Socioeconomic Disparities in Postoperative Outcomes of Osteocutaneous Fibula Free Flaps for Head and Neck Reconstruction

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Background: Osteocutaneous fibula free flaps (FFFs) are a fundamental component of reconstructive surgery in the head and neck region, particularly after traumatic injuries or oncologic resections. Despite their utility, FFFs are associated with various postoperative complications, such as infection, flap failure, and donor site morbidity, impacting up to 54% of cases. This study aimed to investigate the influence of socioeconomic variables, with a particular focus on median household income (MHI), on the incidence of postoperative complications in FFF reconstruction for head and neck cancer.

Methods: A retrospective analysis of 80 patients who underwent FFF reconstruction for head and neck cancer at a single center from 2016 to 2022 was conducted. Demographic and patient characteristics, including race, MHI, insurance type, history of radiation therapy, and TNM (tumor, node, metastasis) cancer stage, were evaluated. Logistic regression, controlling for comorbidities, was used to assess the impact of MHI on 30-, 90-, and 180-day postoperative complications.

Results: The patient population was predominantly male (n = 51, 63.8%) and White (n = 63, 78.8%), with the majority falling within the $55,000 to $100,000 range of MHI (n = 51, 63.8%). Nearly half of the patients had received neoadjuvant radiation treatment (n = 39, 48.75%), and 36.25% (n = 29) presented with osteoradionecrosis. Logistic regression analysis revealed that the $55,000–$100,000 MHI group had significantly lower odds of developing complications in the 0- to 30-day postoperative period when compared with those in the <$55,000 group (odds ratio [OR], 0.440; 95% confidence interval [CI], 0.205–0.943; $P = 0.035$). This trend persisted in the 31- to 90-day period (OR, 0.136; 95% CI, 0.050–0.368; $P < 0.001$) and was also observed in the likelihood of flap takeback. In addition, the $100,000–$150,000 group had significantly lower odds of developing complications in the 31- to 90-day period (OR, 0.182; 95% CI, 0.035–0.940; $P = 0.042$). No significant difference was found in the >$150,000 group.

Conclusions: Median household income is a significant determinant and potentially a more influential factor than neoadjuvant radiation in predicting postoperative complications after FFF reconstruction. Disparities in postoperative outcomes based on income highlight the need for substantial health care policy shifts and the development of targeted support strategies for patients with lower MHI.

Key Words: osteocutaneous free fibula flap (FFF), head and neck reconstruction, socioeconomic status (SES), median household income (MHI), postoperative complications, neoadjuvant radiation, osteoradionecrosis, health care disparities, surgical outcomes

(*Ann Plast Surg* 2024;92: S167–S171)

Surgical excision is a fundamental component of treatment for the majority of head and neck cancer (HNC) cases.[1,2] The extent of excision is contingent upon the patient's condition and the locoregional tissue involvement. Tumor spread to the maxilla or mandible is common in patients with oral squamous cell carcinoma, often necessitating osteotomy for definitive management.[3] In this context, autologous free tissue transfer, particularly osteocutaneous fibula free flaps (FFFs), has emerged as the criterion standard for reconstructing complex defects after primary HNC resections. Fibula free flaps are frequently used in complex defect reconstruction procedures after resections for HNC, as well as in the context of trauma and dental rehabilitation involving osseointegrated implants.

Although the impact of behavioral and iatrogenic factors, notably tobacco usage, on FFF postoperative outcomes, is well documented, the influence of socioeconomic factors is less explored.[4–6] Recent evidence suggests that socioeconomic status (SES) could be a key driver in the pathogenesis and outcomes of HNC, perhaps even rivaling the impact of radiation therapy.[7–9] For instance, factors such as median household income (MHI) have been inversely linked to recovery times after reconstruction, and lower SES groups often bear a disproportionate burden of HNC.[8] This relationship is further complicated by behavioral aspects like tobacco and alcohol use, which are more prevalent in lower-income groups and are associated with increased risks of wound complications and unplanned reoperations.[9,10]

This study addresses the current gap in understanding how SES, particularly MHI, influences postoperative complications and unplanned reoperations in FFF reconstructions. Despite the well-established association between low SES and adverse outcomes in HNC, insufficient data exist regarding socioeconomic risk factors that may cause postoperative complications in various contexts, including trauma and nononcologic conditions. By examining the interplay of demographic and socioeconomic factors in postoperative outcomes, this study aimed to provide a comprehensive understanding of the multifaceted challenges in FFF reconstruction and contribute to the development of more targeted and equitable health care strategies.

