



Determinants of Post-Odontectomy Complications: A PLS-SEM Analysis of Clinical Pathway Effectiveness and Patient Risk Profiles

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<p>Track Record Article</p> <p>Revised: 17 April 2026 Accepted: 22 June 2026 Published: 30 June 2026</p> <p>How to cite : Indharmawan, R., & Kusbaryanto. (2026). Determinants of Post-Odontectomy Complications: A PLS-SEM Analysis of Clinical Pathway Effectiveness and Patient Risk Profiles. <i>Contagion : Scientific Periodical of Public Health and Coastal Health</i>, 8(2), 335–348.</p>	<p style="text-align: center;">Abstract</p> <p><i>This study analyses the effect of clinical pathway implementation on post-odontectomy complications. It examines the influence of patient-related factors on postoperative outcomes at the Dental and Oral Hospital of Universitas Airlangga. Globally, oral diseases remain a major public health burden, emphasizing the need to improve the quality and safety of dental surgical care. However, evidence on the effectiveness of clinical pathways in minor oral surgery, particularly in developing countries, remains limited. A quantitative cross-sectional approach was applied using a survey method. A total of 107 participants were included in this study, consisting of 97 odontectomy patients and 10 healthcare professionals selected through purposive sampling. Data were collected from clinical pathway documents, medical records, and structured questionnaires and analyzed using Partial Least Squares-Structural Equation Modeling (PLS-SEM). The results show that patient-related factors have a significant positive effect on post-odontectomy complications ($\beta = 0.855$; $p < 0.001$), indicating that age, comorbidities, and adherence to postoperative instructions are key determinants. In contrast, Clinical Pathway implementation has no significant direct effect ($\beta = -0.012$; $p = 0.406$) and does not moderate the relationship between patient factors and complications ($\beta = -0.028$; $p = 0.296$). The model demonstrates strong explanatory power ($R^2 = 0.731$). These findings suggest that improving postoperative outcomes requires strengthening patient-centered risk assessment and more effective, consistent implementation of clinical pathways in practice.</i></p> <p>Keywords: <i>Clinical Pathway, Odontectomy, Postoperative Complications, Patient Factors, Healthcare Quality.</i></p>
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INTRODUCTION

Impacted teeth are teeth that fail to erupt completely into the oral cavity because they remain partially or fully embedded in the jawbone. This condition most commonly affects third molars and can interfere with mastication while increasing the risk of various clinical problems (Chaudhary et al., 2024). Globally, the prevalence of impacted third molars ranges from 9.5% to 68%, influenced by genetic factors, jaw development, and population characteristics (Passi et al., 2019; Patel et al., 2024). This wide variation indicates that third molar impaction is a common and clinically significant issue in dental practice.

In Indonesia, dental and oral diseases remain a major public health concern. Dental and oral health issues remain a major public health concern in Indonesia. Recent data from the Indonesian Health Survey (Survei Kesehatan Indonesia/SKI) 2023 indicate that 56.9% of the population aged ≥ 3 years experiences dental and oral health problems, highlighting the persistent burden of oral diseases nationwide (Kemenkes, 2023). Despite ongoing national

efforts, this prevalence shows only a slight decline compared to previous reports, suggesting limited progress in improving oral health outcomes (Ginanjari et al., 2022). Regional studies further highlight the high prevalence of impacted teeth, such as 60.6% in Malang and 94.6% in Semarang (Septina et al., 2021). These findings demonstrate that impacted third molars are a persistent and significant oral health problem in Indonesia, requiring more standardized and effective management.

Impacted third molars typically occur in late adolescence or early adulthood when jaw growth has ceased, and space is limited (Alwan & Zaki, 2024). The primary cause is insufficient eruption space, although other contributing factors include genetic predisposition, jaw discrepancies, and oral habits such as mouth breathing (Cinthura et al., 2020; Trakinienė et al., 2021). In many cases, definitive treatment requires surgical removal through odontectomy. Odontectomy is a common oral surgical procedure performed to remove impacted teeth. Despite careful preoperative, intraoperative, and postoperative management, complications remain frequent. These include dry socket, infection, swelling, trismus, paraesthesia, and, in severe cases, osteomyelitis and cellulitis (Goswami et al., 2020; Mundiya & Sun, 2023). Recent studies indicate that postoperative complications, particularly pain and swelling, remain common following third molar surgery and continue to negatively affect patient recovery and quality of life. The overall incidence of complications has been reported to range from 2.6% to 30.9%, with swelling identified as one of the most prevalent outcomes and strongly influenced by surgical complexity and tooth position (Gojayeva et al., 2024; Miguel et al., 2025; Xie et al., 2025). These complications indicate that current management strategies are not yet fully optimal.

