Popliteal Artery Aneurysm: Systematic Review with ☸SAIMSARA.

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Abstract: The aim of this paper is to provide a comprehensive overview of popliteal artery aneurysms, synthesizing current research on their presentation, etiology, diagnosis, and treatment strategies, as well as identifying key gaps in the literature. The review utilises 217 studies with 15425 total participants (naïve ΣN). Limb salvage rates at 1 year or 12 months for popliteal artery aneurysm (PAA) repair consistently demonstrate high success, with a median unweighted limb salvage rate of 100% and a range from 84.2% to 100%. These high rates are observed across diverse patient populations and treatment modalities, indicating effective limb preservation. However, the heterogeneous study designs and prevalence of retrospective analyses represent a significant limitation, affecting the certainty and generalizability of some findings. A concrete next step is to conduct prospective, randomized controlled trials to compare the long-term efficacy and durability of open versus endovascular repair for popliteal artery aneurysms.

Keywords: Popliteal artery aneurysm; Endovascular repair; Open surgical repair; Thrombosis; Rupture; Limb salvage; Stent-graft; Neutrophil-to-lymphocyte ratio; Apolipoprotein E; Graft patency

Review Stats

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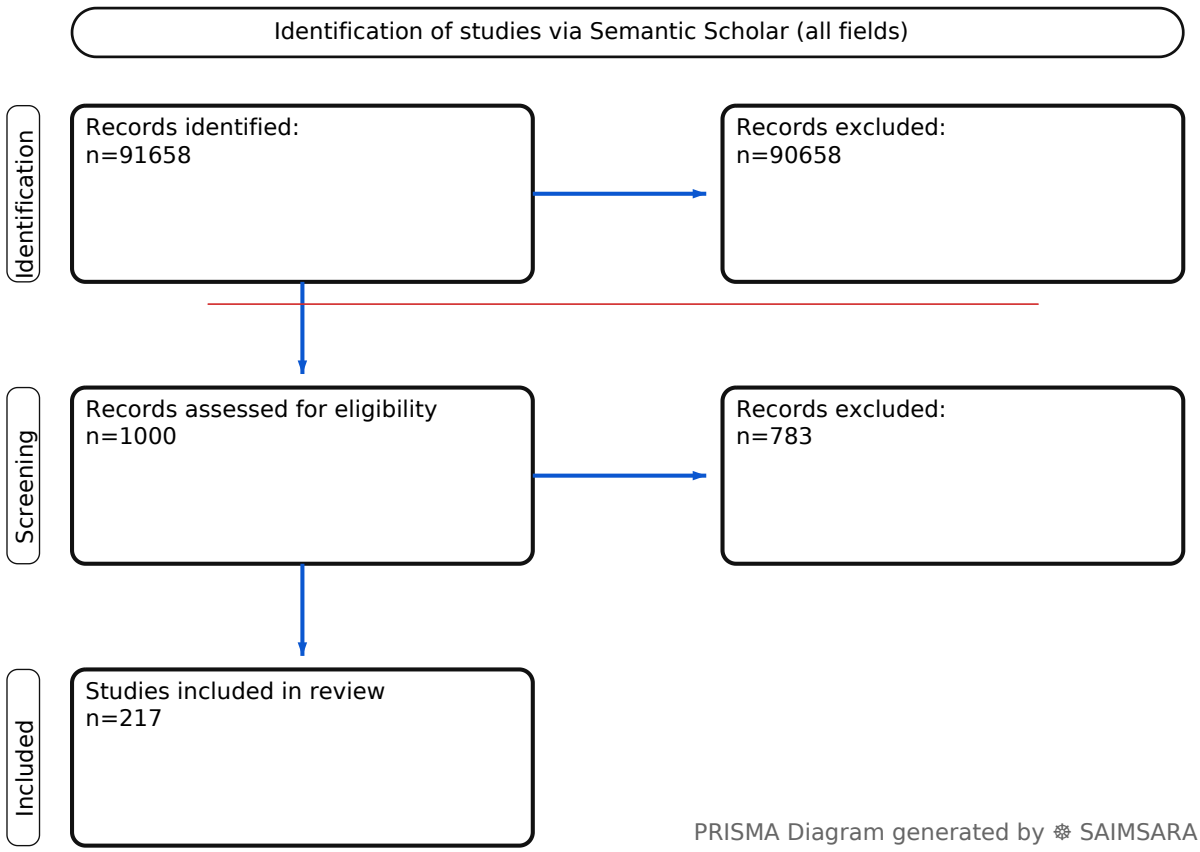
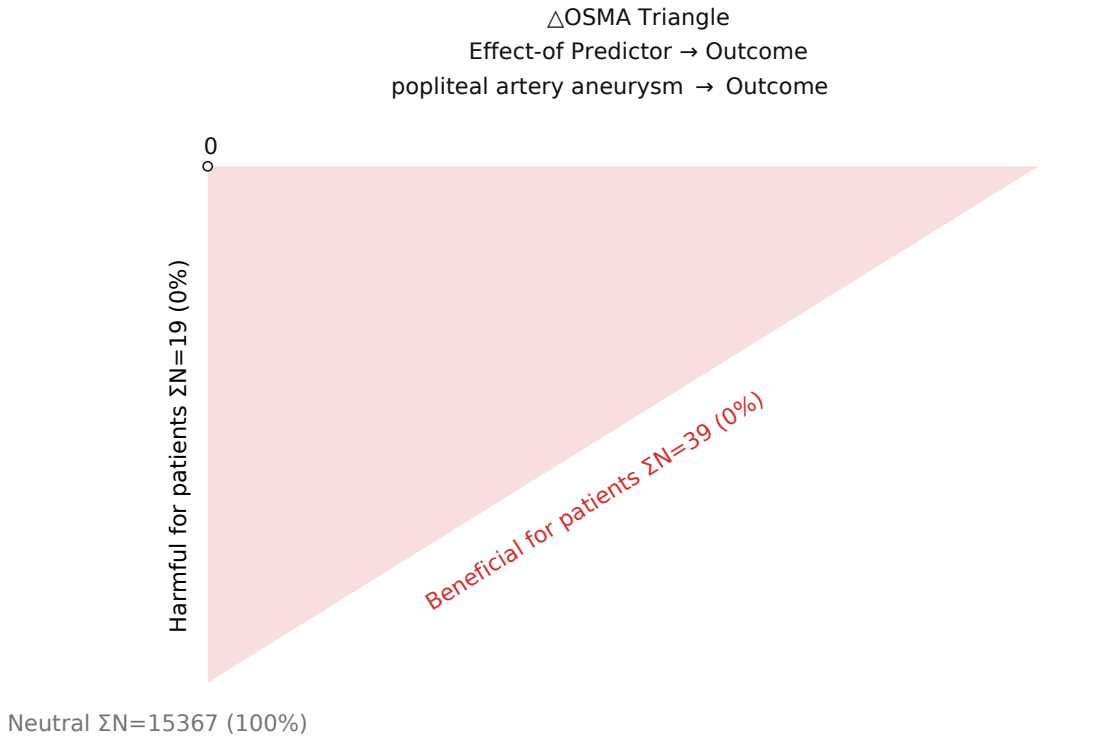
- Plan: Pro (expanded craft tokens; source: Semantic Scholar)
- Source: Semantic Scholar
- Scope: All fields
- Keyword Gate: Fuzzy (≥60% of required terms, minimum 2 terms matched in title/abstract)
- Total Abstracts/Papers: 91658
- Downloaded Abstracts/Papers: 1000
- Included original Abstracts/Papers: 217
- Total study participants (naïve ΣN): 15425



PRISMA Diagram generated by ☸ SAIMSARA



Neutral ΣN=15367 (100%)

△OSMA Triangle generated by ☸SAIMSARA

Outcome-Sentiment Meta-Analysis (OSMA): *(LLM-only)*

Frame: Effect-of Predictor → Outcome • *Source*: Semantic Scholar

Outcome: Outcome Typical timepoints: peri/post-op, 5-y. Reported metrics: %, CI, p.

