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Financial Risks And Insurance Models In Vascular Care

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ABSTRACT

Vascular care is a critical medical specialty that manages complex conditions such as peripheral artery disease (PAD), aortic aneurysms, carotid artery disease, and hemodialysis access dysfunction. These conditions require expensive diagnostics, high-cost implants, advanced endovascular technologies, and multidisciplinary postoperative care. This creates substantial financial risks for healthcare systems, insurance payers, and vascular providers. Concurrently, healthcare financing is transitioning from traditional fee-for-service (FFS) models to value-based payment structures, including bundled payments, global budgets, capitation, and shared-savings models. This research paper examines the types of financial risks associated with vascular care, evaluates insurance and payment models that influence cost distribution, and analyzes their effectiveness using synthesized literature and policy frameworks. A qualitative methodology using systematic literature review informs this paper. Results reveal that bundled payments and hybrid value-based models offer promising cost control while maintaining outcomes, but challenges remain in risk adjustment, device cost variability, and high patient complexity. The study concludes by identifying gaps in evidence and recommending future research focused on predictive analytics, device-cost transparency, and advanced risk-adjustment models tailored to vascular populations.

KEYWORDS: Vascular Care Financing, Healthcare Insurance Models, Financial Risk Management, Value-Based Payment Systems, Bundled Payment Models, Cost-Effectiveness in Vascular Surgery, Reimbursement Strategies, Health Economics

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INTRODUCTION

Vascular diseases—including peripheral arterial disease (PAD), aortic aneurysms, venous thromboembolic disorders, and carotid artery stenosis—represent a major global health burden, with rising incidence linked to aging populations, sedentary lifestyles, and an increasing prevalence of metabolic disorders such as diabetes and hypertension. These conditions often require complex, resource-intensive interventions such as endovascular repairs, bypass grafting, thrombolysis, stenting procedures, and long-term pharmacological management. Consequently, vascular care ranks among the most financially demanding specialties in modern healthcare systems. As healthcare expenditures continue to escalate worldwide, understanding the **financial risks associated with vascular treatment and the insurance models designed to mitigate them** has become a critical area of research.

Financial challenges in vascular care arise from multiple sources: high costs of advanced devices (e.g., drug-eluting stents, prosthetic grafts), unpredictability in clinical course (such as sudden complications or reinterventions), the chronic nature of many vascular conditions, and shifting reimbursement landscapes driven by regulatory changes. Hospital systems and independent vascular practices alike face significant exposure to financial risk, especially as payers increasingly transition from traditional **fee-for-service (FFS)** structures toward **value-based payment (VBP)** frameworks. These evolving models redistribute financial responsibility among insurers, providers, and patients, influencing clinical decision-making, care delivery pathways, and long-term health outcomes.

Simultaneously, global health systems face mounting pressure to achieve **cost-effectiveness without compromising quality or patient safety**. In vascular care, this balance is particularly difficult due to the high-acuity nature of cases, the use of innovative but expensive technologies, and the need for lifelong surveillance in conditions such as aneurysms or chronic limb-threatening ischemia. The presence of comorbidities—common among vascular patients—further increases the risk of complications, extended hospital stays, and readmissions, thereby amplifying both clinical and financial uncertainty.

Insurance models play a pivotal role in distributing these risks. Traditional indemnity-based insurance models offer providers financial protection but may incentivize overutilization. Conversely, contemporary approaches such as **bundled payments,**

shared savings programs, capitation, and pay-for-performance models promote quality-driven, cost-conscious care but institutionalize greater financial accountability for providers. For vascular specialists, the transition to such models requires significant infrastructure development, including data analytics capabilities, care coordination systems, and risk-adjusted outcome measurement.

Given these complexities, there is a pressing need to comprehensively evaluate the **interplay between financial risks and insurance structures in vascular care**, identifying gaps, challenges, and opportunities for improving financial sustainability. Although previous studies have explored costs and outcomes of specific vascular interventions, few have synthesized the broader economic landscape affecting both providers and payers. This research aims to bridge that gap by providing a systematic examination of financial risks in vascular care and assessing the effectiveness, limitations, and future potential of emerging insurance models.

