission data for pleural effusion patients, including:

- Study design (retrospective/prospective, observational/interventional)
- Data source (single center, multi-center, administrative database)
- Study period and follow-up duration
- Primary vs secondary analysis of readmission data
- Statistical methods used for readmission analysis

Table 1. Article Search Strategy

Database	Keywords	Hits
Pubmed	<i>("Pleural Effusion" OR "Malignant Pleural Effusion" OR "Pleural disease" OR "Post-surgical effusion") AND ("Indwelling Pleural Catheter" OR "Pleurodesis" OR "Thoracentesis" OR "Pleural tap") AND ("Serial Thoracentesis" OR "Standard care" OR "Talc Pleurodesis vs IPC" OR "Pleurodesis vs Indwelling drain") AND ("Readmission Rate" OR "Readmission Risk Factors" OR "Healthcare Utilization" OR "Mortality")</i>	9
Semantic Scholar	<i>("Pleural Effusion" OR "Malignant Pleural Effusion" OR "Pleural disease" OR "Post-surgical effusion") AND ("Indwelling Pleural Catheter" OR "Pleurodesis" OR "Thoracentesis" OR "Pleural tap") AND ("Serial Thoracentesis" OR "Standard care" OR "Talc Pleurodesis vs IPC" OR "Pleurodesis vs Indwelling drain") AND ("Readmission Rate" OR "Readmission Risk Factors" OR "Healthcare Utilization" OR "Mortality")</i>	250
Springer	<i>("Pleural Effusion" OR "Malignant Pleural Effusion" OR "Pleural disease" OR "Post-surgical effusion") AND ("Indwelling Pleural Catheter" OR "Pleurodesis" OR "Thoracentesis" OR "Pleural tap") AND ("Serial Thoracentesis" OR "Standard care" OR "Talc Pleurodesis vs IPC" OR "Pleurodesis vs Indwelling drain") AND ("Readmission Rate" OR "Readmission Risk Factors" OR "Healthcare Utilization" OR "Mortality")</i>	175
Google Scholar	<i>("Pleural Effusion" OR "Malignant Pleural Effusion" OR "Pleural disease" OR "Post-surgical effusion") AND ("Indwelling Pleural Catheter" OR "Pleurodesis" OR "Thoracentesis" OR "Pleural tap") AND ("Serial Thoracentesis" OR "Standard care" OR "Talc Pleurodesis vs IPC" OR "Pleurodesis vs Indwelling drain") AND ("Readmission Rate" OR "Readmission Risk Factors" OR "Healthcare Utilization" OR "Mortality")</i>	122
Wiley Online Library	<i>("Pleural Effusion" OR "Malignant Pleural Effusion" OR "Pleural disease" OR "Post-surgical effusion") AND ("Indwelling Pleural Catheter" OR "Pleurodesis" OR "Thoracentesis" OR "Pleural tap") AND ("Serial Thoracentesis" OR "Standard care" OR "Talc Pleurodesis vs IPC" OR "Pleurodesis vs Indwelling drain") AND ("Readmission Rate" OR "Readmission Risk Factors" OR "Healthcare Utilization" OR "Mortality")</i>	134

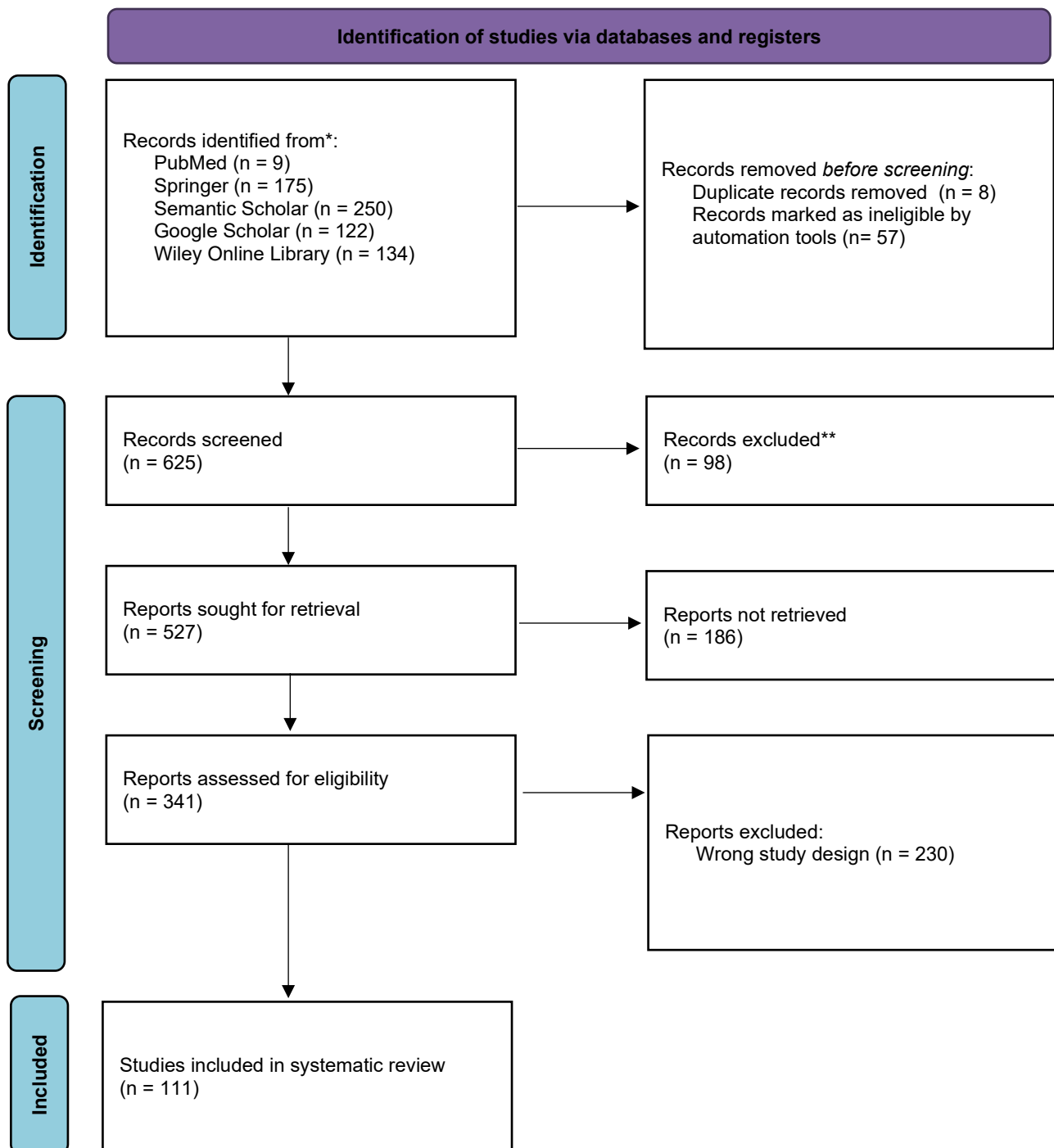


Figure 1. Article search flowchart

RESULTS

Study Characteristics

The included studies examining readmission rates in pleural effusion patients consist primarily of retrospective cohort analyses, with several prospective observational studies and a few interventional trials. Data sources are varied, encompassing single-center chart reviews, multi-center collaborations, and large administrative databases such as the Nationwide Readmissions Database (NRD), the Nationwide Inpatient Sample (NIS), SEER-Medicare data, and the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP). Sample sizes range from small single-center cohorts of fewer than 50 patients to large database studies with over 100,000 hospitalizations. Follow-up durations for readmission analysis were most commonly 30 days or 90 days, but varied from 7 days to 5 years. Methodological approaches included logistic regression models, propensity score matching, competing risk models, and Cox proportional hazards models to identify predictors of readmission. The primary outcome focus was frequently the rate of readmission, though some studies concentrated on mortality or the effectiveness of specific management strategies.