One important factor contributing to postoperative complications is variability in clinical practice. Inconsistent adherence to standard procedures can lead to delays in treatment, suboptimal care, and increased risk of adverse outcomes (Lestari et al., 2020). Clinical pathways are therefore introduced as structured, evidence-based care plans designed to standardize treatment, improve coordination among healthcare providers, and reduce clinical variation (Siswanto & Chalidyanto, 2020). Recent evidence demonstrates that the implementation of clinical pathways can significantly reduce length of stay and improve patient outcomes, particularly in infectious disease management. For example, a 2024 study reported a reduction in hospital length of stay from 5.4 to 3.6 days in neonatal urinary tract infection cases following clinical pathway implementation, without increasing readmission rates (Chang et al., 2024). Furthermore, systematic evidence indicates that clinical pathways are associated

with shorter hospital stays, reduced complications, and improved clinical outcomes across various conditions (Rotter et al., 2025).

However, despite strong evidence in general healthcare settings, research on the effectiveness of clinical pathways in dental surgical procedures, particularly odontectomy, is still limited. Only a few studies have specifically examined whether clinical pathway implementation can reduce postoperative complications in oral surgery. This represents a significant research gap, especially given the high volume and risk associated with odontectomy procedures.

At the Dental and Oral Hospital of Universitas Airlangga, odontectomy remains one of the most frequently performed minor surgical procedures. Medical records show 59 cases in 2023, 56 cases in 2024, and 6 cases in early 2025. Although a clinical pathway for odontectomy has been implemented since 2022, its utilization has not been optimal due to limited staff compliance and perceptions of increased workload. This condition may contribute to variability in care and the persistence of postoperative complications.

Despite the extensive evidence supporting the effectiveness of clinical pathways in major surgical procedures, their application in minor oral surgery, such as odontectomy, remains underexplored. This gap is particularly important given that odontectomy, although classified as a minor procedure, carries a relatively high risk of postoperative complications and is performed in large volumes. From a theoretical perspective, this study is grounded in the Donabedian model (Structure–Process–Outcome), which posits that healthcare quality is determined by the interaction between organizational structures, care processes, and clinical outcomes. In this context, clinical pathway implementation represents a process-level intervention aimed at standardizing care delivery, while postoperative complications reflect outcome-level indicators. Furthermore, the concept of clinical governance emphasizes accountability, continuous quality improvement, and adherence to evidence-based practice in healthcare delivery. Integrating these frameworks provides a comprehensive basis for evaluating whether structured care processes, such as clinical pathways, can effectively improve surgical outcomes in dental practice.

Therefore, this study aims to analyze the effect of Clinical Pathway implementation on post-odontectomy complications and to examine the influence of patient-related factors on postoperative outcomes at the Dental and Oral Hospital of Universitas Airlangga.

METHODS

This study employed a quantitative cross-sectional design to examine the relationships between clinical pathway implementation, patient-related factors, and postoperative complications following odontectomy. A cross-sectional approach was selected to allow simultaneous measurement of variables within a defined timeframe and to capture real-world clinical practice without requiring longitudinal follow-up. This design is appropriate for identifying associations and generating generalizable findings in routine healthcare settings. This study was conducted after obtaining ethical clearance and research permission from the relevant institutions. Ethical approval was granted by the Ethics Committee of Universitas Airlangga (No. 16/UN3.9.3/Etik/PT/2025).

The target population comprised healthcare professionals and patients involved in odontectomy procedures at the Dental and Oral Hospital of Universitas Airlangga. A total of 107 participants were included in this study, consisting of 97 odontectomy patients and 10 healthcare professionals, including oral and maxillofacial surgeons, residents (PPDGS), and nurses. Participants were selected using a purposive sampling technique to ensure the inclusion of individuals with relevant experience and complete data. Inclusion criteria for healthcare professionals were direct involvement in odontectomy procedures, familiarity with the clinical pathway, and willingness to participate. For patients, inclusion criteria included having undergone odontectomy during the study period and having complete medical records and clinical pathway documentation. Participants with incomplete data or those not directly involved in the procedure were excluded.