Common endpoints: Common endpoints: patency, mortality, complications.

Predictor: popliteal artery aneurysm — exposure/predictor. Routes seen: oral. Typical comparator: endovascular treatment for, control, open repair of popliteal, women….

- **1) Beneficial for patients** — Outcome with popliteal artery aneurysm — [201] — ΣN=39
- **2) Harmful for patients** — Outcome with popliteal artery aneurysm — [215] — ΣN=19
- **3) No clear effect** — Outcome with popliteal artery aneurysm — [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27], [28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64], [65], [66], [67], [68], [69], [70], [71], [72], [73], [74], [75], [76], [77], [78], [79], [80], [81], [82], [83], [84], [85], [86], [87], [88], [89], [90], [91], [92], [93], [94], [95], [96], [97], [98], [99], [100], [101], [102], [103], [104], [105], [106], [107], [108], [109], [110], [111], [112], [113], [114], [115], [116], [117], [118], [119], [120], [121], [122], [123], [124], [125], [126], [127], [128], [129], [130], [131], [132], [133], [134], [135], [136], [137], [138], [139], [140], [141], [142], [143], [144], [145], [146], [147], [148], [149], [150], [151], [152], [153], [154], [155], [156], [157], [158], [159], [160], [161], [162], [163], [164], [165], [166], [167], [168], [169], [170], [171], [172], [173], [174], [175], [176], [177], [178], [179], [180], [181], [182], [183], [184], [185], [186], [187], [188], [189], [190], [191], [192], [193], [194], [195], [196], [197], [198], [199], [200], [202], [203], [204], [205], [206], [207], [208], [209], [210], [211], [212], [213], [214], [216], [217] — ΣN=15367

1) Introduction

Popliteal artery aneurysms (PAAs) represent a significant clinical challenge, accounting for nearly 70% of all peripheral artery aneurysms [8]. While often asymptomatic, symptomatic PAAs typically manifest with lower extremity ischemia, a condition that can be acutely limb-threatening [8, 110]. Complications such as thrombosis and distal embolization are common [7], and rupture, though rare, can lead to substantial morbidity and mortality, including limb amputation [8, 83]. The management of PAAs involves a spectrum of diagnostic and therapeutic approaches, ranging from open surgical

repair to various endovascular techniques. This paper synthesizes current understanding of PAA characteristics, risk factors, treatment modalities, and outcomes.

2) Aim

The aim of this paper is to provide a comprehensive overview of popliteal artery aneurysms, synthesizing current research on their presentation, etiology, diagnosis, and treatment strategies, as well as identifying key gaps in the literature.

3) Methods

Systematic review with multilayer AI research agent: keyword normalization, retrieval & structuring, and paper synthesis (see SAIMSARA About section for details).

- **Bias:** Qualitatively inferred from study design fields. The included literature predominantly consists of retrospective studies, mixed designs (often including case reports), and a limited number of prospective cohorts and randomized controlled trials. This introduces potential biases such as selection bias, information bias, and a lack of generalizability due to small sample sizes in many reports.

4) Results

4.1 Study characteristics:

The studies encompassed a diverse range of designs, primarily retrospective cohorts, mixed studies (often including case reports), and some prospective cohorts and randomized controlled trials. Patient populations varied, including those undergoing urgent or elective PAA repair [1], individuals with symptomatic or ruptured PAAs [2, 83], and specific groups such as pediatric patients [33, 76, 101], patients with Marfan syndrome [10, 215], or those with concomitant abdominal aortic aneurysms (AAAs) [129, 191]. Follow-up periods ranged from short-term assessments (e.g., 24 hours, 30 days) [1] to mid-term (e.g., 14.8 months, 27 months) [13, 178] and long-term evaluations (e.g., 5 years, 25 years) [12, 201].