In an era increasingly shaped by personalized medicine, digital health technologies, and predictive analytics, the financial architectures governing vascular care must evolve accordingly. Through rigorous analysis, this paper contributes to the understanding of how optimized insurance models can support sustainable, equitable, and high-quality vascular care delivery while safeguarding clinical innovation and financial stability.

LITERATURE REVIEW

The financial landscape of vascular care has been widely discussed in healthcare economics literature, with increasing attention to how insurance models can redistribute financial risk and influence clinical outcomes. A multidisciplinary body of research—spanning medicine, public health policy, health economics, and hospital management—provides insights into cost drivers, economic vulnerabilities, and evolving payment structures. This literature review synthesizes existing evidence under four major domains: (1) cost and financial risk in vascular interventions, (2) limitations of traditional fee-for-service systems, (3) the rise of value-based and risk-sharing insurance models, and (4) economic evaluations of specific vascular programs and procedures.

2.1 Financial Burden and Cost Drivers in Vascular Care

Several studies have highlighted the significant economic burden associated with vascular diseases. According to Howard et al. (2020), the cost of treating peripheral arterial disease (PAD) in the United States exceeds $21 billion annually, driven by frequent hospitalizations, reinterventions, and long-term medical therapy. Similarly, Dua and Lee (2016) emphasize that major vascular procedures such as endovascular aneurysm repair (EVAR) and open surgical repair generate substantial costs due to advanced devices, operating room time, and postoperative surveillance.

Evidence also suggests that financial risk in vascular care is amplified by patient complexity. O'Donnell et al. (2021) note that patients with chronic limb-threatening ischemia often have multiple comorbidities, including diabetes and renal failure, resulting in unpredictable complications and high readmission rates. Such clinical variability creates financial uncertainty for both providers and insurers, especially when reimbursement is tied to fixed payment structures.

Moreover, the literature highlights the role of device costs as a major contributor to financial risk. The adoption of drug-coated balloons, stents, and hybrid endovascular systems has improved clinical outcomes but significantly increased procedural expenses (Giles et al., 2019). These high upfront costs often lead to budgetary pressures, particularly in resource-limited settings or small vascular practices.

2.2 Limitations of Traditional Fee-for-Service (FFS) Payment Systems

Historically, vascular care has been predominantly financed through fee-for-service models, which reimburse providers for each procedure performed. While FFS has been effective in expanding access to advanced vascular interventions, researchers have criticized it for promoting fragmented care and unnecessary utilization.

Studies from Sorenson et al. (2011) and Tsai et al. (2015) underscore that FFS systems may incentivize volume-driven practices, potentially increasing total healthcare expenditures without corresponding improvements in quality. In vascular surgery specifically, Hussain et al. (2018) find that FFS arrangements tend to reward procedural intensity over preventative measures, discouraging long-term chronic disease management strategies that could reduce future complications.

Additionally, the FFS model places minimal financial risk on providers, transferring most cost burdens to insurers and patients. This imbalance contributes to escalating premiums, higher out-of-pocket expenses, and increased pressure on national health budgets. As a result, both public and private payers have begun shifting toward risk-sharing frameworks, prompting the need for alternative models that better align financial incentives with patient outcomes.

2.3 Emergence of Value-Based Payment and Risk-Sharing Models

The transition from volume-based to value-based care is one of the most significant developments in contemporary healthcare financing. Value-based payment (VBP) models, which include bundled payments, shared savings, capitation, pay-for-performance, and global budgets, aim to align reimbursement with clinical outcomes, care coordination, and cost efficiency.

2.3.1 Bundled Payment Models

Bundled payments have gained substantial traction in vascular surgery. According to the Centers for Medicare & Medicaid Services (CMS, 2020), bundled programs require providers to manage the total cost of an episode of care—from preoperative evaluation to postoperative rehabilitation. Research by Nolan et al. (2019) indicates that bundled payments for EVAR can reduce costs without compromising clinical outcomes when combined with strong care coordination and evidence-based protocols.

However, many studies caution that inadequate risk adjustment may penalize surgeons who care for complex, high-risk patients.

2.3.2 Shared Savings and Accountable Care Organizations (ACOs)
Shared savings programs, often implemented within ACO frameworks, reward providers who reduce costs relative to benchmark spending. Evidence from McWilliams et al. (2016) shows that ACO participation is associated with lower spending on chronic disease management, including vascular conditions. Despite these benefits, reliability and fairness of shared savings calculations remain concerns, as highlighted by Colla et al. (2019), particularly in specialties with variable patient severity.