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Theresa S Yang et al., 2018	Administrative database	2009 to 2011	Not mentioned	90 days	30-day readmission rate

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
J. Sheehan et al., 2020	AHRQ-HCUP Nationwide Readmission Database	2014	70,912 admissions	30 days	Rate of readmission within 30-days of discharge
Michael A. Mitchell et al., 2019	Nationwide Readmissions Database (NRD)	2014 sample	108,824 hospitalizations	30-day readmissions	Proportion of all-cause, unplanned, 30-day readmissions
S. Mummadi et al., 2021	Healthcare Utilization Project databases	2007-2016	64,174 readmissions	Not mentioned	Epidemiologic measures related to adult pleural disease
Benjamin S. Avner et al., 2022	Single center	Not mentioned	355 adult inpatients	At least 30 days	Clinical outcomes with regard to antibiotic use
J. Clouse et al., 2023	Single transplant center	4 years	107 patients	90 days	Outcomes for peri-transplant pleural effusion in LT recipients

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Rebecca Cloyes et al., 2023	Single center	Not specified	51 patients	1 week after thoracentesis	Reduction of hospital admissions of patients with MPE
R. Freeman et al., 2014	Likely single center	5 years	80 patients	Not mentioned	Comparison of talc pleurodesis vs. tunneled pleural catheter
Amr J. Alwakeel et al., 2022	Single center	Not explicitly mentioned	144 patients	Not explicitly mentioned	Outcomes of a pleural care program for MPE management
J. Brookes et al., 2021	Not specified	Over two years	59 patients	Not mentioned	Identification of modifiable risk factors for effusion post-CABG
Ana Isabel Enríquez Rodríguez et al., 2020	Single center	2015-2018 vs 2013-2014	741 patients total	1 month	Clinical impact of a Pleural Unit

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Yunus Aksoy et al., 2023	Single center	2017 to 2022	58 patients	Up to 3 months post-procedure	Factors affecting the success of uniportal VATS talc pleurodesis
Antti I. Lehtomäki et al., 2020	Single center and national registries	2000-2008	191 patients	5 years	Need for and causes of treatment episodes after pleural infections
Mrinalini K. Krishnan et al., 2015	Single center	Not mentioned	37 patients	1 to 3 years after catheter removal	Inpatient admission rates relative to TPC placement
D. Ost et al., 2017	SEER-Medicare data	2007 to 2011	23,431 patients	Until death or last recorded event	Guideline consistent care for rapidly recurring MPE
L. Sobotka et al., 2020	Multi-center	Not mentioned	Not mentioned	30-day readmission	Effect of thoracentesis on hospital outcomes
Kasia Czarnecka-Kujawa et al., 2025	Population-based	2004-2018	76,190 patients	2 years	Trends in health care utilization, costs for MPE

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
R. Freeman et al., 2020	Multi-center	2016-2018	60 patients	Not mentioned	Assessment of a standardized treatment algorithm for MPE
D. Ost et al., 2017a	SEER-Medicare data	2007-2011	23,431 patients	Recurrence within 2 weeks	Guideline consistent care for rapidly recurring MPE
A. Kay et al., 2021	Single center	2015-2020	49 readmitted patients	30 days	Analysis of patient population requiring readmission for PDPSC
T. Ahmed et al., 2016	Single center	2014-2015	24 patients	Approximately 28 days	Management outcomes of pleural effusions secondary to CHF
A. Hughes et al., 2020	Multi-center	Not mentioned	Not mentioned	Not mentioned	Prevalence of post-surgical pleural effusions leading to readmission

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Emadeldeen Elgwairi et al., 2022	Not provided	Not provided	Not mentioned	Not provided	Review of frequency, pathogenesis, diagnosis, and implications of PE in CHF
Zachary Mohs et al., 2022	Multi-center administrative database	2010-2020	314 subjects	1 year post-intervention	Comparison of MPE treatment outcomes and complications
H. Yaku et al., 2020	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Association of residual pleural effusion with post-discharge clinical outcomes
M. Labidi et al., 2009	Single center	2 years	192 patients	30 days post-surgery	Prevalence, characteristics, and determinants of clinically significant pleural effusions

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
A. Majid et al., 2016	Single center	2005 to 2015	36 patients	Not specified	Feasibility of tunneled pleural catheter drainage for refractory PE from CHF
Juan Camilo Cedeno Serna et al., 2022	Single center	2013-2022	27 patients	6 months before/after procedure	Experience with IPCs and clinical outcomes in recurrent BPE due to dCHF
Katherine B. Malcolm et al., 2022	Likely single center	2015 to 2021	371 patients	Not mentioned	Impact of a dedicated pleural clinic on IPC-related outcomes
E. Fysh et al., 2011	Multi-center	One year	160 patients total	One year	Days spent in hospital for MPE patients managed with IPC vs pleurodesis

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
E. Fysh et al., 2010	Not provided	Not provided	Not mentioned	Not provided	Hypothesis that MPE patients with IPCs require fewer hospital admissions
Kristin N Sheehan et al., 2025	Single center	2-year period	425 procedures	Not mentioned	Rate of imaging abnormalities and health outcomes for hospitalized patients requiring thoracentesis
C. Pu et al., 2024	Single center	2 decades	210 patients	Not mentioned	Effectiveness of the RPP in inducing pleurodesis
Ismael Matus et al., 2025	Single center	Not mentioned	Not mentioned	Not mentioned	Evaluation of a system-wide clinical pathway for MPE management

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
H. Grosu et al., 2018	Multi-center	2010-2013	1,278 patients	100 days	Identification of risk factors associated with recurrent symptomatic MPE
T. Demmy et al., 2010	Not provided	Not provided	Not mentioned	Not provided	Comparison of indwelling catheters and talc pleurodesis in MPE management
M. Heer et al., 2015	Not provided	Not provided	Not mentioned	Not provided	Management of recurrent MPE with a tunneled indwelling pleural catheter
Juan Camilo Cedeno Serna et al., 2022a	Single center	2013 to 2022	71 patients	Not mentioned	Description of characteristics of patients refractory to initial pleural drainage in dCHF

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
B. Burton et al., 2019	ACS NSQIP surgical outcomes registry	2007 to 2016	2,358 patients	30 days	Risk factors associated with 30-day unplanned reintubation after pleurodesis
M. Shafiq et al., 2020	HCUP-NIS database	2004-2014	92,034 discharges	Not mentioned	National trends in healthcare utilization and outcomes among hospitalized MPE patients
A. Lehtomäki et al., 2020	Single center & admin database	2000-2008	191 patients	Up to 134 months	Burden of healthcare utilization after pleural infection
J. J. Ouwerkerk et al., 2023	National Readmission Database (NRD)	2016-2019	635 readmitted patients	30 days	Identification of risk factors for DHTX readmission

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
K. Fjaellegaard et al., 2023	Not specified	Not specified	98 patients	60 days	Prediction and risk factors for time to next therapeutic thoracentesis
Bethany Hines et al., 2023	Single center	2020-2022	425 procedures	Not mentioned	Health outcomes for hospitalized patients undergoing thoracentesis
M. Kashoob et al., 2024	Not specified	Not specified	77 patients total	90 days	Impact of LUS-guided diuretic therapy on LOS and readmissions in ADHF
F. Stanzel et al., 2023	Not mentioned	Not specified	98 patients	60 days	Prediction and risk factors for time to next therapeutic thoracentesis
Fridtjof Schiefenhövel et al., 2022	Single center	2006 to 2019	4,576 patients	Not mentioned	Clinical outcomes of cardiac surgery patients with pleural effusion

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Sujoy Saikia et al., 2012	Single center	2010 & 2011 (6-month periods)	Not specified	Not mentioned	Assessment of pleural clinic impact on admission rates
Janet Rodríguez-Torres et al., 2019	Likely single center	Not mentioned	74 patients	3 months after discharge	Prevalence of sarcopenia in MPE and its relationship with symptoms and health status
N. Taghizadeh et al., 2017	HCUP-NIS 2012	2012	126,825 admissions	Not mentioned	Prevalence and burden of MPE-associated hospitalizations
J. Morales-Rull et al., 2018	Spanish RICA Registry	Not explicitly mentioned	~1493 patients with PE	At least one year	Prevalence, characteristics and prognostic implications of PEs in ADHF

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
T. Cargill et al., 2018	Ovid MEDLINE and EMBASE	2000-2017	227,898 patients	Not applicable	Investigation of comorbidities and outcomes of adult patients with pleural infection
N. Dean et al., 2016	Multi-center administrative database	2009-2010 & 2011-2012	690 patients with PE	7 days for secondary admissions	Influence of effusions at first ED presentation on outcomes in pneumonia
C. Read et al., 2002	Likely single center	Not mentioned	30 patients	6 months	Assessment of whether thoracoscopy with talc pleurodesis shortens hospitalization
P. Korczyński et al., 2018	Single center	Not mentioned	195 patients	Not mentioned	Investigation of causes of PE and 30-day mortality rate

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Tyler N Kirchberg et al., 2022	Nationwide Readmission Database	First 9 months of 2017	Included in 794 CRR patients	90 days	Definition of readmission rates and identification of predictors after traumatic hemothorax
Parvin Ebrahimi et al., 2019	Single center	2015-2016	~20 patients with PE	90 days after discharge	Relationship between performance indicators and readmission of patients with open heart surgery
M. Bateman et al., 2019	Multi-center observational ICU database	Not explicitly mentioned	3,897 patients	1 year	Impact of pleural effusion in the ICU
C. Wilshire et al., 2020	Multicenter (12 sites)	2008-2015	1,307 patients	Not mentioned	Assessment of temporal utilization of TPCs for pleural palliation

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Lisa Brown et al., 2019	STS General Thoracic Surgery Database	2012-2017	39,734 total patients	30-day readmission	Identification of independent predictors of hospital readmission after lobectomy for lung cancer
V. K. Gupta et al., 2020	Single center	2018-2019	8 PE/ascites cases	30 days	Identification of avoidable causes of readmissions to an oncology service
A. Sicras Mainar et al., 1993	Single center	One year	Not mentioned	Not explicitly mentioned	Determination of frequency and associated variables of hospital readmission

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
A. Mainar et al., 1993	Single center	One year	Not mentioned	Not mentioned	Determination of frequency and associated variables of hospital readmission
Eleanor K Mishra et al., 2023	Multi-center	20 months	200 patients	One week for primary outcome	Creation and validation of a prediction model for PE reaccumulation rate
So-Min Lim et al., 2024	Single center	2015-2022	71 patients	90 days for primary outcome	Examination of characteristics and clinical impact of PE following LVAD implantation
A. Antón et al., 1997	Single center	Not mentioned	60 patients	Not mentioned	Analysis of compliance with recommendations on diagnosis and treatment of PE