4.2 Main numerical result aligned to the query:

Limb salvage rates at 1 year or 12 months for popliteal artery aneurysm (PAA) repair consistently demonstrate high success. The median unweighted limb salvage rate reported was 100% [77, 177], with a range from 84.2% to 100% [86].

4.3 Topic synthesis:

- **Clinical Presentation and Complications:** PAAs are the most common peripheral artery aneurysms, accounting for nearly 70% [8]. Symptomatic PAAs often present with lower extremity ischemia [8, 110], and higher percent thrombus is significantly associated with symptomatic PAAs (RRR 15.2; CI 2.69-72.3; P<0.01) and acutely limb-threatening events (RRR 17.9; CI 3.76-85.0; P<0.01) [2]. Rupture, though rare, carries a 13% perioperative mortality rate [83].
- **Risk Factors and Associations:** Men exhibit a considerably higher prevalence of PAAs than women (11.1% vs. 2.5%; $p < 0.001$) [111]. PAAs frequently co-occur with other aneurysms, notably abdominal aortic aneurysms (AAAs), found in less than 3% of men with small AAAs [129, 141], and bilateral popliteal arteries show high correlation (ϕ 0.35 to 0.67) [194, 211]. Conditions like Marfan syndrome [10, 143, 215], Behçet's disease [180, 185], and popliteal artery entrapment syndrome [51, 90, 186, 188] are also linked.
- **Inflammatory and Molecular Markers:** A preoperative neutrophil-to-lymphocyte ratio (NLR) > 5 identifies high-risk PAA patients and negatively impacts long-term freedom from major amputation ($p = 0.038$) [1]. Apolipoprotein E (ApoE) is highly expressed in PAA tissue and may contribute to restoring contractile smooth muscle cell phenotype and reducing cell proliferation [3].
- **Diagnostic Modalities:** Ultrasound is a key diagnostic tool [30, 119, 126, 127, 149, 213], with contrast-enhanced ultrasound (CEUS) offering detailed PAA status information [192]. Multidetector computed tomography angiography (MDCTA) is valuable for thrombosed aneurysms and entrapment syndrome [90].
- **Open Surgical Repair (OR):** OR, including bypass grafting (often with autologous vein grafts for better patency [5]) or end-to-end anastomosis [6, 68], demonstrates excellent outcomes in elective settings, with zero mortality and 100% limb salvage [77]. Long-term results extending to 25 years have been reported [56, 59, 201].
- **Endovascular Repair (ER):** ER, utilizing various stent-grafts (e.g., Viabahn [14], Wallgraft [28, 118], Hemobahn [125], multilayer stents [65, 109, 151]), shows high technical success rates (median 100% [12, 105], range 83.3-100% [86]). It is associated with reduced in-hospital length of stay and fewer red blood cell transfusions compared to OR [12].
- **Comparative Effectiveness:** While some studies report no significant differences in major outcomes between OR and ER [5], others suggest OR might offer greater limb salvage and fewer reinterventions at mid-term [86]. ER can achieve good early and long-term outcomes [12], and prospective randomized studies have compared these approaches for asymptomatic PAAs [44, 66, 74].
- **Outcomes and Patency:** Technical success for ER is high (median 100% [12, 105]). Primary patency rates vary by follow-up, including 61.1% (short/medium term) [13], 79.3% (early midterm) [71], 53.3% (12 months) [177], and 90% (mean 27 months) [178]. Limb salvage rates are consistently high, ranging from 84.2% to 100% at 1 year [77, 86, 177].

- **Thrombosis Management:** PAAs are frequently complicated by thrombosis and distal embolization [7], posing a continuing surgical challenge in acute limb ischemia [31]. Preoperative intraarterial thrombolysis is discussed as a strategy before surgical revascularization for acute ischemia [25, 62, 117, 160, 167].
- **Post-Intervention Complications:** Endoluminal mural thrombotic apposition (EMTS) is common post-ER, often helical, and increases with follow-up duration [4]. Limb flexion can cause stent-graft foreshortening, curvature, and tortuosity [80]. Type II endoleaks can occur after surgical exclusion [32] and may lead to rupture of excluded aneurysms [37]. New aneurysms may also form after PAA surgery [27].