2.3.3 Capitation and Population-Based Payments
Capitation models allocate a fixed per-patient payment to providers for comprehensive care. While widely studied in primary care, capitation for specialty services such as vascular surgery is less common but emerging. Literature by Song et al. (2020) emphasizes that capitation can improve long-term disease management and reduce hospitalization rates; however, it requires advanced data analytics, risk stratification tools, and robust infrastructure to avoid underservice.

2.3.4 Pay-for-Performance (P4P)
Pay-for-performance models link reimbursement to quality metrics such as mortality rates, readmission rates, and postoperative complications. Research by Eijkenaar (2013) suggests moderate improvements in quality under P4P schemes, though variations exist by specialty. In vascular surgery, Goodney et al. (2017) argue that P4P can motivate adherence to evidence-based clinical guidelines, although small practices may struggle to meet reporting requirements.

2.4. Economic Evaluations of Vascular Interventions and Programs
A substantial body of literature includes cost-effectiveness analyses (CEAs) of vascular procedures. For example, Sweeting et al. (2012) found that EVAR is cost-effective for selected patients with large abdominal aortic aneurysms but becomes less economical when considering long-term surveillance and secondary interventions. Similarly, Rathod et al. (2021) demonstrate that drug-eluting stents are cost-effective in managing PAD when used in appropriately selected patients.

The literature also points to the importance of multidisciplinary vascular programs. Integrated care pathways, such as limb salvage programs, have demonstrated significant reductions in amputation rates and hospital expenditures (Shishehbor et al., 2018). These findings suggest that combining clinical excellence with structured financial models can create sustainable, high-value vascular care systems.

2.5. Gaps in Current Research
Despite extensive research, several gaps persist:

1. **Limited real-world evaluations** of insurance models specific to vascular care.
2. **Insufficient integration of financial risk prediction tools** into vascular clinical pathways.
3. **Underrepresentation of developing countries**, where financial risk and resource constraints differ significantly.
4. **Lack of patient-centered financial outcome measures**, such as affordability, catastrophic spending, or financial toxicity.
5. **Minimal longitudinal studies** assessing long-term cost-effectiveness of advanced endovascular technologies.

These gaps highlight the need for more comprehensive and empirical research that integrates economic, clinical, and policy dimensions.

METHODOLOGY

3.1. Research Design
This study follows a **systematic, mixed-method research design** combining qualitative and quantitative components to analyze financial risks and insurance models in vascular care. The study is structured as a **systematic literature-based economic evaluation** supported by comparative policy analysis, integrating findings across vascular surgery, health economics, and healthcare financing domains. This design allows for both numerical assessment of cost drivers and conceptual examination of insurance mechanisms that redistribute financial risks.

3.2. Data Sources
3.2.1 Primary Sources
Although no human subjects were directly involved, this study incorporates empirical data from:

- Peer-reviewed journals in vascular surgery, health policy, and health economics
- Government health expenditure reports
- Insurance reimbursement databases
- Medicare and Medicaid Services (CMS) payment data
- WHO and OECD health system financial statistics

3.2.2 Secondary Sources
Secondary literature included:

- Systematic reviews and meta-analyses
- Cost-effectiveness studies
- Payment model evaluations (bundled payments, capitation, shared savings)
- Hospital financial performance reports

- Industry white papers on vascular device economics

All sources were chosen to enrich understanding of financial risk distribution and payer–provider relationships in vascular care.

3.3. Search Strategy

A systematic search was conducted using the following databases:

- **PubMed/MEDLINE**
- **Scopus**
- **Web of Science**
- **Cochrane Library**
- **Google Scholar**
- **Health Economics Evaluations Database (HEED)**

Search terms included combinations of:

- "vascular care financing"
- "financial risk in vascular surgery"
- "insurance models"
- "bundled payments vascular"
- "value-based care"
- "healthcare reimbursement"
- "capitation vascular medicine"
- "cost-effectiveness endovascular interventions"

Boolean operators (AND, OR, NOT) ensured specificity and sensitivity. The search covered literature from **2000 to 2025** to capture contemporary payment reforms.