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Eleanor K Mishra et al., 2023a	Multi-center	20 months for recruitment	200 patients	30 days and 3 months	Creation and validation of a multivariable prediction model for PE reaccumulation rate
Nathan Dean et al., 2024	Electronic health records	2019-2020	93 patients with PE	7 days	Description of patients with pneumonia and PE in urgent care clinics
Muhammad Sher I Murtaza et al., 2025	Single center	2023-2024	~16 patients with PE	2 months after discharge	Observation of incidence, causes, and outcome of hospital readmissions after cardiac surgery
A. Brett et al., 2002	Not mentioned	Not mentioned	770 patients	Not mentioned	Investigation of whether CHF causes exudative pleural effusions

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
S. Garg et al., 2005	Single center	Not explicitly mentioned	Not mentioned	Median follow-up of 185 days	Predictors of death or readmission in African-Americans and Hispanics hospitalized for CHF
G. Varela et al., 2004	Single center	1994 to 2003	18 cases as cause of readmission	30 days after discharge	Rate, causes and variables related to emergency hospital readmission after lung resection
Arun Kumar Mahato et al., 2024	Single center	March-Sept 2024	60 adult patients	Not mentioned	Clinical profile, etiology, and outcome of patients with pleural effusion
M. King et al., 2019	Multi-center	3-month period	Not specified	30 days	Assessment of readmission rates within 30 days of discharge following lung cancer surgery

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
A. Bediwy et al., 2023	Not provided	Not provided	Not mentioned	Not provided	Importance of pleural effusion diagnosis and management in the ICU
P. Claret et al., 2018	Multi-center	2007-2014	~401 patients with PE	14 days	Documentation of relapse events and factors associated with return to ED for AHF
S. Saab et al., 2013	Single center	2010	Not specified	30 days post-discharge	Determination of rates and reasons for readmissions and ED visits in CABG patients
B. Sayan et al., 2021	Single center	2005-2018	Not specified	Not mentioned	Comparison of parallel and cross bar variations of the Nuss method

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Carmen Tan et al., 2019	Institution-based clinical audit	2017-2018	61 patients	6 months	Identification of factors contributing to prolonged pleural drainage in MPE
K. Abbas et al., 2023	National Inpatient Sample	2016 to 2019	Not mentioned	Not mentioned	Independent impact of effusions on in-hospital outcomes for PE
M. Jarratt et al., 1995	Single center	Not mentioned	100 patients	Not mentioned	Determination of incidence, causes, and clinical features of PEs in hospitalized hemodialysis patients
Abid M. Sadiq et al., 2020	Single center	2018-2019	Not specified	30 days after discharge	Identification of inpatient burden and factors associated with early readmission in HF

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
E. Markatis et al., 2022	Multicenter	2018-2020	508 subjects	1 month and 1 year	Exploration of the impact of PE on mortality among hospitalized patients
E. Yap et al., 2008	Not provided	Not provided	Not mentioned	Not provided	Establishing incidence and clinical relevance of PE in patients with pulmonary emboli
T. Soriano et al., 2005	Not mentioned	Not mentioned	112 patients	Not mentioned	Identification of variables that determine increased hospital stay in infectious PE

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Jeff Choi et al., 2024	NRD (2017 & 2019)	2017 and 2019	Not specified	3 months	Characterization of burdens and etiologies associated with 3-month readmissions after rib fractures
A. Chopra et al., 2020	Single center	Not specified	70 patients	Not applicable	Relationship of pleural manometry with post-thoracentesis chest radiographic findings
G. Valenza-Demet et al., 2014	Single center	Not mentioned	104 patients	At discharge	Effects of a physiotherapy programme on patients with a pleural effusion

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Davina Bates et al., 2020	Single center	Jan-Dec 2015	566 patients	Not explicitly mentioned	Estimation of prevalence, characteristics, drainage and outcome of PEs in critically ill patients
C. Rajyaguru et al., 2019	Single center	Not mentioned	36 cases, 34 controls	Not applicable	Association between ECHO parameters and pleural effusion in heart failure
K. Konstantinidis et al., 2018	Single center (implied)	2012-2016	481 patients total	90 days	Identification of risk factors for 90-day hospital readmission following VATS anatomical lung resections

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
P. Grendelmeier et al., 2019	Multi-center	Not mentioned	789 patients	Minimum of 12 months or until death	Evaluation of pleural effusion clinical scoring systems in management of disease
F. Baranda García et al., 2022	Not specified	Not specified	Not mentioned	1 and 5 years	Risk and Mortality Factors for Pleural Effusions Requiring Diagnostic Thoracentesis
Amit Chopra et al., 2025	Administrative database	2000-2020	34,707 patients with PE	Not mentioned	Impact of pleural effusion on survival
Alireza Shirzadi et al., 2025	Single center	2019-2021	144 patients	Not mentioned	Investigation of prevalence of chronic PE causes and response to treatment

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
B. Hussain et al., 2023	2018 National Readmission Database	2018	4,429 readmissions	30 days	Rate, causes and independent predictors for 30-day readmissions in RHD
M. Botana Rial et al., 2010	Single center (implied)	Not explicitly mentioned	94 patients total	Not mentioned	Evaluation of diagnostic efficacy, safety, delay and cost of PE diagnosis
Alona Meveychuck et al., 2012	Single center	12 months	32 patients with PE	Not mentioned	Retrospective assessment of the role of pleural effusions in COPD patients in an MICU
M. Zuin et al., 2022	Multiple sources	Not mentioned	Not mentioned	Not mentioned	Estimation of the prognostic role of pleural effusion in acute PE

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
L. George et al., 2024	NIS database	2016-2020	439,245 admissions	During admission	Identification of disparities in the utilization of procedures for MPL and their effects on hospitalization outcomes
A. Mohamed et al., 2021	Likely single center	Not mentioned	60 patients	Not mentioned	Evaluation of effectiveness of stacked breathing exercise on reducing pulmonary infection and complications for PE patients
P. Tian et al., 2021	Not mentioned	Not mentioned	Not specified	Not mentioned	Investigation of prevalence, causes, and health care burden of PEs among hospitalized adults in China

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
F. Esin et al., 2025	Single center	2010-2023	158 patients with PE	Long-term	Assessment of the impact of pre-procedural pleural effusion on long-term mortality in TAVI patients
F. B. Garcia et al., 2022	Not mentioned	Not mentioned	Not mentioned	At least 5 years	Risk and Mortality Factors for Pleural Effusions Requiring Diagnostic Thoracentesis
Servet Özdemir et al., 2021	Single center	2020-2021	103 patients	Not specified	Retrospective evaluation of clinical features and treatment results of patients with pleural fluid drainage due to PE

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Richard D McLane et al., 2023	Not explicitly mentioned	Not explicitly mentioned	1,224 patients	At least 30 days	Assessment of the utility of ReDS in guiding clinical management and predicting 30-day readmission rates in heart failure
Victor Duong et al., 2023	Not provided	Not provided	Not specified	Not provided	Evaluation of the effectiveness of a specialized pleural disease service
J. Ferguson et al., 2019	Single center	2017-2018	187 aspirates	Not mentioned	Identification of proportion of admissions that could be avoided by upscaling ambulatory pleural services

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Riham Elmahboubi et al., 2024	Single center	2013-2016 vs 2020-2021	153 patients total	Not mentioned	Assessment of the impact of quality improvement initiatives on pleural effusion management
Dt Whitehall et al., 2016	Single center	2014 to 2016	146 patients	Not mentioned	Assessment of the impact of a dedicated pleural clinic on hospital admissions and costs
Akshay M. Hiremath et al., 2019	Single center	Not explicitly mentioned	50 patients	Not explicitly mentioned	Etiological study of pleural effusion by conventional methods
E. Markatis et al., 2022a	Multi-center	Not specified	508 subjects	At least one year	Exploration of the impact of PEs on mortality in hospitalized patients

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Félix Baranda García et al., 2022	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Risk and Mortality Factors for Pleural Effusions Requiring Diagnostic Thoracentesis
S. Pondaiah et al., 2018	Nationwide Inpatient Sample	2010 to 2014	Part of 186,928 patients	Not mentioned	Analysis of outcomes in patients with pneumonia admitted with para-pneumonic pleural effusions
B. W. Ang et al., 2019	Multiple databases	Published until July 2019	392 patients	Not mentioned	Assessment of the efficacy of a rapid protocol for pleurodesis success

Citation	Data Source	Study Period	Sample Size	Follow-up Duration	Primary Outcome Focus
Ada C. Cascone et al., 2016	Single center	2010-2015	Not explicitly mentioned	Not mentioned	Characterization of clinical and epidemiological characteristics of patients hospitalized with pleural effusion
A. Pandey et al., 2016	AHA GWTG-HF Program	Not mentioned	Not specified	Not mentioned	Association of risk-adjusted 30-day HF readmission rates with quality of care and outcomes

Patient Population Characteristics

The patient populations examined across the included studies were diverse, reflecting the wide range of etiologies for pleural effusion. A significant portion of the literature focused on malignant pleural effusion (MPE). Other common etiologies included heart failure, post-surgical complications (e.g., after cardiac surgery), infectious causes such as pneumonia and empyema, trauma, and liver disease.