5) Discussion

5.1 Principal finding:

Limb salvage rates at 1 year or 12 months for popliteal artery aneurysm (PAA) repair consistently demonstrate high success, with a median unweighted limb salvage rate of 100% [77, 177] and a range from 84.2% to 100% [86], indicating effective preservation of the affected limb across various treatment modalities.

5.2 Clinical implications:

- Preoperative NLR > 5 can identify high-risk PAA patients, particularly concerning freedom from major amputation, suggesting its utility in risk stratification [1].
- The presence of higher percent thrombus is strongly associated with symptomatic PAAs and acutely limb-threatening events, highlighting the importance of early detection and intervention for thrombosed aneurysms [2].
- Both open repair (OR) and endovascular repair (ER) are viable options for PAA, with OR potentially offering greater limb salvage and fewer reinterventions at mid-term, while ER provides benefits such as reduced hospital stay and transfusions [5, 12, 86].
- Given the high prevalence of PAAs in men (11.1% vs. 2.5% in women) and their frequent co-occurrence with abdominal aortic aneurysms (AAAs), vigilance for PAAs is warranted in male patients, especially those with known AAA [111, 129, 191].
- Regular ultrasound surveillance is a valuable tool for both initial diagnosis and long-term follow-up of PAAs, allowing for monitoring of aneurysm size and patency [119, 122, 213].

5.3 Research implications / key gaps:

- **Comparative Long-Term Outcomes** — There is a need for more prospective, randomized controlled trials comparing the long-term efficacy, durability, and reintervention rates of open versus endovascular repair for various PAA anatomies and clinical presentations [44, 66, 74].
- **Biomarker Predictive Value** — Further research is required to prospectively validate the predictive power of inflammatory markers (e.g., NLR) and molecular markers (e.g., ApoE) in larger cohorts to guide personalized PAA management and identify patients at higher risk of adverse outcomes [1, 3].
- **Optimal Thrombolysis Strategies** — Studies are needed to establish optimal protocols for preoperative intraarterial thrombolysis in acute limb ischemia due to thrombosed PAAs, including agent choice, duration, and patient selection criteria, to improve revascularization outcomes [25, 62, 117].
- **Device Performance in Complex Anatomy** — Research should focus on evaluating the long-term performance of specific endovascular devices (e.g., stent-grafts, multilayer stents) in challenging PAA anatomies, such as those crossing the joint line or exhibiting significant tortuosity, considering factors like EMTS and foreshortening [4, 13, 80].
- **Pathophysiology of PAA Growth** — Deeper investigation into the molecular and cellular mechanisms driving PAA formation and progression, including the role of ApoE and inflammatory processes, could lead to novel pharmacological targets for disease modification [3, 85, 154].

5.4 Limitations:

- **Heterogeneous Study Designs** — The included literature comprises a wide array of study designs, predominantly retrospective cohorts and case reports, limiting the ability to draw strong causal inferences or generalize findings.
- **Small Sample Sizes** — Many studies, particularly case reports and single-center retrospective analyses, involve very small patient numbers, which restricts the statistical power and generalizability of their results.
- **Lack of Standardized Outcomes** — Reporting of key outcomes like patency rates and reintervention rates varies significantly in terms of definitions, follow-up durations, and statistical methods, hindering direct comparison and synthesis.
- **Qualitative Data Dominance** — A substantial portion of the extracted information consists of qualitative observations or case descriptions without quantifiable metrics, limiting comprehensive quantitative analysis.
- **Bias in Retrospective Studies** — The prevalence of retrospective study designs introduces inherent biases, such as selection bias and recall bias, which can affect the

reliability of reported associations and outcomes.