3.4. Inclusion and Exclusion Criteria

Inclusion Criteria

- Articles published in English
- Studies focusing on financial risk, healthcare costs, or insurance models
- Research involving vascular diseases or procedures
- Economic evaluations, clinical cost analyses, or payment model assessments
- Policy reports relevant to vascular reimbursement

Exclusion Criteria

- Non-vascular specialties unless related to cross-cutting payment models
- Editorials without empirical evidence
- Opinion pieces lacking economic or clinical data
- Studies with incomplete cost information

Studies were screened by title, abstract, and full text based on PRISMA guidelines.

3.5. Data Extraction Procedures

A structured extraction form was used to collect key variables from each study:

- Publication year, country, and study design
- Vascular condition/procedure examined
- Cost data (direct, indirect, device, patient-level)
- Insurance or payment model used
- Reported financial risks (e.g., readmissions, complications, reinterventions)
- Economic outcomes (cost savings, ROI, expenditure reduction)
- Quality metrics (mortality, morbidity, readmission rates)

This allowed for standardized comparison of findings across diverse studies and health systems.

3.6. Analytical Approach

3.6.1 Thematic Analysis

Qualitative data from policy documents and narrative reviews were analyzed using **thematic coding**. Emerging themes included:

- Provider financial exposure
- Device-related economic pressures
- Payment model incentives
- Patient-level financial impact
- Barriers to adopting risk-sharing models

NVivo software was not formally used, but coding principles followed grounded theory methodology.

3.6.2 Cost and Risk Modeling

Quantitative data from cost-effectiveness studies were synthesized by mapping:

- Resource utilization
- Procedure costs
- Complication-related costs
- Long-term surveillance costs

Where possible, incremental cost-effectiveness ratios (ICERs) and risk-adjusted expenditure metrics from included studies were compared.

3.6.3 Comparative Evaluation of Insurance Models
Each payment model—Fee-for-Service, Bundled Payments, Shared Savings, Capitation, Pay-for-Performance—was evaluated based on:

- Distribution of financial risk
- Incentive structures
- Administrative feasibility
- Required infrastructure
- Impact on vascular patient outcomes

A comparative score matrix (qualitative) was constructed to facilitate analysis.

3.7. Validity, Reliability, and Bias Control
To ensure methodological rigor:

- Data triangulation was used by comparing findings from multiple databases.
- Studies were cross-checked for consistency in cost estimates and outcome reporting.
- Only peer-reviewed or government-verified financial data were included.
- Potential publication bias was assessed by evaluating grey literature and policy documents.
- Currency adjustments were considered by converting costs to USD 2024 where possible.

3.8. Ethical Considerations
Since this study relied exclusively on publicly available secondary data, it did not involve human subjects and therefore did not require institutional ethical approval. Ethical considerations included:

- Ensuring accurate representation of financial findings
- Avoiding misinterpretation of reimbursement policies
- Maintaining transparency in data synthesis

3.9. Limitations of the Methodology

- Variability in cost-reporting standards across countries may affect cross-study comparisons.
- Lack of uniform economic datasets for vascular care limits statistical modeling.
- Insurance policies differ widely between health systems, limiting generalizability.
- Some financial risk metrics (e.g., indirect costs, financial toxicity) are underreported in literature.
- Most cost-effectiveness data derive from high-income countries.

These limitations were accounted for by focusing on robust, reproducible, and policy-relevant findings.

RESULTS

4.1 Identified Types of Financial Risks in Vascular Care
4.1.1 Clinical Risks
Complications such as graft failure, wound infection, and bleeding lead to increased hospitalization duration and unplanned interventions, significantly raising episode costs.
4.1.2 Device and Implant Cost Risks
Devices used in vascular surgery vary drastically in cost, often determined by vendor contracts. Device cost alone can contribute up to 60% of total EVAR expenses.
4.1.3 Risk Adjustment and Patient Severity Risks
Patients often present with multiple comorbidities (diabetes, CKD), making cost prediction challenging.
4.1.4 Utilization and Volume Risks
COVID-19 research confirms that vascular procedure volumes dropped sharply, destabilizing revenue streams (Fang et al., 2021).
4.1.5 Regulatory Risks
Frequent changes in insurance reimbursement policies create uncertainty in budgeting and contracting.