Data were collected from multiple sources to ensure comprehensive measurement. Clinical pathway implementation was assessed using a compliance checklist derived from the standard odontectomy clinical pathway form. Patient-related factors and postoperative complications were obtained from medical records using a structured data extraction form. In addition, a structured questionnaire was administered to healthcare professionals to evaluate adherence to and perceptions of clinical pathway implementation. The questionnaire items were developed based on relevant literature and measured using a Likert scale. Content validity was established through expert review, while construct validity and reliability were assessed using SmartPLS through outer model evaluation.

Data analysis was conducted using Partial Least Squares Structural Equation Modelling (PLS-SEM) with SmartPLS version 4. The analysis consisted of two stages: evaluation of the measurement model to assess indicator validity and reliability, followed by evaluation of the structural model to examine path coefficients and the significance of relationships between

variables. PLS-SEM was chosen due to its suitability for complex models and its robustness in handling relatively small sample sizes.

RESULTS

This study reports the findings of the PLS-SEM analysis examining the relationships between Patient Factors, Clinical Pathway Implementation, and Post-Odontectomy Complications. The results indicate that Patient Factors have a significant effect on postoperative complications, while Clinical Pathway Implementation shows no significant direct or moderating effect.

The measurement model meets the required validity and reliability criteria, and the structural model demonstrates substantial explanatory power, indicating that the proposed model adequately explains variation in post-odontectomy complications.

Table 1. Characteristics of Odontectomy Patients (n=97)

No	Characteristics	Response Category	Frequency (n)	Percentage (%)
1	Gender	Male	36	37.1
		Female	61	62.8
2	Age (years)	Youngest age	23	23.7
		Oldest age	42	43.2
		Mean age \pm SD	30	30.9
3	History of Comorbidities	None	57	58.7
		Diabetes	22	22.6
		Hypertension	17	17.5
		Others (specify)		
4	Type of Odontectomy Procedure	Open method	37	38.1
		Closed method	60	61.8
5	Time Since Procedure	\leq 1 week ago	30	30.9
		1–2 weeks ago	23	23.7
		> 2 weeks ago	44	45.3
6	Follow-up Visit History	Yes	75	77.3
		No	22	22.6

Table 2. Characteristics of Medical Personnel Respondents (n=10)

No	Characteristics	Response Category	Frequency (n)	Percentage (%)
1	Gender	Male	3	30
		Female	7	70
2	Age	Youngest age	27	27
		Oldest age	35	35
3	Position/Profession	Specialist Doctor	6	60
		Resident (PPDS)	4	40
		Nurse	2	20
4	Years of Work Experience	< 1 year	3	30
		1–3 years	4	40
		> 3 years	2	20
5	Have you attended Clinical Pathway training?	Yes	9	90
		No	1	10

No	Characteristics	Response Category	Frequency (n)	Percentage (%)
6	Frequency of handling odontectomy cases	< 5 cases	4	40
		5–10 cases	3	30
		> 10 cases per month	3	30