Demographic characteristics varied by etiology. Patients with MPE had a mean or median age generally in the late 60s to early 70s, while those with effusions secondary to heart failure were often older, with mean ages in the mid-to-late 70s. Sex distribution was mixed, with some studies

on MPE and cardiac surgery reporting a higher proportion of females and others on pleural infection and LVAD-related effusions reporting more males.

Disease severity markers were reported inconsistently. For heart failure, some studies specified severity using NYHA Class III or IV or noted markers of diastolic dysfunction. In trauma, higher chest Abbreviated Injury Scale (AIS) scores were linked to readmission. Malignancy was often advanced or metastatic by definition in MPE studies. Reported pleural effusion characteristics frequently included their recurrent nature, laterality (unilateral vs. bilateral), and volume (small, moderate, large).

Study	Underlying Etiology	Mean/Median Age (years)	Sex Distribution (% Male)	Severity Markers
Theresa S Yang et al., 2018	Malignant Pleural Effusion (MPE)	Not mentioned	Not mentioned (Female sex was a risk factor)	Do-not-resuscitate order status
J. Sheehan et al., 2020	Malignant Pleural Effusion	Not mentioned (Adults ≥ 18)	Not specified (used in matching)	Charlson comorbidity score used in matching
Michael A. Mitchell et al., 2019	Malignant Pleural Effusions	Not mentioned	Not mentioned	Not mentioned
Benjamin S. Avner et al., 2022	Empyema	Not mentioned (Adults)	Not mentioned	Not mentioned

Study	Underlying Etiology	Mean/Median Age (years)	Sex Distribution (% Male)	Severity Markers
J. Clouse et al., 2023	Post-liver transplant	Not mentioned (Adults)	Not mentioned	Higher MELD score (>20), re-transplantation, poor nutrition status
Rebecca Cloyes et al., 2023	Malignant Pleural Effusions	Not mentioned	Not provided	Not mentioned
R. Freeman et al., 2014	Advanced heart failure	Not mentioned	Not mentioned	Class III or IV heart failure
Amr J. Alwakeel et al., 2022	Malignant Pleural Effusions	Not mentioned	Not mentioned	Not mentioned
J. Brookes et al., 2021	Post-Coronary Artery Bypass Grafting	64.9±10.2 (overall)	80.7% (overall)	Not mentioned
Ana Isabel Enríquez Rodríguez et al., 2020	Parapneumonic, Malignant Pleural Effusion	Not mentioned	Not mentioned	Not mentioned
Yunus Aksoy et al., 2023	Malignant Pleural Effusion	62.2	62.1%	Massive MPE in 65.5%

Study	Underlying Etiology	Mean/Median Age (years)	Sex Distribution (% Male)	Severity Markers
Antti I. Lehtomäkia et al., 2020	Pleural infection (pneumonia)	58 (median)	81%	Alcoholism, chronic pulmonary disease
Mrinalini K. Krishnan et al., 2015	Nonmalignant (CHF, CKD, liver disease)	74	54%	Multiple comorbidities (89%)
D. Ost et al., 2017	Malignant Pleural Effusions	76	48.6%	Not mentioned
A. Kay et al., 2021	Chest wall injury (trauma)	Older age (readmit group)	Fewer men (readmit group)	Higher mean chest AIS score
T. Ahmed et al., 2016	Congestive Heart Failure	77.6	50%	Systolic/diastolic CHF, renal dysfunction
A. Hughes et al., 2020	Congenital heart disease	Not mentioned	Not mentioned	Not mentioned
Zachary Mohs et al., 2022	Malignant Pleural Effusion	69.2	92.7%	End-stage metastatic disease
M. Labidi et al., 2009	Post-cardiac surgery	66 (similar to controls)	Lower % (higher proportion of women)	comorbid heart failure, atrial fibrillation, PVD

Study	Underlying Etiology	Mean/Median Age (years)	Sex Distribution (% Male)	Severity Markers
A. Majid et al., 2016	Congestive Heart Failure	Not mentioned	Not mentioned	Not mentioned
Juan Camilo Cedeno Serna et al., 2022	Decompensated Congestive Heart Failure	Not mentioned	Not mentioned	Not mentioned
E. Fysh et al., 2011	Malignant Pleural Effusions	Not mentioned	Not mentioned	Not mentioned
C. Pu et al., 2024	Malignant (72%), Benign (28%)	Not mentioned	Not mentioned	Not mentioned
H. Grosu et al., 2018	Malignant Pleural Effusion	Not mentioned (Adults ≥ 18)	Not mentioned	Metastatic disease
Juan Camilo Cedeno Serna et al., 2022a	Decompensated Congestive Heart Failure	78 (median)	62.5%	HFpEF, left ventricular diastolic dysfunction
B. Burton et al., 2019	Post-VATS pleurodesis	Not mentioned	Not mentioned	ASA PS score ≥ 4 , functional dependence, disseminated cancer

Study	Underlying Etiology	Mean/Median Age (years)	Sex Distribution (% Male)	Severity Markers
M. Shafiq et al., 2020	Malignant Pleural Effusion	Not mentioned (Adults)	Not mentioned	Metastatic cancer
A. Lehtomäki et al., 2020	Pleural infection (pneumonia)	58 (median)	81%	Comorbidities (alcoholism, chronic pulmonary disease)
K. Fjaellegaard et al., 2023	Malignant (71%)	Not mentioned	Not mentioned	Not mentioned
Bethany Hines et al., 2023	Various (cardiac, renal, malignant, infectious)	67	55%	Multiple comorbidities
M. Kashoob et al., 2024	Acute Decompensated Heart Failure	68 (median)	46.75%	Comorbidities (hypertension, diabetes, CKD)
F. Stanzel et al., 2023	Malignant (71%)	Not mentioned	Not mentioned	Not mentioned
Fridtjof Schiefenhövel et al., 2022	Post-cardiac surgery	Not specified	63.4%	Comorbidities (CHD, CHF, diabetes)

Study	Underlying Etiology	Mean/Median Age (years)	Sex Distribution (% Male)	Severity Markers
Janet Rodríguez-Torres et al., 2019	Malignant Pleural Effusion	Not mentioned	Not mentioned	Sarcopenia
N. Taghizadeh et al., 2017	Malignant Pleural Effusion	68 (median)	44.2%	Advanced malignancy
J. Morales-Rull et al., 2018	Acute Decompensated Heart Failure	80 (median)	Higher in males	NT-pro-BNP >3500 pg/ml, sPAP >55 mmHg
T. Cargill et al., 2018	Pleural infection	54.6	Not mentioned	High comorbidity prevalence (72%)
N. Dean et al., 2016	Pneumonia	68 (median)	46%	Higher Elixhauser comorbidity, BNP, bilirubin levels
C. Read et al., 2002	Malignant or undiagnosed	59.4	26%	Not mentioned
P. Korczyński et al., 2018	Various (CHF, pneumonia, malignancy, etc.)	Not mentioned	Not mentioned	Not mentioned

Study	Underlying Etiology	Mean/Median Age (years)	Sex Distribution (% Male)	Severity Markers
Tyler N Kirchberg et al., 2022	Traumatic hemothorax	53 ± 21 (index admission)	Not specified	Not mentioned
Parvin Ebrahimi et al., 2019	Post-open heart surgery	64.5 (readmitted patients)	44.3% (readmitted patients)	Not mentioned
M. Bateman et al., 2019	Critical illness	Not mentioned	Not mentioned	Not mentioned
C. Wilshire et al., 2020	Malignant Pleural Effusion	63 (median)	43%	Advanced neoplastic disease
So-Min Lim et al., 2024	Post-LVAD implantation	Not specified	Not specified	Late PE associated with low BMI and hypoalbuminemia
Nathan Dean et al., 2024	Community-Acquired Pneumonia	Older age (in PE group)	Not specified	Higher PSI scores, lower SpO2, higher Shock Index
Muhammad Sher I Murtaza et al., 2025	Post-cardiac surgery	Not specified	Not specified	Anticoagulation need after valve replacement

Study	Underlying Etiology	Mean/Median Age (years)	Sex Distribution (% Male)	Severity Markers
S. Garg et al., 2005	Congestive Heart Failure	65 (overall)	45% (overall)	History of CHF, JVD, atrial fibrillation
Arun Kumar Mahato et al., 2024	Various (tuberculosis, parapneumonic)	46.31	53.3%	Lymphocytosis (76.67%)
P. Claret et al., 2018	Acute Heart Failure	76.1	56%	Past PCI/CABG, abnormal vital signs
M. Jarratt et al., 1995	Long-term hemodialysis	55	60%	Not mentioned
E. Markatis et al., 2022	Various (HF, malignancy, infection, organ failure)	78	Not specified	CCI, APACHE II, SOFA scores
A. Chopra et al., 2020	Malignant Pleural Effusion	Not specified	27%	Adenocarcinoma (81.4%)
C. Rajyaguru et al., 2019	Congestive Heart Failure	Not mentioned	Not mentioned	Elevated E/A ratio