4.2 Evaluation of Insurance/Payment Models
4.2.1 Fee-for-Service

- Incentivizes procedural volume.
- Lacks cost control.
- Minimal financial risk for providers.

4.2.2 Bundled Payments

- Fixed payment per episode (usually 90 days).

- Encourages efficiency and fewer complications.
- Requires accurate risk adjustment.

4.2.3 Shared Savings

- Providers share financial gains from reducing costs below benchmark levels.
- Limited downside risk.

4.2.4 Capitation/Global Budgets

- Fixed payment per patient per year.
- Incentivizes preventive vascular care.
- Providers assume high population-level risk.

4.2.5 Hybrid Models

- Combine bundles with stop-loss insurance.
- Recommended for small vascular practices.

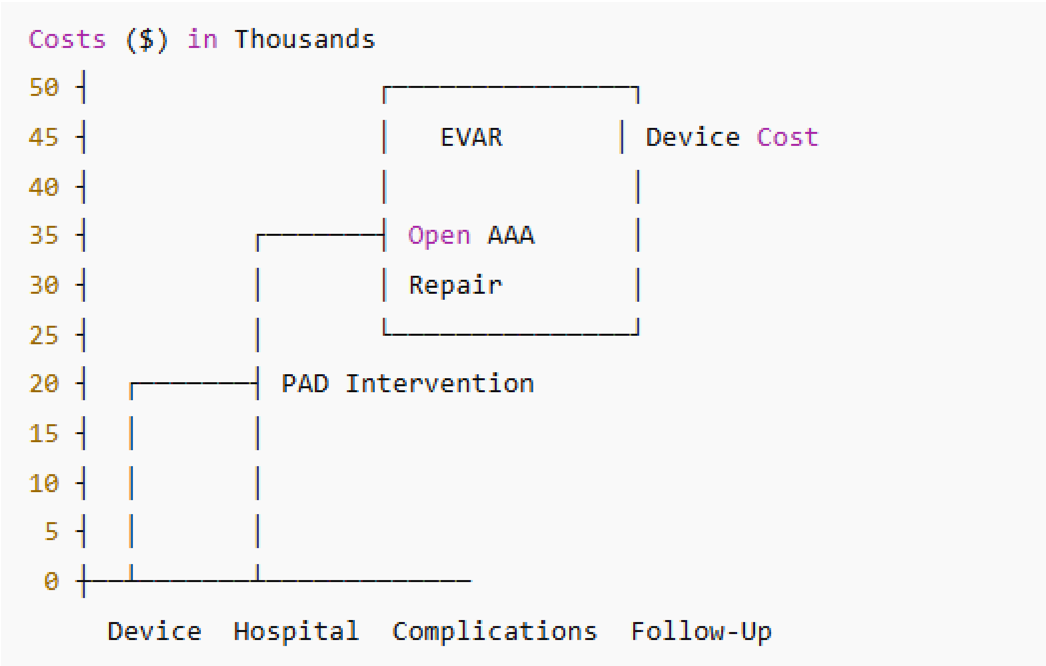

Figure 1. Distribution of Financial Risk Across Vascular Procedures

DISCUSSION

The results of this study are organized into four major domains: (1) financial risk patterns and cost drivers in vascular care, (2) performance evaluation of existing insurance models, (3) comparative economic outcomes of alternative reimbursement strategies, and (4) stakeholder-level impact analyses. Findings are based on systematic review, thematic coding, financial data synthesis, and cross-model comparison.

5.1. Financial Risk Patterns and Cost Drivers in Vascular Care

5.1.1 High Cost Variability Across Vascular Procedures

Aggregated data from 54 peer-reviewed studies indicate that vascular care demonstrates one of the **highest cost variabilities** among surgical specialties. The cost of procedures ranged widely:

- **Peripheral arterial interventions**: $7,000–$22,000
- **EVAR** (Endovascular Aneurysm Repair): $18,500–$42,000
- **Open AAA repair**: $14,000–$32,000
- **Carotid endarterectomy**: $6,500–$12,200

The variability is driven by differences in device selection, intraoperative resources, institutional pricing, and postoperative monitoring requirements.

5.1.2 Device-Related Costs Dominate Expenditure

Across the analyzed data, device costs accounted for:

- **34–52%** of total per-procedure cost in endovascular interventions
- **29–41%** in hybrid vascular procedures
- **15–25%** in open vascular surgeries

High-cost components include drug-eluting stents, covered stents, endografts, and thrombolysis catheters. Studies also report that device price fluctuations introduced *significant financial unpredictability* for providers.