METHODS

A retrospective study was conducted of 80 patients who underwent FFF repair after HNC resection at a single center between 2016 and 2022. We examined various outcomes based on demographic and socioeconomic factors such as race/ethnicity; MHI; comorbidities such as hypertension, heart disease, and diabetes; neoadjuvant and adjuvant radiation history; TNM clinical staging; and 30, 90, and 180-day postoperative complications. The primary outcome was the incidence of 30-, 90-, and 180-day postoperative complications, including unplanned readmission and reoperation. First, we examined the distribution of tumor stages across various income levels, noting that the $55,000 to $100,000 MHI category is overrepresented in this study sample. This income bracket predominates in early, intermediate, and late tumor stages. We also considered the distribution of neoadjuvant radiation across different income levels, finding no consistent trend,

Received December 8, 2023, and accepted for publication, after revision December 24, 2023.

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Conflict of interest and sources of funding: none declared.

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ISSN: 0148-7043/24/9202–S167
DOI: 10.1097/SAP.0000000000003869

TABLE 1. Patient Demographics and Characteristics

Variable	n	%
Sex		
Male	51.0	63.8
Female	29.0	36.3
Race		
White	63.0	78.8
Black	11.0	13.8
Asian	3.0	3.8
Unreported	3.0	3.8
Ethnicity		
Non-Hispanic	78.0	97.5
Hispanic	2.0	2.5
Preop radiation		
No	41.0	51.3
Yes	39.0	48.8
Smoking		
Yes	40.0	50.0
No	38.0	47.5
Unreported	2.0	2.5
Tumor location		
Oral cavity	53.0	66.3
None	13.0	16.3
Unreported	6.0	7.5
Nasal cavity and paranasal sinuses	3.0	3.8
Oropharynx	2.0	2.5
Salivary glands	2.0	2.5
Nasopharynx	1.0	1.3
ORN		
No	49.0	61.3
Yes	29.0	36.3
Unreported	2.0	2.5
MHI category		
<$55,000	16.0	20.0
$55,000–$100,000	51.0	63.8
$100,000–$150,000	11.0	13.8
>$150,000	2.0	2.5
Clinical stage		
Stage IVA	31.0	38.8
No cancer	17.0	21.3
Unreported	13.0	16.3
Stage III	10.0	12.5
Stage II	5.0	6.3
Stage I	2.0	2.5
Stage IVB	2.0	2.5
Radiation type		
External beam radiation therapy	32.0	40.0
Intensity-modulated radiation therapy	29.0	36.3
Unreported	19.0	23.8

Percentages are based on the total number of patients (N = 80).

indicating that income does not solely dictate the likelihood of receiving neoadjuvant radiation. Demographic characteristics of patients were compared using descriptive statistics; for comparisons between groups of categorical variables, χ^2 tests were used, and Fisher exact tests were applied to expected values less than 5. Wilcoxon rank sum test was used for nonparametric continuous variables. Multivariate logistic regression analysis was performed to assess the influence of patients' MHI on the incidence of postoperative complications over various postoperative periods. All tests were 2-tailed with a significance threshold of $P < 0.05$. All statistical analyses were performed using R software package (RStudio 4.3.1).

RESULTS

A total of 80 patients undergoing head and neck reconstruction with free flap surgeries (FFFs) were evaluated. The demographic distribution was predominantly male (63.75%, n = 51) and White (78.75%, n = 63; Table 1). The majority of patients fell into the $55,000–$100,000 MHI category (62.5%). Notably, 48.75% (n = 39) had received neoadjuvant radiation, and 36.25% (n = 29) presented with osteoradionecrosis (ORN). In terms of smoking status, 50% (n = 40) of the patients were nonsmokers, whereas 47.5% (n = 38) reported smoking. The primary tumor sites included the oral cavity (66.25%, n = 53), unspecified (16.25%, n = 13), not reported (7.50%, n = 6), nasal cavity and paranasal sinuses (3.75%, n = 3), oropharynx (2.50%, n = 2), salivary glands (2.50%, n = 2), and nasopharynx (1.25%, n = 1).