Measurement Model: Validity and Reliability Assessment

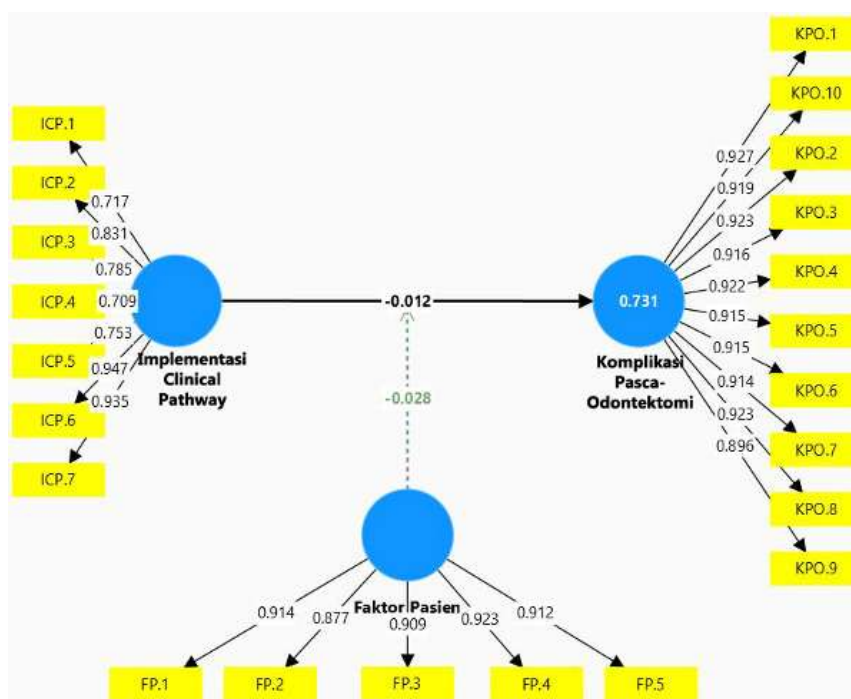


Figure 1. Validated Research Model

The structural equation model estimated using Partial Least Squares Structural Equation Modelling (PLS-SEM) is illustrated in Figure 1. This model delineates the interconnections among latent components, namely Clinical Pathway Implementation, Patient Factors, and Post-Odontectomy Complications, as well as their respective indicators. The assessment of the measurement model reveals that all indicators possess factor loadings over 0.70, hence satisfying the convergent validity criterion proposed by Sarstedt et al. (2021). The highest loading values were found in indicators FP.4 and POC.3, while the indicators with the lowest loading values were still within acceptable limits, so overall, the measurement model can be considered adequate.

Table 3. Convergent Validity Test

Variable/ Construct	Indicator	Loading Factor	Cronbach's Alpha	AVE	Remarks
Clinical Pathway Implementation	ICP.1	0.801	0.939	0.666	Valid
	ICP.2	0.717			Valid
	ICP.3	0.831			Valid
	ICP.4	0.785			Valid
	ICP.5	0.709			Valid
	ICP.6	0.935			Valid
	ICP.7	0.753			Valid
Patient Factors	FP.1	0.914	0.946	0.823	Valid
	FP.2	0.877			Valid
	FP.3	0.909			Valid
	FP.4	0.923			Valid
	FP.5	0.912			Valid
Post- Odontectomy Complications	KPO.1	0.927	0.979	0.841	Valid
	KPO.2	0.919			Valid
	KPO.3	0.923			Valid
	KPO.4	0.923			Valid
	KPO.5	0.915			Valid
	KPO.6	0.915			Valid
	KPO.7	0.914			Valid
	KPO.8	0.896			Valid
	KPO.9	0.914			Valid
	KPO.10	0.910			Valid

As shown in Table 3, all indicator loadings exceed the recommended threshold of 0.70, indicating that the measurement model achieves satisfactory convergent validity. The relatively high loading values across indicators confirm that each observed variable contributes meaningfully to its respective latent construct. Notably, several indicators (e.g., ICP.6, FP.4, and multiple KPO items) exhibit loadings above 0.90, reflecting strong indicator reliability and reinforcing the robustness of the measurement model.

Furthermore, the Average Variance Extracted (AVE) values for all constructs are substantially above the minimum threshold of 0.50, demonstrating that the constructs capture a considerable proportion of variance from their indicators. In particular, the high AVE values observed for Patient Factors (0.823) and Post-Odontectomy Complications (0.841) indicate a strong level of construct convergence.

However, the consistently high loading values observed in Table 3, particularly within the Post-Odontectomy Complications construct, may also suggest a degree of indicator redundancy. While high loadings strengthen internal consistency, they may indicate that certain indicators capture overlapping dimensions of the same construct, potentially limiting the conceptual breadth of measurement.

Overall, the results presented in Table 3 confirm that the measurement model satisfies established criteria for convergent validity. Nevertheless, future studies may benefit from refining the measurement indicators to achieve a more balanced representation between internal consistency and construct diversity, thereby enhancing the explanatory depth and generalizability of the model.

Table 4. Data Reliability Construct (n = 107)

Construct	Cronbach's Alpha	Composite Reliability (rhoa)	Composite Reliability (rhoc)	Average Variance Extracted (AVE)	Remarks
Patient Factors	0.946	0.946	0.959	0.823	Reliable
Clinical Pathway Implementation	0.939	0.891	0.932	0.666	Reliable
Post-Odontectomy Complications	0.979	0.979	0.981	0.841	Reliable

Table 4 presents the reliability and convergent validity of all constructs included in the model. All constructs demonstrate high internal consistency, as indicated by Cronbach's Alpha values exceeding the recommended threshold of 0.70. Notably, the Post-Odontectomy Complications construct shows the highest reliability ($\alpha = 0.979$), followed by Patient Factors ($\alpha = 0.946$) and Clinical Pathway Implementation ($\alpha = 0.939$).