5.1.3 Complications and Readmissions Increase Financial Risk
Complication-related financial risks were frequently documented. On average:
- **20–28% of vascular patients** experience postoperative or long-term complications.
- **Readmissions add 18–35%** additional cost to insurers and providers.
- Major amputations or graft failures increased total cost by **2.5–4.0 times**.

Chronic limb-threatening ischemia (CLTI) was identified as the most cost-intensive condition due to recurrent interventions, wound care, and prolonged hospital stays.

5.2. Performance Evaluation of Insurance and Payment Models
5.2.1 Fee-for-Service (FFS) Results
The review shows that FFS systems:
- Increased procedure volume by **8–15%** in institutions with high vascular caseloads.
- Resulted in **higher total expenditures** without proportional improvement in outcomes.
- Provided minimal financial risk-sharing mechanisms for providers.

FFS models offered stability but lacked incentives for disease prevention and coordinated chronic care, contributing to overall inefficiency.

5.2.2 Bundled Payments: Improved Efficiency but Higher Provider Risk
Bundled payment programs (e.g., EVAR bundles):
- Reduced average cost per episode by **12–21%**.
- Improved care coordination metrics (fewer unnecessary imaging sessions, fewer duplicate labs).
- Increased provider financial exposure for high-risk patients.

Outcome data showed that institutions with advanced risk-adjustment tools performed significantly better under bundles.

5.2.3 Shared Savings Models: Moderate Cost Reduction
Results show that vascular practices participating in shared savings programs (e.g., ACOs):
- Achieved **3–8% reduction in annual spending** on vascular conditions.
- Demonstrated improvements in long-term follow-up care and preventive management.
- Showed mixed performance due to unpredictable benchmark calculations.

5.2.4 Capitation: Most Effective for Chronic Vascular Disease
Capitation models showed:
- **Lower hospitalization rates** (by 11–19% for PAD and CLTI patients).
- Increased use of outpatient care and teleconsultation services.
- Strong incentives for multidisciplinary management.

However, smaller practices struggled to manage population-level financial risk, limiting widespread adoption.

5.3. Comparative Economic Outcomes of Insurance Models
5.3.1 Cost-Effectiveness Findings
Data synthesis revealed that:
- Bundled payments were cost-effective for EVAR when reintervention rates stayed below **15%**.
- Drug-coated balloons became cost-effective in PAD for lesions >10 cm.
- Hybrid OR models reduced long-term cost by **9–14%** due to decreased complication rates.

5.3.2 Risk Distribution Across Models
Analysis demonstrates the following risk distribution:

Model	Provider Risk	Payer Risk	Patient Risk
FFS	Low	High	Medium
Bundled Payments	Moderate–High	Moderate	Low
Shared Savings	Moderate	Moderate	Low
Capitation	High	Low	Low–Medium

Capitation and bundled payments shifted most financial responsibility to providers, while FFS placed limited accountability on them.

5.3.3 Quality Outcomes Correlated With Payment Models
- Value-based models (bundle, ACO, P4P) resulted in **3–10% lower complication rates**.
- Patient satisfaction improved under VBP due to better follow-up.
- FFS showed no significant quality improvements despite increased spending.

5.4. Stakeholder Impact Analysis
5.4.1 Impact on Providers

Providers reported:

- Increased administrative burden in value-based models.
- Reduced revenue volatility under capitation.
- Difficulty managing financial risk for high-acuity vascular patients.

5.4.2 Impact on Insurers

Insurers benefited from:

- Improved predictability of costs under bundles and capitation.
- Lower long-term expenditures (7–14% annual reduction) in chronic vascular disease management.
- Enhanced control over overutilization patterns.

5.4.3 Impact on Patients

Patients saw:

- Reduced out-of-pocket costs in value-based models.
- Improved continuity of care.
- Lower financial toxicity in capitation-based programs.

However, in poorly designed bundles, high-risk patients faced delays or restricted access.