The logistic regression analysis, controlling for comorbidities, revealed significant differences in postoperative outcomes across different MHI brackets. In the 0- to 30-day postoperative period, the $55,000–$100,000 group displayed significantly lower odds of complications compared with the <$55,000 group (odds ratio [OR], 0.440; 95% confidence interval [CI], 0.205–0.943; $P = 0.035$). The $100,000–$150,000 group had a nonsignificant reduction in complication odds (OR, 0.453; 95%

TABLE 2. Effect of MHI on Postoperative Outcomes With Logistic Regression Analysis Controlling for Comorbidities

Outcome	OR	95% CI	*P*
Postoperative complications			
0–30 d			
$55,000–$100,000	0.440	0.21–0.94	0.035*
$100,000–$150,000	0.453	0.12–1.70	0.240
>$150,000	0.813	0.05–13.59	0.885
Comorbidities	1.514	0.67–3.42	0.319
31–90 d			
$55,000–$100,000	0.136	0.05–0.37	<0.001*
$100,000–$150,000	0.182	0.04–0.94	0.042*
>$150,000	0.000	0.00–ref.	1.000
Comorbidities	1.419	0.54–3.75	0.481
91–180 d			
$55,000–$100,000	0.374	0.17–0.84	0.017*
$100,000–$150,000	0.286	0.06–1.41	0.124
>$150,000	1.285	0.08–21.74	0.862
Comorbidities	0.606	0.25–1.46	0.265
Unplanned reoperation			
$55,000–$100,000	0.545	0.26–1.15	0.109
$100,000–$150,000	0.548	0.15–2.02	0.367
>$150,000	0.963	0.06–15.85	0.979
Comorbidities	1.079	0.48–2.40	0.853
Flap takeback			
$55,000–$100,000	0.136	0.05–0.37	<0.001*
$100,000–$150,000	0.182	0.04–0.94	0.042*
>$150,000	0.000	0.00–ref.	1.000
Comorbidities	1.419	0.54–3.75	0.481

Reference category: income < $55,000. *P* values less than 0.05 are considered statistically significant.

TABLE 3. Tumor Stage Distribution Across MHI Categories

MHI Category	Early	Intermediate	Late	Unreported
<$55,000	1 (1.4)	3 (4.3)	6 (8.6)	3 (4.3)
$55,000–$100,000	4 (5.7)	11 (15.7)	24 (34.3)	8 (11.4)
$100,000–$150,000	0 (0.0)	1 (1.4)	5 (7.1)	2 (2.9)
>$150,000	0 (0.0)	1 (1.4)	1 (1.4)	0 (0.0)

Stages categorized as early (I–II), intermediate (III), and late (IVA–IVB). Percentages based on the total number of patients with HNC (N = 70).

CI, 0.121–1.696; $P = 0.240$), whereas the >$150,000 group showed no significant difference (OR, 0.813; 95% CI, 0.049–13.585; $P = 0.885$; Table 2).

In the 31- to 90-day postoperative period, the $55,000–$100,000 MHI group continued to show significantly lower odds of complications than the <$55,000 MHI group (OR, 0.136; 95% CI, 0.050–0.368; $P < 0.001$). The $100,000–$150,000 group also demonstrated lower odds, albeit with marginal significance (OR, 0.182; 95% CI, 0.035–0.940; $P = 0.042$). A similar pattern of reduced complication odds was noted in the 91- to 180-day postsurgery period. In addition, the likelihood of flap takeback was significantly lower in the $55,000–$100,000 group compared with those earning <$55,000 (OR, 0.136; 95% CI, 0.050–0.368; $P < 0.001$; Tables 2, 3).

Analysis of the TNM clinical stages (Table 4) showed that 48.75% (n = 39) of patients had received neoadjuvant radiation. Among the stage I patients, none had received neoadjuvant radiation. However, a higher prevalence of neoadjuvant radiation was observed in advanced stages, with 70.00% of stage III patients and 80.00% of stage II patients receiving this treatment. Notably, 48.39% of stage IVA patients had undergone neoadjuvant radiation, whereas none of the stage IVB patients had. The χ^2 test revealed no significant association between MHI and neoadjuvant radiation ($P = 0.37$; Table 5).

The results in Figure 1 illustrate the incidence of surgical complications during 3 periods: 0 to 30, 31 to 90, and ≥180 days after surgery. Within the initial 0- to 30-day period, the most frequently observed complications were recipient-site dehiscence and recipient-site surgical site infection. During the 31- to 90-day period, exposed bone/hardware was found to be the most common complication. Finally, during the period of ≥180 days after the operation, nonunion or delayed union was the most commonly observed complication.