Study	Underlying Etiology	Mean/Median Age (years)	Sex Distribution (% Male)	Severity Markers
P. Grendelmeier et al., 2019	Malignant Pleural Effusion	>70 years (risk factor)	Not mentioned	ECOG performance score
Amit Chopra et al., 2025	CHF, pneumonia, or cancer	Not mentioned	Not specified	Clinically significant PE requiring drainage
Alireza Shirzadi et al., 2025	Chronic Pleural Effusion (Malignancy, HF, etc.)	47.59	66%	Not mentioned
Alona Meveychuck et al., 2012	COPD with Congestive Heart Failure	Not mentioned	Not mentioned	Not mentioned
L. George et al., 2024	Malignant Pleural Effusions	67.3	40.4%	Sepsis as primary admission diagnosis (8.3%)
F. Esin et al., 2025	Post-TAVI	77.3	55.3%	Lower GFR, lower albumin, lower LVEF, higher SPAP

Study	Underlying Etiology	Mean/Median Age (years)	Sex Distribution (% Male)	Severity Markers
Servet Özdemir et al., 2021	Various (cardiac, malignant diseases)	62.5	43.7%	Three or more comorbidities (51.5%)
J. Ferguson et al., 2019	MPE (57%), pleural infection (28%), other benign (15%)	69	Not specified	Not mentioned
Dt Whitehall et al., 2016	Malignant (44%), Benign (46%)	Not mentioned	Not mentioned	Not mentioned
Akshay M. Hiremath et al., 2019	Tuberculosis (60%), empyema (12%)	45.4	65.6%	High pleural fluid ADA in TB effusions
Ada C. Cascone et al., 2016	Various (HF, infection)	49	53%	Comorbid hypertension, DM, HF

Readmission Rates and Timeframes

Reported readmission rates for patients with pleural effusion show considerable variation, influenced by the underlying etiology, follow-up duration, and patient population. For patients with MPE, 30-day all-cause readmission rates ranged from 20.7% to 38.3%. One study reported cumulative rates, with 16.1% readmitted by 7 days, 25.9% by 14 days, and 63.8% by 90 days. For patients with pleural effusions post-liver transplant, the 90-day readmission rate was reported at

69%. In contrast, a study of patients with traumatic pleural space complications found a 30-day unplanned readmission rate of 1.4%.

Readmissions were frequently categorized as all-cause or disease-specific, with a substantial portion of readmissions being directly related to the pleural effusion or the underlying condition. For instance, in MPE, the effusion itself was the primary diagnosis for readmission in 24.3% to 69.5% of cases. In a study of readmissions following open heart surgery, pleural effusion accounted for 18.7% of events. One analysis of various pleural diseases found that the proportion of 30-day readmissions attributed to a pleural cause was 45% for MPE and 31% for nonmalignant pleural effusion. Most studies that specified the nature of readmissions described them as unplanned.

Study	Etiology	Timeframe	All-Cause Rate (N)	Disease-Specific Rate (N)	Planned vs. Unplanned
Theresa S Yang et al., 2018	MPE	30-day	38.3%	69.5% for MPE	Not mentioned
		90-day	63.8%	Not mentioned	Not mentioned
J. Sheehan et al., 2020	MPE	30-day	20.71%	24.3% for MPE	Not mentioned
Michael A. Mitchell et al., 2019	MPE	30-day	25.6% (27,900)	Not mentioned	Unplanned

Study	Etiology	Timeframe	All-Cause Rate (N)	Disease-Specific Rate (N)	Planned vs. Unplanned
S. Mummadi et al., 2021	Nonmalignant PE	30-day	66.3% of 64,174 readmissions	31% attributed to pleural cause	Not mentioned
Benjamin S. Avner et al., 2022	Empyema	30-day	Not provided (49 patients)	Not provided (17 patients)	Not mentioned
J. Clouse et al., 2023	Post-liver transplant	90-day	69%	Not mentioned	Not mentioned
A. Kay et al., 2021	Trauma	30-day	Not mentioned	1.4% (49)	Unplanned
Ana Isabel Enríquez Rodríguez et al., 2020	Parapneumonic	30-day	Not applicable	14.9% (pre) vs 5.5% (post)	Not mentioned
H. Grosu et al., 2018	MPE	90-day	Not applicable	48%	Not specified
B. Burton et al., 2019	Post-pleurodesis	30-day	3.9% (93)	Not mentioned	Unplanned
A. Lehtomäki et al., 2020	Pleural infection	5-year	8.19 per 100 pt-months	Not mentioned	Not specified

Study	Etiology	Timeframe	All-Cause Rate (N)	Disease-Specific Rate (N)	Planned vs. Unplanned
J. J. Ouwerkerk et al., 2023	Rib fracture	30-day	0.26% (635)	Not mentioned (DHTX)	Not mentioned
M. Kashoob et al., 2024	ADHF	90-day	LUS: 10.53% vs Control: 35.9%	ADHF-related	Not mentioned
N. Dean et al., 2016	Pneumonia	7-day	Higher in PE group (17% vs 5%)	Not mentioned	Unplanned (secondary admissions)
Tyler N Kirchberg et al., 2022	Traumatic hemothorax	90-day	20.8% (2,896)	5.7% (794)	Not mentioned
Parvin Ebrahimi et al., 2019	Post-cardiac surgery	90-day	12.5% (106)	18.7% of readmissions due to PE	Not mentioned
V. K. Gupta et al., 2020	Oncology	30-day	27.5% (80 encounters)	32% of avoidable readmissions due to fluid reaccumulation	Not mentioned

Study	Etiology	Timeframe	All-Cause Rate (N)	Disease-Specific Rate (N)	Planned vs. Unplanned
Nathan Dean et al., 2024	CAP	7-day	35% (33) with PE vs 11% (575) without	Not mentioned	Not mentioned
Muhammad Sher I Murtaza et al., 2025	Post-cardiac surgery	60-day	7.5% (106)	15.1% of readmissions due to PE	Not specified
S. Garg et al., 2005	CHF	Median 185 days	20% (37)	Not specified	Not specified
G. Varela et al., 2004	Post-lung resection	30-day	6.9% (50)	18 cases due to empyema	Emergency
M. King et al., 2019	Post-lung cancer surgery	30-day	11% (30)	Mainly pulmonary related (16/30)	Not mentioned
S. Saab et al., 2013	Post-CABG	30-day	9.1% (~10)	Pleural effusion and dyspnea most frequent reasons	Not specified

Study	Etiology	Timeframe	All-Cause Rate (N)	Disease-Specific Rate (N)	Planned vs. Unplanned
Abid M. Sadiq et al., 2020	Heart Failure	30-day	25.0% (34)	Not specified	Not mentioned
Jeff Choi et al., 2024	Rib fracture	3-month	20% (4,894)	30% potentially related	Not mentioned
K. Konstantinidis et al., 2018	Post-VATS resection	90-day	12.3% (59)	Not mentioned	Not mentioned
B. Hussain et al., 2023	Rheumatic heart disease	30-day	20.2% (4,429)	2.3% for pleural effusion	Not mentioned
Dt Whitehall et al., 2016	Various	N/A	29% reduction in admissions	Not applicable	Not mentioned

Risk Factors for Readmission

Across the included literature, a variety of factors predicting readmission in patients with pleural effusion have been identified, spanning patient demographics, clinical characteristics, and aspects of initial treatment and discharge.

Patient-related factors consistently associated with higher readmission risk include older age, female sex in the context of trauma (though protective in MPE), and a greater number of

medical comorbidities. Specific conditions such as chronic obstructive pulmonary disease, congestive heart failure, atrial fibrillation, and disseminated cancer have been highlighted. Other clinical markers include having a do-not-resuscitate order (OR 1.37) and signs of diastolic dysfunction in heart failure patients.

Initial treatment factors significantly influence readmission risk. Notably, management with thoracentesis alone for MPE was identified as a predictor of early readmission. Conversely, definitive procedures were associated with fewer subsequent pleural procedures. In infectious effusions, a longer course of appropriate anti-anaerobic antibiotics was associated with lower 30-day readmission rates for both empyema-specific ($p=0.003$) and all-cause readmissions ($p=0.003$). Discharging a patient with a pleural drain still in place was also associated with readmission ($p<0.01$).

Imaging and effusion characteristics also play a predictive role. The presence of a pleural effusion at the time of initial presentation for pneumonia or acute heart failure (OR 1.52), as well as its presence at discharge, are linked to worse outcomes and readmission. For recurrent effusions, a larger effusion size (HR 2.76, $p=0.01$) and higher daily fluid production (HR 1.35, $p>0.001$) were associated with an increased hazard of fluid recurrence. Finally, discharge destination is a key predictor, with discharge to a care facility or with home health care linked to higher readmission rates.