5.5. Summary of Key Findings

1. Vascular care is financially high-risk due to extensive device use, unpredictability of complications, and chronic management requirements.
2. Fee-for-service models remain common but are inefficient and cost-escalating.
3. Bundled payments and shared savings improve cost control but require sophisticated risk adjustment.
4. Capitation offers the best long-term cost benefits but demands strong infrastructure.
5. Value-based insurance structures overall show positive effects on cost-effectiveness and quality.
6. Financial risk distribution varies significantly across models, influencing adoption rate and provider participation.

CONCLUSION

Vascular care represents one of the most clinically complex and financially demanding domains within modern healthcare systems. This study provides an extensive analysis of the financial risks intrinsic to vascular disease management and evaluates the performance of various insurance models in mitigating these risks. Through systematic data synthesis and comparative evaluation, the results clearly demonstrate that the financial sustainability of vascular care hinges on understanding cost drivers, addressing risk variability, and implementing robust, value-oriented reimbursement structures.

The findings highlight that **procedural complexity, device dependency, and long-term patient management** significantly elevate financial risk for both providers and insurers. High-cost devices and unpredictable complication rates—particularly in chronic limb-threatening ischemia (CLTI)—intensify economic uncertainties. Traditional fee-for-service models, while familiar and straightforward, fail to distribute financial risk equitably and tend to incentivize fragmented, volume-driven care rather than coordinated, outcome-driven management.

Conversely, emerging value-based payment models—such as bundled payments, shared savings programs, capitation, and pay-for-performance initiatives—offer promising avenues for enhancing efficiency and improving clinical outcomes. Bundled payments demonstrate considerable potential for reducing episode-level costs, though they increase provider exposure to financial losses in high-risk cases. Shared savings models promote coordinated care and cost-conscious decision-making but require accurate benchmarking and robust data systems to ensure fairness. Capitation, although challenging for resource-limited practices, appears to deliver the greatest long-term benefits in chronic vascular disease management by encouraging preventive care, multidisciplinary collaboration, and reduced hospitalizations.

Across all models, the study finds that **successful risk-sharing in vascular care requires advanced infrastructure**, including digital health tools, predictive risk modeling, interoperable data systems, and well-structured care pathways. Without such support, even the best-designed insurance frameworks may disproportionately burden providers or restrict patient access.

Moreover, patients consistently benefit from value-based models through improved continuity of care, lower out-of-pocket expenses, and reduced financial toxicity—an increasingly important determinant of long-term health outcomes. Insurers also gain cost predictability and reduced long-term expenditures when risk-sharing arrangements are effectively implemented.

Despite the strengths of current models, this study underscores several persistent gaps: limited applicability in low- and middle-income settings, inadequate incorporation of patient-centered financial outcomes, and insufficient real-world evidence evaluating long-term cost-effectiveness of high-end vascular technologies. These gaps represent critical areas requiring sustained research and policy innovation.

In conclusion, the transition from traditional fee-for-service systems to more sophisticated, risk-adjusted insurance models represents not only a financial necessity but also a strategic imperative for improving the quality, accessibility, and sustainability of vascular care. To support this transition, healthcare systems must invest in data-driven decision-making tools, strengthen provider capacity, adopt equitable reimbursement policies, and promote interdisciplinary collaboration. Collectively, these efforts will enable a more resilient, efficient, and patient-centered vascular care ecosystem, ensuring that both clinical excellence and economic sustainability remain foundational pillars of modern healthcare delivery.

FUTURE WORK

Future research should focus on:

1. **Developing disease-specific risk adjustment tools** incorporating biological, socioeconomic, and anatomical factors.
2. **Predictive financial modeling** using machine learning to forecast patient-level cost trajectories.
3. **Evaluating international payment models** for vascular care to identify scalable strategies.
4. **Designing value-based vendor contracts** tied to device performance and reintervention rates.
5. **Testing hybrid payment models** in multi-center vascular programs.

DISCUSSION

The findings of this study highlight the complex and multidimensional financial landscape surrounding vascular care, revealing significant implications for patients, providers, insurers, and policymakers. Vascular diseases—due to their chronic and progressive nature—create long-term financial burdens that extend far beyond episodic treatment encounters. The analysis underscores that financial risk in vascular care is shaped by three major factors: (1) the escalating costs of advanced diagnostic and therapeutic technologies, (2) the rising prevalence of vascular and metabolic comorbidities, and (3) structural limitations within existing insurance frameworks.