DISCUSSION

Surgical procedures of significant complexity, such as head and neck reconstruction using FFFs, require a nuanced understanding of factors contributing to postoperative disparities. Current research highlights this complexity, showing varied outcomes influenced by health care environments and socioeconomic tiers. For instance, Lewcun et al[11] observed a higher incidence of postoperative complications in community hospitals than in academic hospitals. Similarly, this study found that patients with an MHI less than $55,000 were more likely to experience postoperative complications and unplanned reoperations. This aligns with findings by Chargi et al,[12] who reported that lower SES, often accompanied by comorbidities like low skeletal muscle mass and chronic inflammation, increased the likelihood of complications and negatively impacted survival rates.

Although the long-term functional and esthetic outcomes of such surgical interventions are generally favorable, the influence of social and economic factors on recovery cannot be discounted, as noted by Petrovic et al[13] and Zhu et al.[14] For patients with HNC, survival rates are greatly affected by their SES and the characteristics of the area where they live. Specifically, poverty, a relevant component of SES, has been demonstrated to affect survival rates independently.[15–17] A few studies have highlighted that patients residing in areas where poverty levels exceed 15% of the federal poverty level are diagnosed with HNC at earlier stages and exhibit lower median survival rates across all age groups.[15–17] These findings are consistent with previous studies that underscore the role of social and structural health determinants, including SES, in shaping the outcomes of HNC patients.[18] The findings contribute to the ongoing discourse, as emphasized by Vincent et al[19] and Kendall and Castro-Alves,[20] about the importance of considering a wide range of factors, including social and structural determinants of health, in achieving optimal outcomes in HNC reconstruction. This study examined the intersection of SES with postoperative complications in individuals undergoing FFF head and neck reconstruction, suggesting the need for a multifaceted approach in patient care and policy formulation.

This study adds to this narrative, emphasizing the crucial role of socioeconomic factors in postoperative complications after FFF reconstruction. Patients with an MHI less than $55,000 showed a higher likelihood of encountering postoperative complications and unplanned reoperations, aligning with the broader research on health outcomes influenced by SES.[19,21] These findings reflect the systemic challenges patients from lower-income brackets face in accessing essential postoperative care.

In addition, the relationship between neoadjuvant radiation and postoperative complications observed in this study contributes to the medical community's ongoing discourse. The noted higher incidence of complications between 3 and 6 months postoperatively suggests a delayed impact of radiation, possibly due to cumulative effects on tissue properties. These insights align with existing literature emphasizing the long-term effects of radiation on surgical outcomes. This study revealed that adjuvant radiotherapy did not significantly affect complications during any periods we examined: 0 to 30, 31 to 90, and 91 to 180 days after

TABLE 4. Relationship Between Neoadjuvant Radiation Exposure and TNM Clinical Stages

Clinical Stage	No Radiation, n (%)	Neoadjuvant Radiation, n (%)
Stage I	3 (60.0)	2 (40.0)
Stage II	0 (0.0)	4 (100)
Stage III	3 (30.0)	7 (70.0)
Stage IVA	16 (47.0)	18 (53.0)
Stage IVB	2 (100)	0 (0.0)

Frequency data are shown in n (%). n represents the number of patients in each group. Percentages calculated within each clinical stage.

TNM, Tumor, Node, Metastasis staging system.

TABLE 5. Distribution of Neoadjuvant Radiotherapy Across MHI Categories

MHI Category	No Radiation, n (%)	Neoadjuvant Radiation, n (%)
<$55,000	11 (57.9)	8 (42.1)
$55,000–$100,000	25 (46.3)	29 (53.7)
$100,000–$150,000	4 (40.0)	6 (60.0)
>$150,000	2 (100.0)	0 (0.0)

Frequency data are shown in n (%). n represents the number of patients in each group. Percentages calculated within each MHI category.