5.5 Future directions:

- **Prospective Comparative Trials** — Conduct randomized controlled trials comparing open versus endovascular repair for specific PAA presentations to establish superior long-term outcomes [44, 66, 74].
- **Standardized Outcome Reporting** — Develop and implement standardized definitions and reporting guidelines for PAA outcomes, including patency, limb salvage, and complications, across studies.
- **Biomarker Validation Studies** — Prospectively validate the utility of inflammatory markers like NLR [1] and molecular markers like ApoE [3] for PAA risk stratification and personalized treatment.
- **Long-Term Device Performance** — Investigate the long-term durability and performance of various endovascular devices, including stent-grafts and multilayer stents, in diverse PAA anatomies [4, 43].
- **Patient-Specific Hemodynamic Modeling** — Utilize computational fluid dynamics to understand intra-stent hemodynamics and predict thrombosis risk in individual patients undergoing endovascular repair [115].

6) Conclusion

Limb salvage rates at 1 year or 12 months for popliteal artery aneurysm (PAA) repair consistently demonstrate high success, with a median unweighted limb salvage rate of 100% [77, 177] and a range from 84.2% to 100% [86]. These high rates are observed across diverse patient populations and treatment modalities, indicating effective limb preservation. However, the heterogeneous study designs and prevalence of retrospective analyses represent a significant limitation, affecting the certainty and generalizability of some findings. A concrete next step is to conduct prospective, randomized controlled trials to compare the long-term efficacy and durability of open versus endovascular repair for popliteal artery aneurysms.

References

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Figure 1. Publication-year distribution of included originals