Similarly, Composite Reliability values (ρ_a and ρ_c) for all constructs are above 0.90, confirming strong indicator consistency and stability of the measurement model. Furthermore, all Average Variance Extracted (AVE) values exceed 0.50, indicating adequate convergent validity, where each construct explains a substantial proportion of variance in its indicators. These results confirm that all constructs meet the recommended thresholds for reliability and validity, indicating that the measurement model is robust and suitable for subsequent structural model analysis.

Structural Model Evaluation (R-Square)

Table 5. R-Square and Adjusted R-Square Values of Post-Odontectomy Complication Variables

Dependent Construct	R-square (R ²)	Adjusted R-square
Post-Odontectomy Complications	0.731	0.723

Assessment of the structural model revealed an R-square value of 0.731 for the Post-Odontectomy Complications variable, as shown in Table 5. This indicates that 73.1% of the variance in post-odontectomy complications can be explained by Patient Factors and Clinical Pathway Implementation, including their interaction effects. According to the criteria proposed by Hair et al. (2021), this R-square value is considered substantial, suggesting that the model demonstrates strong explanatory power. The adjusted R-square value of 0.723 further supports the robustness of the model after accounting for the number of predictors included.

Table 6. Inner Model Testing

H	Hypothesis	Path Coefficient (O)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	p-value	Decision
H1	Patient Factors → Post-Odontectomy Complications	0.855	0.068	12.493	0.000	Supported
H2	Clinical Pathway Implementation → Post-Odontectomy Complications	-0.012	0.050	0.238	0.406	Not Supported
H3	Patient Factors × Clinical Pathway Implementation → Post-Odontectomy Complications	-0.028	0.052	0.537	0.296	Not Supported

The present study provides robust evidence that Patient Factors are the primary determinants of Post-Odontectomy Complications, as indicated by a strong and statistically significant effect ($\beta = 0.855$; $p < 0.001$). The magnitude of this relationship suggests that variability in biological and behavioral characteristics such as age, systemic conditions, and postoperative adherence substantially outweighs system-level interventions in shaping surgical outcomes. This finding reinforces the argument that postoperative complications are inherently multifactorial but predominantly patient-driven.

DISCUSSION

This finding is consistent with recent evidence indicating that patient-related factors significantly increase the risk of adverse outcomes following oral surgery. Recent studies have shown that variables such as age, systemic conditions, and surgical complexity are significantly associated with postoperative complications, including pain, swelling, and infection (da Silveira, 2022). Similarly, recent clinical studies have confirmed that postoperative pain and edema remain the most prevalent complications after third molar surgery and are significantly

influenced by individual patient characteristics (Gojayeva et al., 2024; Xie et al., 2025). Collectively, these findings suggest that patient heterogeneity remains a critical and persistent challenge in achieving optimal clinical outcomes.

In contrast, Clinical Pathway Implementation does not demonstrate a significant direct effect on Post-Odontectomy Complications ($\beta = -0.012$; $p = 0.406$). This indicates that the mere existence of a structured clinical pathway is insufficient to influence postoperative outcomes. Rather than functioning as a direct determinant, clinical pathways appear to operate as facilitating tools whose effectiveness depends on contextual and behavioral factors. This interpretation is supported by previous studies highlighting that the impact of clinical pathways is contingent upon implementation fidelity, interdisciplinary coordination, and organizational readiness (Güner, 2020; Heymans et al., 2022).

Notably, this finding diverges from studies reporting positive effects of clinical pathway implementation in reducing complications and improving clinical outcomes (Karunakaran et al., 2021; Huang et al., 2024). Such inconsistencies underscore the importance of contextual factors, suggesting that the effectiveness of clinical pathways is not universal but conditional upon the quality of execution. In this study, suboptimal adherence and perceived increases in workload may have limited the practical impact of the pathway, thereby attenuating its expected benefits.

Furthermore, the absence of a significant moderating effect ($\beta = -0.028$; $p = 0.296$) indicates that Clinical Pathway Implementation does not mitigate the influence of Patient Factors on postoperative complications. This finding suggests that standardization alone is insufficient to counterbalance the strong and direct influence of patient-related risks. Consistent with recent literature, clinical pathways are primarily designed to reduce process variation, but they may lack the flexibility required to address complex and individualized clinical conditions (Luo et al., 2024; Blyleven et al., 2024).