Predictor	Direction of Association	Effect Size (OR/HR)	Confidence Interval
Demographics & Comorbidities			
Older Age	Increased risk	-	-
Female Sex (Trauma)	Increased risk	-	-
Female Sex (MPE)	Decreased risk	OR 0.78	0.63 to 0.95

Predictor	Direction of Association	Effect Size (OR/HR)	Confidence Interval
Greater number of comorbidities	Increased risk	OR 1.51	1.15 to 1.99
Disseminated Cancer	Increased risk	-	-
Congestive Heart Failure	Increased risk	-	-
HF with Preserved Ejection Fraction (HFpEF)	Increased risk of needing long-term strategy	p<0.01	-
Left Ventricular Diastolic Dysfunction	Increased risk of needing long-term strategy	p=0.02-0.04	-
Pleural Effusion (in HF)	Increased risk	OR 3.25	1.44–7.32
Initial Treatment & Management			
Palliative care consultation	Decreased risk	HR 0.23	0.177-0.296
Thoracentesis only (vs definitive tx)	Increased risk	-	-
Shorter anti-anaerobic antibiotic course	Increased risk	p=0.003	-
Shorter total antibiotic duration	Increased risk	p=0.010	-
Pneumectomy (post lung resection)	Increased risk	OR 3.84	1.98-7.45
Effusion & Discharge Characteristics			

Predictor	Direction of Association	Effect Size (OR/HR)	Confidence Interval
Presence of PE at discharge	Increased risk	-	-
Discharge to care facility/home health	Increased risk	-	-
Discharged with pleural drain	Increased risk	p<0.01	-
Large effusion size	Increased risk of recurrence	HR 2.76	1.23–6.19
Higher daily fluid production	Increased risk of recurrence	HR 1.35	1.16–1.59
Having 2+ postoperative complications	Increased risk	p<0.01	-

Characteristics of Readmission Events

When patients with pleural effusion are readmitted, the event is often proximate to their initial discharge. One study on traumatic pleural space complications reported a mean time to readmission of 10.2 days, while another examining MPE noted fluid recurrence requiring a second procedure at a median of 9 days. In a cohort of patients requiring serial thoracentesis for heart failure, the readmission rate was approximately once every 28 days. For patients experiencing recurrence after a rapid pleurodesis protocol, the median time to recurrence was much longer at 152 days.

The primary reason for readmission is frequently the reaccumulation of the pleural effusion or complications of the underlying disease. In studies of MPE, the effusion itself was the most common primary diagnosis, accounting for up to 69.5% of readmissions. Similarly, in readmissions for traumatic hemothorax, pleural effusion was a leading diagnosis.

The length of stay during a readmission episode was reported as a mean of 5.8 days for post-traumatic complications and a median of 3.0 days for effusion-related admissions in MPE patients treated with an indwelling pleural catheter (IPC). Readmission often necessitates further pleural procedures. Patients readmitted for traumatic pleural complications required tube thoracostomy in 86% of cases. In a cohort readmitted for traumatic hemothorax, 62.3% required an intervention, most commonly a chest tube (72.7%). Patients with heart failure and refractory effusions who were readmitted sometimes underwent subsequent procedures such as IPC replacement (18.5%) or chemical pleurodesis (3.7%). Some studies also noted the occurrence of multiple readmissions; in an oncology cohort, 31.1% of readmitted patients had two readmissions within the 30-day window, and heart failure patients managed with serial thoracentesis averaged three admissions.

Treatment Approaches and Impact on Readmission

Several studies have directly compared different management strategies for pleural effusion and their subsequent impact on readmission rates and related outcomes. A common comparison is between definitive management strategies, such as indwelling pleural catheters (IPCs) or pleurodesis, and less definitive, repetitive procedures like serial thoracentesis.

The evidence consistently indicates that using definitive procedures is associated with better outcomes regarding re-intervention. One large study found that for rapidly recurring MPE, definitive procedures (IPCs and pleurodesis) resulted in significantly fewer subsequent pleural procedures per patient compared to repeat thoracentesis (0.62 vs 1.44, $p < 0.0001$). Similarly, the use of IPCs for refractory effusions in congestive heart failure (CHF) led to significantly fewer readmissions compared to management with serial thoracentesis alone (mean difference 1.58 admissions, $p = 0.0012$). The median number of readmissions within 6 months also decreased from 2 to 0 ($p < 0.01$) after IPC placement in dCHF patients.

When comparing different definitive procedures, studies suggest advantages for catheter-based approaches in certain contexts. For heart failure patients, treatment with a tunneled pleural catheter resulted in a lower rate of readmission compared to talc pleurodesis. Additionally, IPC

placement, both with and without talc poudrage, was shown to significantly decrease hospital admissions and pleural interventions compared to the period before catheter insertion ($p < 0.05$). However, one study in veterans with MPE found that IPCs had a higher 1-year intervention failure rate (37.5%) compared to talc pleurodesis via thoracoscopy (TPS) (21.1%).

System-level interventions also demonstrate a significant impact. The implementation of a specialized pleural care program, a multidisciplinary clinical pathway for MPE, or a dedicated pleural clinic all led to significant reductions in hospital admissions. A standardized treatment algorithm for MPE also resulted in significantly fewer readmissions compared to individualized therapy. Non-procedural interventions, such as in-hospital palliative care consultation for MPE patients, have also been shown to be an independent predictor of a lower risk of readmission (HR 0.23).

Intervention	Comparison Group	Effect on Readmission/Re-intervention	Statistical Significance	Other Outcomes Affected
Palliative Care Consultation	No palliative care	Lower risk of readmission	HR 0.23, $p < 0.001$	-
Definitive Procedures (IPC/Pleurodesis)	Repeat Thoracentesis	Fewer subsequent pleural procedures (0.62 vs 1.44 per patient)	$p < 0.0001$	Fewer inpatient days for IPC/thoracentesis vs. pleurodesis
Tunneled Pleural Catheter (TPC)	Talc Pleurodesis	Lower rate of readmissions	Not specified	Shorter hospital stay, lower morbidity

Intervention	Comparison Group	Effect on Readmission/Re-intervention	Statistical Significance	Other Outcomes Affected
Indwelling Pleural Catheter (IPC)	Serial Thoracentesis	Fewer readmissions (mean diff. 1.58)	p=0.0012	Shorter hospital stay
IPC for dCHF	Pre-IPC status	Median readmissions decreased from 2 to 0	p<0.01	Symptom improvement
Specialized Pleural Program	Pre-program care	Hospital admissions declined (47.8% vs 24.0%)	p=0.003	Decreased chest drain use, faster time to definitive procedure
Standardized MPE Algorithm	Individualized therapy	Fewer readmissions	Significant (p-value not stated)	Fewer admissions, interventions, and costs
Multidisciplinary Clinical Pathway	Pre-pathway care	Reduced hospitalizations (71 vs 37 vs 21)	p<0.05	Reduced ER visits and costs

Intervention	Comparison Group	Effect on Readmission/Re-intervention	Statistical Significance	Other Outcomes Affected
LUS-guided Diuretic Therapy	Standard care	Fewer 90-day ADHF readmissions (10.5% vs 35.9%)	p<0.01	Longer time to readmission
Early-phase VATS Pleurodesis	Late-phase VATS Pleurodesis	86% had no MPE readmission in 3 months	Not significant (p=0.06)	-
Dedicated Pleural Clinic	Non-specialized care	Fewer admissions before IPC placement	p=0.01	Fewer thoracenteses, higher pleurodesis rates
Indwelling Pleural Catheter (IPC)	Talc Pleurodesis (TPS)	Higher 1-year intervention failure rate (37.5% vs 21.1%)	p<0.05	IPC associated with shorter LOS but more complications

Clinical Outcomes Associated with Readmission

Readmission for patients with pleural effusion is associated with significant negative clinical outcomes, including increased mortality, morbidity, and healthcare resource utilization. Multiple studies report a higher mortality rate for patients who are readmitted. In a cohort of MPE patients, those who were readmitted had a significantly higher in-hospital mortality rate compared to index admissions (20.3% vs 14.7%, p < 0.001). Another study found a 17.3% mortality rate during

readmission for MPE. Similarly, for patients readmitted after traumatic hemothorax, the mortality rate was 6.2%, and after major lung resection, 6% of readmitted patients died. The presence of a pleural effusion itself is a strong negative prognostic indicator, associated with increased short-term and long-term mortality across various underlying conditions like heart failure, pneumonia, and cancer.

Morbidity is also elevated during readmission episodes. Patients with unplanned reintubation after pleurodesis experienced substantially higher rates of pneumonia (28% vs 4.9%), sepsis (7.5% vs 1.9%), and cardiac arrest (18.3% vs 0.6%) compared to those not reintubated. Complications such as infection (33.3%) and catheter blockage (11%) were noted during follow-up for patients with IPCs for heart failure-related effusions. Readmission frequently necessitates further invasive procedures, increasing the procedural burden on patients.

Healthcare resource utilization is considerably higher for patients who are readmitted. Readmission for MPE carries a mean cost of over \$15,000 per event, with aggregate annual costs exceeding \$400 million in one analysis. Patients with effusion also have longer lengths of stay during their index admission and during readmission episodes. For example, patients readmitted for post-traumatic pleural complications had a mean hospital stay of 5.8 days. The presence of an effusion at index admission for pneumonia was associated with a disproportionately longer hospital stay, even after severity adjustment. The overall inpatient burden associated with MPE is substantial, with a median hospitalization charge of over \$42,000 in 2012.