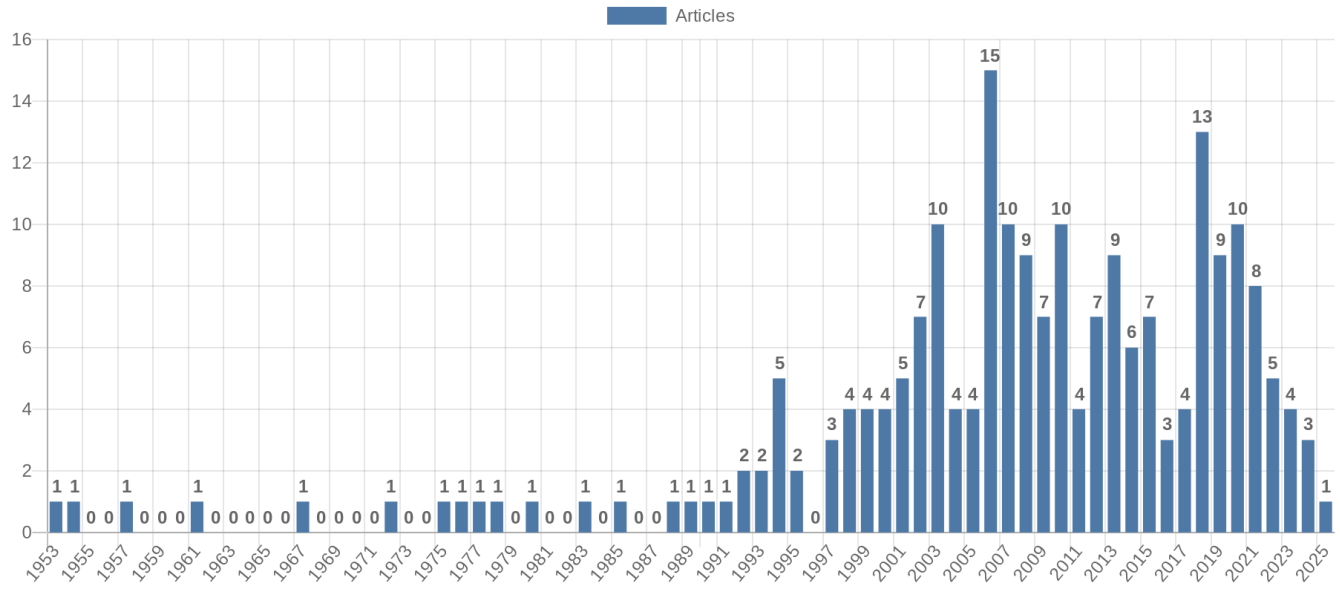

Figure 2. Study-design distribution of included originals

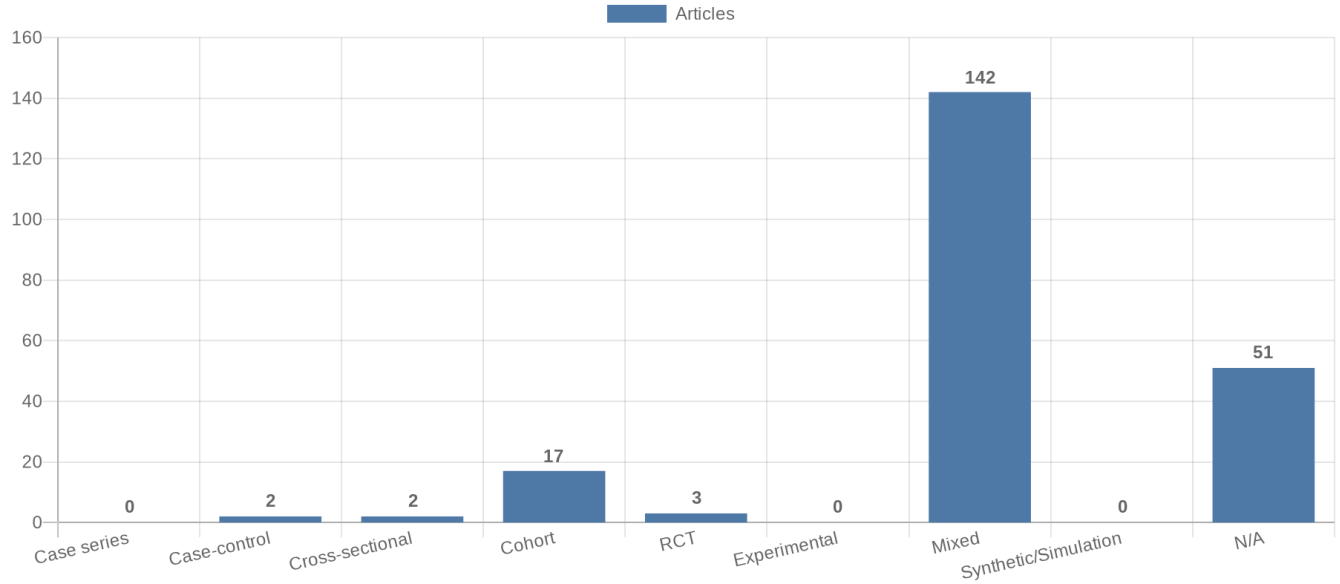

Figure 3. Study-type (directionality) distribution of included originals