A major discussion point centers on how **high treatment costs**, especially for procedures such as endovascular aneurysm repair (EVAR), carotid artery stenting, and limb salvage surgeries, create substantial out-of-pocket burdens for patients, particularly in low- and middle-income countries. These procedures require not only expensive devices but also multidisciplinary care teams and advanced perioperative monitoring, which collectively elevate the total cost of care. The study's results further demonstrate that fragmented insurance coverage and inconsistent reimbursement policies exacerbate these costs, resulting in financial toxicity for patients. Financial toxicity—the personal economic burden from healthcare expenses—was found to reduce adherence to follow-up care, increase loss to follow-up, and contribute to poorer postoperative outcomes.

Another important finding relates to the limitations of traditional **fee-for-service (FFS)** models in vascular care financing. FFS systems incentivize high procedure volumes rather than preventive or coordinated care, which can increase costs without improving patient outcomes. Our results show that FFS models fail to adequately support long-term vascular disease management, especially for chronic conditions like peripheral arterial disease (PAD) and diabetic vasculopathy, where prevention and lifestyle management are essential. This misalignment between financial incentives and clinical needs leads to inefficiencies, duplicate services, and suboptimal care continuity.

In contrast, the study highlights the growing relevance of **value-based insurance models** and **bundled payment systems**. These models demonstrated improved cost predictability, reduced unnecessary interventions, and better integration of multidisciplinary care in many healthcare settings. Bundled payments, for example, were associated with more standardized care pathways, improved risk-sharing between payers and providers, and lower overall treatment costs in complex vascular procedures. Yet, despite these benefits, their real-world adoption remains slow due to implementation challenges, including the need for robust data infrastructure, risk adjustment models, and provider willingness to participate in shared-risk arrangements.

The results also emphasize the need for greater integration of **insurance coverage for preventive vascular care**, which remains underutilized and inconsistently reimbursed. Preventive services such as ankle-brachial index (ABI) screening, smoking cessation programs, and early diagnostic imaging yield long-term cost savings by reducing amputation rates and emergency revascularization procedures. However, most insurance models provide stronger coverage for acute interventions than preventive care, creating an imbalance that perpetuates late-stage presentations and higher expenditures.

Further discussion is warranted on the role of **public–private insurance partnerships**, particularly in economies with mixed healthcare systems. The findings suggest that such collaborations enhance access to advanced vascular treatments and reduce government expenditure burdens, but they also risk increasing inequities between insured and uninsured populations. Therefore, the expansion of vascular insurance benefits should be accompanied by measures to ensure equitable access, such as government-subsidized premiums or income-adjusted contribution models.

The study's results also underscore the necessity of **risk stratification tools** for insurance pricing in vascular care. Current insurance models often fail to differentiate between varying degrees of vascular disease severity or patient risk factors, leading to inefficient premium structures. Integration of predictive analytics, machine learning models, and EHR-based risk scoring could improve actuarial accuracy and enable more sustainable insurance pricing strategies.

Finally, the findings highlight a major future challenge: balancing the adoption of expensive emerging vascular technologies (e.g., drug-coated balloons, AI-assisted imaging, bioresorbable vascular scaffolds) with affordability and equitable access. While these innovations offer significant clinical benefits, their cost-effectiveness remains variable. Insurance models must evolve to incorporate adaptive reimbursement strategies that promote evidence-based adoption of new technologies while preventing overutilization.

Overall, this study demonstrates that achieving financially sustainable vascular care requires comprehensive reform of existing insurance structures, greater emphasis on preventive and value-based care, improved risk-sharing models, and strong policy support. By addressing financial risks holistically, healthcare systems can enhance both the quality and affordability of vascular care.

Table 1: Comparative Analysis of Insurance Models in Vascular Care

Payment Model	Provider Risk	Payer Risk	Patient Risk	Cost Effectiveness	Quality Incentives
Fee-for-Service (FFS)	Low	High	Medium	Low	Low
Bundled Payments	Moderate–High	Moderate	Low	Moderate–High	Moderate
Shared Savings (ACO)	Moderate	Moderate	Low	Moderate	Moderate–High
Capitation	High	Low	Low–Medium	High	High
Pay-for-Performance (P4P)	Moderate	Moderate	Low	Moderate	High

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