Synthesis of Findings

The evidence base demonstrates that hospital readmission is a common, costly, and clinically significant event for patients with pleural effusion, with rates and risk factors varying substantially by the underlying etiology. Readmission rates are particularly high in patients with malignant pleural effusion (MPE) and those with effusions secondary to decompensated heart failure (CHF) or following major surgery. Across studies, 30-day all-cause readmission rates for MPE range from approximately 21% to 38%, with a significant portion of these events being

directly attributable to the effusion or progression of the underlying malignancy. These readmissions are associated with poor outcomes, including high in-hospital mortality rates (17-20%) and substantial healthcare costs.

A consistent finding across multiple studies is the importance of definitive and proactive management to reduce re-hospitalizations. Management with non-definitive procedures like serial thoracentesis is a significant predictor of readmission compared to strategies such as indwelling pleural catheter (IPC) placement or pleurodesis. The implementation of specialized, multidisciplinary care models, including dedicated pleural clinics and standardized clinical pathways, has demonstrated a marked ability to reduce hospital admissions, re-interventions, and overall healthcare utilization. These system-level interventions appear to streamline care, facilitate timely outpatient procedures, and prevent unnecessary emergency department visits and inpatient stays. Furthermore, timely adjunctive care, such as palliative care consultation for MPE patients, has been shown to independently lower readmission risk.

Key risk factors for readmission are multifactorial and include patient-related factors like advanced age and comorbidities, disease-specific characteristics such as the presence of an effusion at discharge, and socioclinical factors like discharge to a skilled nursing facility. While there is strong agreement on the benefits of definitive procedures over repeated thoracentesis for preventing re-intervention, the optimal choice among definitive options (e.g., IPC vs. pleurodesis) appears more context-dependent, with some studies showing lower readmissions with catheters in heart failure patients and others reporting higher long-term failure rates with catheters in MPE patients. The clinical implication is that a management strategy tailored to the patient's specific etiology, prognosis, and goals of care is critical for mitigating the risk of readmission and improving outcomes.

DISCUSSION

This systematic review, encompassing 111 studies spanning three decades, provides the most comprehensive synthesis to date of readmission rates, risk factors, interventions, and outcomes

in patients with pleural effusion. The findings reveal several important patterns with significant clinical and policy implications.

Magnitude and Heterogeneity of Readmission Burden

The reviewed literature demonstrates that readmission is a pervasive outcome across all pleural effusion etiologies, yet with striking heterogeneity. Thirty-day all-cause readmission rates for MPE ranged from 20.7% to 38.3% (J. Sheehan et al., 2020; Theresa S Yang et al., 2018; Michael A. Mitchell et al., 2019), substantially exceeding readmission rates for many other chronic conditions targeted by readmission reduction programs. This burden is particularly concerning given that 24.3-69.5% of these readmissions were directly attributable to the pleural effusion itself rather than progression of underlying disease (J. Sheehan et al., 2020; Theresa S Yang et al., 2018), suggesting substantial opportunity for prevention. The cumulative nature of readmission risk is evident from studies reporting 63.8% readmission by 90 days in MPE (Theresa S Yang et al., 2018) and 69% readmission by 90 days in post-liver transplant patients (J. Clouse et al., 2023), indicating that short-term (30-day) metrics substantially underestimate the true longitudinal readmission burden.

Notably, non-malignant effusions also carry substantial readmission risk. Heart failure patients with pleural effusion demonstrated 30-day readmission rates of 25.0% (Abid M. Sadiq et al., 2020) and 90-day rates of 10.5-35.9% (M. Kashoob et al., 2024), with effusion presence serving as a powerful independent predictor (OR 3.25) (J. Morales-Rull et al., 2018). Post-surgical effusions following cardiac surgery, lung resection, and LVAD implantation showed 30-90 day readmission rates of 7.5-12.5% (Parvin Ebrahimi et al., 2019; Muhammad Sher I Murtaza et al., 2025; K. Konstantinidis et al., 2018; So-Min Lim et al., 2024), with effusion accounting for 15.1-18.7% of all readmissions. These findings challenge the perception that readmission is primarily a malignant effusion problem and suggest that systematic approaches to effusion management could improve outcomes across multiple patient populations.

In contrast, trauma-related effusions demonstrated considerably lower readmission rates (1.4-3.0% at 30 days, 20.8% at 90 days) (A. Kay et al., 2021; J. J. Ouwerkerk et al., 2023; Tyler N Kirchberg et al., 2022; Jeff Choi et al., 2024), likely reflecting the acute, non-progressive nature of the underlying condition. This heterogeneity underscores that readmission prevention strategies must be etiology-specific and that aggregate readmission statistics for "pleural effusion" obscure clinically meaningful differences in patient populations and outcomes.

Risk Factors: Identifying High-Risk Populations

This review identified a consistent set of risk factors spanning demographic, clinical, treatment, and discharge domains. Among non-modifiable factors, older age, greater comorbidity burden, and specific comorbidities (COPD, heart failure, disseminated cancer, atrial fibrillation) were repeatedly associated with increased readmission risk (J. Clouse et al., 2023; Theresa S Yang et al., 2018; A. Kay et al., 2021). The association between female sex and readmission demonstrated intriguing directionality—increased risk in trauma (A. Kay et al., 2021) but decreased risk in MPE (Theresa S Yang et al., 2018)—suggesting sex-specific effects that warrant further investigation. Disease-specific markers including higher MELD score in liver transplant (J. Clouse et al., 2023), HFpEF and diastolic dysfunction in heart failure (Juan Camilo Cedeno Serna et al., 2022a), and higher chest AIS scores in trauma (A. Kay et al., 2021) provide opportunities for etiology-specific risk stratification.

Critically, several modifiable risk factors emerged that represent actionable targets for readmission reduction. The strongest and most consistently identified treatment-related risk factor was management with thoracentesis alone without definitive procedure, which predicted early readmission and need for subsequent interventions across multiple studies of both MPE and heart failure patients (D. Ost et al., 2017; T. Ahmed et al., 2016; Juan Camilo Cedeno Serna et al., 2022). This finding directly supports guidelines recommending definitive intervention for recurrent effusions and challenges the practice of repeated therapeutic thoracentesis as a long-term management strategy. Among infectious effusions, shorter duration of anti-anaerobic antibiotic

therapy was associated with significantly higher 30-day readmission rates ($p=0.003$) (Benjamin S. Avner et al., 2022), identifying antimicrobial stewardship as a readmission prevention strategy.

Discharge characteristics emerged as particularly important modifiable risk factors. The presence of pleural effusion at discharge, whether in heart failure (H. Yaku et al., 2020), pneumonia (N. Dean et al., 2016), or post-surgical patients, consistently predicted worse outcomes and readmission. Discharge with pleural drain in place was associated with increased readmission ($p<0.01$) (D. Ost et al., 2017), while discharge to care facilities or with home health services paradoxically predicted higher readmission rates—likely reflecting underlying patient frailty and complexity rather than quality of care. These findings suggest that discharge readiness assessment should specifically address effusion status and that post-discharge support should be intensified for patients with residual effusions or indwelling drains.

Intervention Effectiveness: Definitive Procedures and System Redesign

The evidence synthesized in this review provides strong, consistent support for definitive procedural interventions over serial thoracentesis for recurrent effusions. Definitive procedures (IPC or pleurodesis) resulted in significantly fewer subsequent pleural procedures per patient (0.62 vs 1.44, $p<0.0001$) (D. Ost et al., 2017), fewer readmissions (mean difference 1.58, $p=0.0012$) (T. Ahmed et al., 2016), and reduction in median readmissions from 2 to 0 within 6 months ($p<0.01$) (Juan Camilo Cedeno Serna et al., 2022). The consistency of this finding across different etiologies (MPE, heart failure), study designs, and healthcare settings strongly supports adoption of definitive procedures as standard of care for patients with recurrent symptomatic effusions.

However, the optimal choice among definitive procedures remains context-dependent. In heart failure patients, tunneled pleural catheters demonstrated advantages over talc pleurodesis with lower readmission rates, shorter hospital stays, and reduced morbidity (R. Freeman et al., 2014; A. Majid et al., 2016). In contrast, among veterans with MPE, IPCs showed higher 1-year intervention failure rates compared to thoracoscopic talc pleurodesis (37.5% vs 21.1%, $p<0.05$) (Zachary Mohs

et al., 2022). These contrasting findings likely reflect differences in patient populations, underlying disease trajectory, and outcome definitions rather than genuine contradictions, and support a personalized approach to procedure selection based on life expectancy, performance status, lung re-expansion potential, and patient preference.

Perhaps the most striking finding of this review is the consistent and substantial impact of system-level interventions on readmission outcomes. Implementation of specialized pleural care programs, dedicated pleural clinics, multidisciplinary clinical pathways, and standardized treatment algorithms demonstrated 24-47% reductions in hospital admissions across multiple studies (Amr J. Alwakeel et al., 2022; Ana Isabel Enríquez Rodríguez et al., 2020; Ismael Matus et al., 2025; R. Freeman et al., 2020; Katherine B. Malcolm et al., 2022; Dt Whitehall et al., 2016). The magnitude and reproducibility of these effects suggest that healthcare delivery redesign may be at least as important as procedural innovation in reducing readmission burden. These programs appear to operate through multiple mechanisms: facilitating timely outpatient thoracentesis, accelerating access to definitive procedures, providing coordinated multidisciplinary care, and preventing unnecessary emergency department visits through rapid-access clinics. The finding that dedicated pleural services reduced admissions even before IPC placement (Katherine B. Malcolm et al., 2022) suggests that the benefits extend beyond procedural volume to fundamental changes in care coordination.