From a theoretical perspective, these findings challenge the assumption that system-level standardization mechanisms, such as clinical pathways, are inherently effective in improving clinical outcomes. Instead, the results highlight the need to conceptualize clinical pathways as part of a broader, integrated care framework. The dominance of patient-related factors suggests that outcome variability cannot be fully addressed through protocol standardization alone but requires the incorporation of patient-centered approaches, including risk stratification and personalized care models.

From a practical standpoint, the findings reveal a critical gap between the availability of clinical pathways and their effective utilization in routine practice. The lack of significant

impact suggests that implementation barriers such as limited adherence, insufficient training, and perceived workload burden must be addressed to enhance pathway effectiveness. Strengthening implementation strategies through continuous monitoring, staff engagement, and adaptive use of pathways is therefore essential.

In addition, the findings emphasize the importance of integrating clinical pathways with comprehensive patient risk assessment. Identifying high-risk patients prior to surgery and tailoring perioperative and postoperative management accordingly may provide a more effective strategy for reducing complications. This approach aligns with the growing emphasis on personalized medicine and patient-centered care in contemporary healthcare systems.

This study contributes to the literature by providing empirical evidence that distinguishes the relative influence of patient-related and system-level factors in the context of odontectomy. Unlike previous studies that predominantly highlight the benefits of clinical pathways, the present findings demonstrate that their effectiveness is conditional and context-dependent. By revealing the limited direct and moderating effects of clinical pathways, this study advances the understanding of how and under what conditions such interventions can improve clinical outcomes.

Overall, the findings suggest that improving post-odontectomy outcomes requires a balanced and integrative approach. While clinical pathways offer a structured framework for standardizing care, their effectiveness depends on implementation quality and alignment with patient-specific risk profiles. Future efforts should therefore focus on enhancing both the fidelity of pathway implementation and the integration of patient-centered strategies to achieve more consistent and clinically meaningful improvements in outcomes.

This study has several limitations that should be acknowledged. First, the cross-sectional design limits the ability to infer causal relationships between Clinical Pathway Implementation, patient-related factors, and post-odontectomy complications. Second, the study was conducted in a single tertiary dental hospital with a relatively limited sample size, which may restrict the generalizability of the findings across different healthcare settings and patient populations. Third, reliance on medical records and self-reported questionnaire data may introduce potential information and reporting bias, particularly in relation to pathway adherence and postoperative behavior. Furthermore, the present study primarily evaluated procedural compliance and did not comprehensively capture organizational dimensions such as institutional culture, leadership support, interdisciplinary coordination, and workload dynamics, which may substantially influence the effectiveness of clinical pathway implementation.

Despite these limitations, the study provides important theoretical and practical contributions. The findings suggest that standardized clinical pathways alone may not be sufficient to reduce postoperative complications without integration with patient-centered risk assessment and personalized perioperative management. This reinforces the growing perspective within healthcare quality research that outcome improvement requires both system-level standardization and adaptive care approaches tailored to patient heterogeneity. From a practical standpoint, healthcare institutions should strengthen implementation fidelity through continuous monitoring, professional training, and interdisciplinary collaboration to optimize pathway utilization in oral surgical services. Future studies are recommended to employ longitudinal and multicenter designs with broader organizational and behavioral variables to enhance external validity and further explore adaptive models of clinical pathway implementation in dental surgery practice.

CONCLUSIONS

This study demonstrates that patient factors have a significant influence on post-odontectomy complications, indicating that individual characteristics such as age, comorbidities, and adherence to postoperative instructions are the primary determinants of clinical outcomes. In contrast, Clinical Pathway Implementation does not show a significant effect on reducing complication rates, suggesting that standardized protocols alone are insufficient without consistent and effective implementation.

Furthermore, the absence of a significant moderating effect indicates that clinical pathways do not attenuate the strong influence of patient-related factors. These findings highlight the importance of integrating patient-centered risk assessment with system-based interventions to improve postoperative outcomes.

However, the results should be interpreted with caution due to several limitations, including the cross-sectional design, single-center setting, and potential information bias from medical records and questionnaire data. Future studies employing longitudinal and multicenter designs are recommended to enhance the generalizability and robustness of the findings.

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