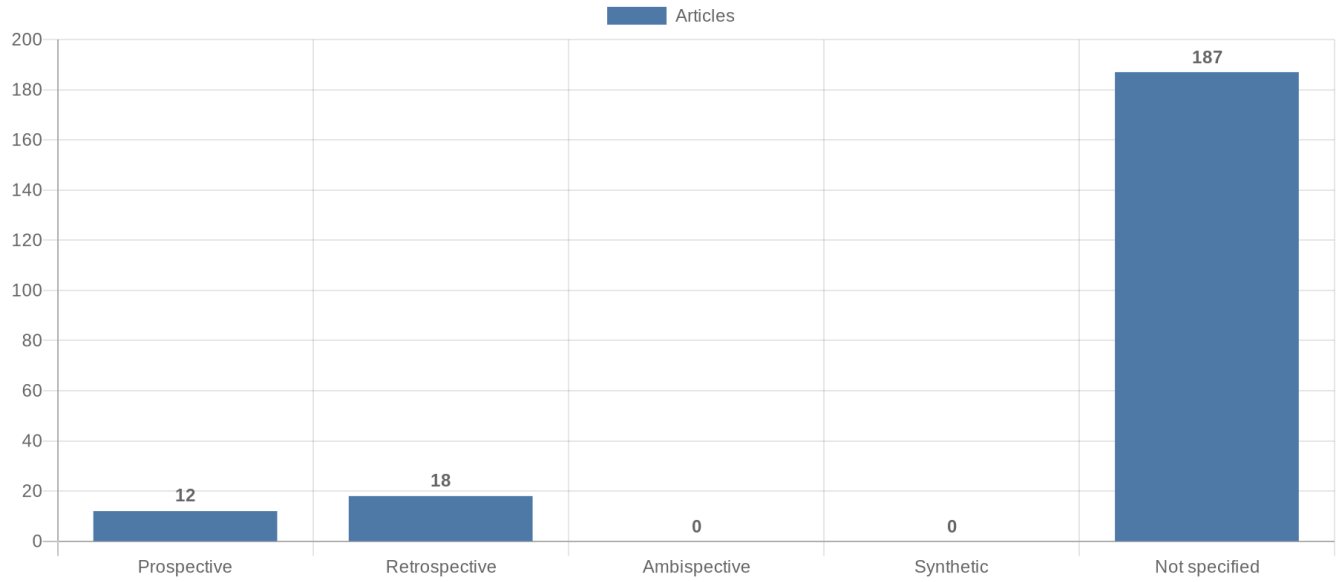

Figure 4. Main extracted research topics

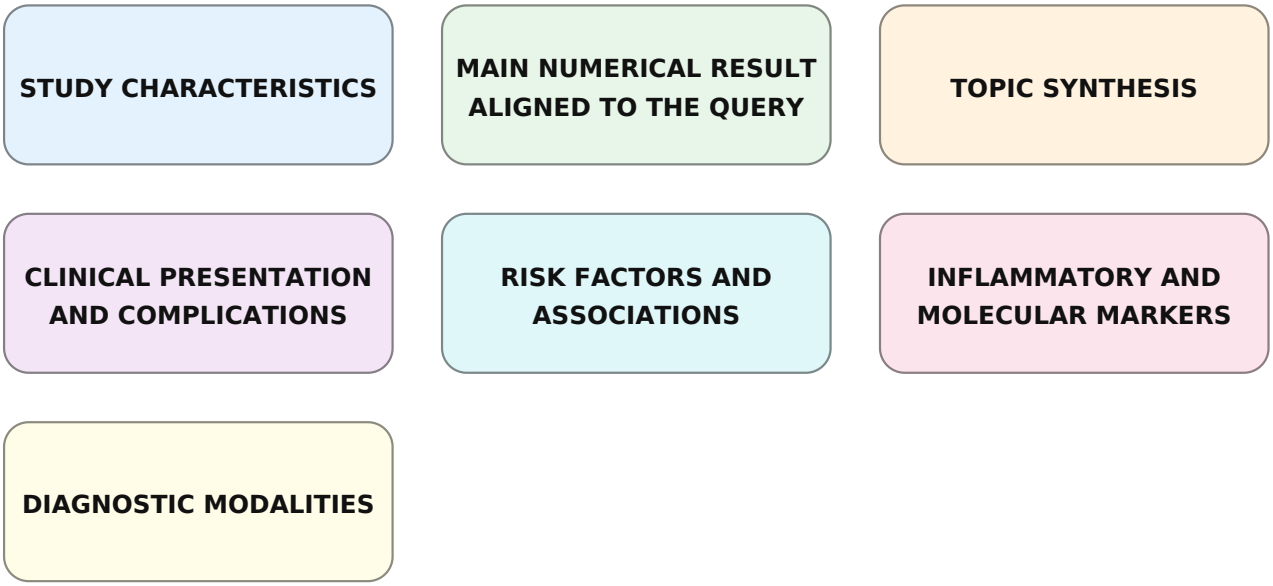

Figure 5. Limitations of current studies (topics)

Figure 6. Future research directions (topics)