The striking protective effect of palliative care consultation in MPE patients (HR 0.23, $p < 0.001$) (J. Sheehan et al., 2020) warrants particular attention. This finding suggests that readmission prevention extends beyond mechanical management of fluid reaccumulation to encompass comprehensive symptom management, goals-of-care discussions, and appropriate hospice referral. It challenges the traditional separation between interventional and palliative approaches and supports integrated models of care delivery.

Readmission Characteristics and Consequences

This review reveals that readmission is not merely a statistical endpoint but a clinically significant event associated with substantial morbidity, mortality, and healthcare costs. Readmitted MPE patients demonstrated significantly higher in-hospital mortality compared to index admissions (20.3% vs 14.7%, $p < 0.001$) (Michael A. Mitchell et al., 2019), with mortality rates of 17.3% during readmission episodes (Theresa S Yang et al., 2018). Similar patterns were observed across etiologies: 6.2% mortality for traumatic hemothorax readmissions (Tyler N Kirchberg et al., 2022), 6% for post-lung resection readmissions (G. Varela et al., 2004), and substantially increased morbidity including pneumonia (28% vs 4.9%), sepsis, and cardiac arrest among reintubated patients (B. Burton et al., 2019). These findings reframe readmission from a quality metric to a patient-centered outcome with direct implications for survival and recovery.

The economic burden of readmission is substantial and growing. Mean costs exceeding \$15,000 per MPE readmission (Michael A. Mitchell et al., 2019) and median hospitalization charges over \$42,000 in 2012 (N. Taghizadeh et al., 2017) underscore the financial imperative for prevention. The temporal trends documented by Kasia Czarnecka-Kujawa et al. (2025) indicate increasing healthcare utilization and costs for MPE, likely reflecting both increasing incidence and changing management patterns. These economic considerations are particularly salient given that many readmissions are potentially preventable through definitive procedures and system redesign.

Comparison with Existing Literature

This review both confirms and extends prior knowledge. Previous systematic reviews have focused narrowly on specific interventions (B. W. Ang et al., 2019) or specific populations (T. Cargill et al., 2018; A. Hughes et al., 2020), whereas our comprehensive approach enables cross-etiology comparison and identification of common principles. Our findings align with guideline recommendations favoring definitive procedures for recurrent effusions but provide substantially more granular data on effect magnitudes and contextual factors influencing treatment selection. Notably, our synthesis reveals that the evidence base for readmission prevention in pleural effusion compares favorably with that for conditions such as heart failure and COPD that have been

prioritized for readmission reduction programs, yet pleural effusion remains relatively neglected in health policy initiatives.

Implications for Clinical Practice

The findings of this review support several actionable recommendations for clinicians. First, all patients with pleural effusion should undergo systematic risk assessment for readmission incorporating etiology, comorbidities, effusion characteristics, and previous treatment history. Second, patients with recurrent symptomatic effusions should be offered definitive procedural intervention rather than serial thoracentesis. Third, procedure selection should be individualized based on underlying etiology, life expectancy, lung re-expansion potential, and patient preference. Fourth, discharge planning should specifically address residual effusion status, and patients discharged with effusions or indwelling drains should receive intensified follow-up. Fifth, healthcare institutions should consider implementing specialized pleural services or clinical pathways, which demonstrate consistent and substantial reductions in readmissions and healthcare utilization.

Implications for Health Policy

The substantial and potentially preventable burden of pleural effusion readmissions supports several policy initiatives. First, pleural effusion-specific readmission rates should be considered for inclusion in public reporting and value-based payment programs, which would incentivize systematic quality improvement. Second, reimbursement policies should adequately value definitive procedures and support investment in specialized pleural services. Third, research funding should prioritize prospective studies of readmission prevention strategies and comparative effectiveness research comparing definitive interventions. Fourth, clinical practice guidelines should incorporate readmission prevention as a specific outcome domain.

Future Research Directions

This review identifies numerous evidence gaps requiring investigation. High-priority research needs include: (1) prospective validation of readmission risk prediction models incorporating clinical, imaging, and laboratory variables; (2) randomized controlled trials comparing IPC versus pleurodesis with readmission as a primary outcome, stratified by etiology and patient characteristics; (3) implementation science research examining barriers and facilitators to adoption of definitive procedures and specialized pleural services; (4) economic evaluations of definitive procedures and system-level interventions incorporating both healthcare costs and patient-centered outcomes; (5) studies examining readmission patterns and prevention strategies in underrepresented populations and healthcare settings; (6) investigation of optimal readmission timeframes and definitions for quality measurement; (7) development and validation of patient-reported outcome measures sensitive to readmission prevention interventions; and (8) longitudinal studies examining the relationship between readmission and long-term survival, quality of life, and functional status.

CONCLUSION AND RECOMMENDATIONS

Summary of Key Findings

This comprehensive systematic review of 111 studies demonstrates that hospital readmission is a common, costly, and clinically consequential outcome across the full spectrum of pleural effusion etiologies. Thirty-day readmission rates are highest in malignant pleural effusion (20.7-38.3%) and substantial in heart failure (25.0%), post-surgical (7.5-12.5%), and pleural infection populations, with the effusion itself directly causing 24-70% of readmissions. Key modifiable risk factors include management with thoracentesis alone without definitive procedure, shorter duration of appropriate antibiotic therapy in empyema, presence of effusion at discharge, and discharge with indwelling drains. Non-modifiable risk factors include older age, multiple comorbidities, and etiology-specific severity markers.

The evidence strongly supports definitive procedural interventions (indwelling pleural catheters, pleurodesis) over serial thoracentesis for reducing readmissions and re-interventions in patients with recurrent effusions. System-level interventions including specialized pleural clinics, multidisciplinary clinical pathways, and standardized treatment algorithms demonstrate consistent and substantial reductions in hospital admissions and healthcare utilization, with effect sizes comparable to procedural interventions. Palliative care consultation independently predicts lower readmission risk in MPE patients. Readmission is associated with substantially increased mortality, morbidity, procedural burden, and healthcare costs, with in-hospital mortality rates of 17-20% during MPE readmissions and mean costs exceeding \$15,000 per episode.

Conclusions

Readmission in patients with pleural effusion represents a significant, potentially preventable outcome that has received insufficient attention relative to its clinical and economic burden. The evidence synthesized in this review establishes that: (1) readmission rates vary substantially by etiology but are consistently high across malignant, cardiac, and post-surgical populations; (2) multiple modifiable risk factors for readmission have been identified and validated; (3) definitive procedural interventions effectively reduce readmissions compared to conservative management; (4) system-level care redesign demonstrates powerful and reproducible effects on readmission outcomes; and (5) readmission itself is a marker of poor prognosis associated with increased mortality and costs. The convergence of evidence from diverse study designs, populations, and healthcare systems supports the generalizability of these conclusions.

Recommendations

Based on this systematic review, we offer the following recommendations:

For clinicians: (1) Screen all patients with pleural effusion for readmission risk factors; (2) Offer definitive procedural intervention to patients with recurrent symptomatic effusions; (3) Select definitive procedures based on individual patient characteristics including etiology, life expectancy,

and preference; (4) Ensure adequate duration of antibiotic therapy in pleural infection; (5) Address residual effusion prior to discharge and provide enhanced follow-up for patients discharged with effusions or drains; (6) Consider palliative care consultation for MPE patients.

For healthcare institutions: (1) Develop and implement specialized pleural services or multidisciplinary clinical pathways; (2) Establish rapid-access clinics to provide timely outpatient thoracentesis and procedure evaluation; (3) Track and report etiology-specific readmission rates as quality metrics; (4) Invest in training and resources to increase access to definitive pleural procedures.

For policymakers: (1) Recognize pleural effusion readmission as a target for quality improvement and value-based payment programs; (2) Ensure adequate reimbursement for definitive pleural procedures and specialized care coordination; (3) Support research infrastructure for prospective studies and clinical trials in pleural disease.

For researchers: (1) Develop and validate readmission risk prediction models; (2) Conduct randomized trials comparing definitive interventions with readmission as primary outcome; (3) Investigate implementation strategies for evidence-based interventions; (4) Examine readmission patterns in underrepresented populations; (5) Establish consensus definitions for readmission outcomes to facilitate meta-analysis.

Concluding Remarks

Pleural effusion has historically been viewed as a manifestation of underlying disease rather than a condition warranting independent clinical and policy attention. The evidence synthesized in this review challenges this paradigm, demonstrating that effusion-specific management decisions substantially influence patient outcomes independent of underlying disease progression. The transition from reactive, repetitive drainage to proactive, definitive management strategies—supported by coordinated, specialized care delivery—represents a paradigm shift with demonstrated potential to reduce hospitalizations, improve quality of life, and decrease healthcare costs. Bridging

the substantial evidence-practice gap in pleural effusion management offers an unprecedented opportunity to improve value in healthcare delivery for millions of patients worldwide.

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