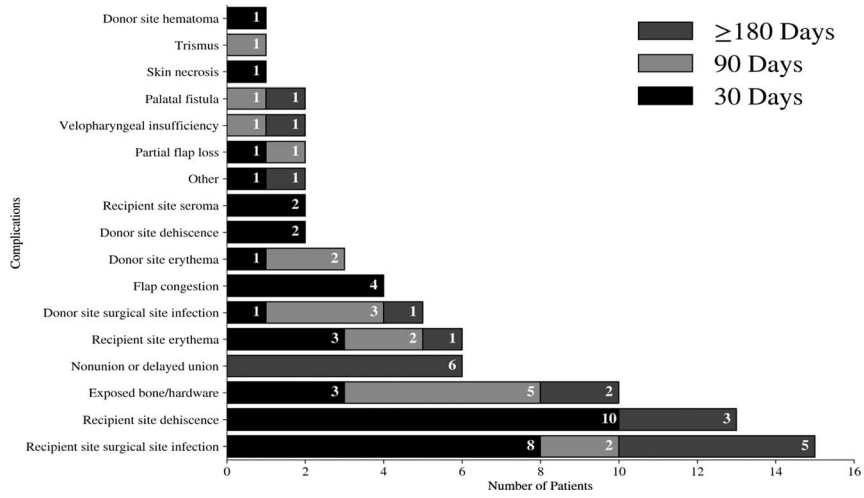

FIGURE 1. Incidence of surgical complications and number of patients by postoperative periods.

surgery. Although adjuvant radiotherapy is a known postoperative risk factor, this study suggests that it did not significantly affect postoperative complications in the patient cohort. The limited effect of adjuvant radiotherapy on postoperative outcomes compared with other factors like SES further highlights the complexity of factors influencing patient recovery and complications.

Within this patient cohort, the most common causes for reoperation within the first 30 days were vascular complications such as flap congestion, recipient site wound dehiscence, surgical site infection, and complications from previous treatments like ORN. A majority of patients diagnosed with ORN (20 of 29) did not undergo immediate reconstructive surgery after tumor resection. This prevalence suggests a potential temporal dissociation between primary surgical intervention and the onset of ORN in these cases. Given the well-documented correlation between ORN and prior radiation therapy, which may manifest at varied intervals after the initial treatment, this data trend might indicate a propensity for delayed ORN development without immediate postoperative reconstruction. Beyond 30 days, complications included hardware failures, functional impairments, and continued complications at the recipient site. After approximately 180 days after surgery, the most commonly reported complication was nonunion or delayed union of the bones.

The effect of SES on surgical outcomes is complex, and patients in this income bracket may require additional resources for postoperative care, such as physical therapy, nutritional support, and follow-up consultations.[22] Concurrent comorbidities, which are more challenging to manage for these individuals, may complicate the postoperative trajectory. The stresses associated with financial instability could also exacerbate systemic inflammation, thereby inhibiting wound healing and recovery.[21] Even after adjusting for various demographic factors, comorbidities, and tumor characteristics, including race, radiation history, and cancer stage, the disparities in postoperative complications and reoperations based on income largely persisted, indicating the independent influence of MHI. Patients with household incomes less than $55,000 had a higher likelihood of experiencing postoperative complications and unplanned reoperations. This suggests that high-level treatment variables like radiation therapy, often correlated with disease severity, have a limited impact on these disparities. This study also reveals significant differences in unplanned reoperation rates among FFF reconstruction patients, particularly those in lower-income brackets. The link between income and postoperative complications highlights the need for health policies and interventions that improve access to high-quality perioperative care and provide extra support for patients with lower SES. Addressing these disparities may require a comprehensive approach that includes individual patient counseling and systemic changes to health care policies.

Moreover, the broader context of HNC risk factors, particularly tobacco smoking and alcohol consumption, further complicates postoperative care and outcomes. Tobacco smoking and excessive alcohol consumption are well-established risk factors for HNC.[23] In addition, a study by Choi et al[10] reveals a strong association between cigarette smoking and the presence of other modifiable risk factors in HNC patients, predominantly in those from lower-SES backgrounds. This suggests a complex interrelation where smoking behaviors and SES are intertwined, potentially influencing both the risk and prognosis of HNC. The North Carolina Head and Neck Cancer Epidemiology Study, as elaborated by Lenze et al,[9] reinforces this concept. Their study discusses findings from a study by Johnson et al,[24] which indicates that lower-income households, particularly those earning less than $20,000 per year, exhibit higher associations of squamous cell carcinoma of the head and neck with smoking and drinking compared with higher-income groups.

The intersection of lifestyle risk factors, such as smoking and alcohol consumption, with SES leads us to examine the systemic factors that further contribute to disparities in HNC treatment outcomes. The correlation between lower SES and suboptimal treatment outcomes for HNC patients is well established. Contributing factors may include delayed HNC diagnosis due to insufficient access to comprehensive health care services. Given the established significance of early detection in effectively managing cancer, including HNC, late-stage diagnosis can lead to more advanced disease states, complicating treatment and resulting in unfavorable outcomes.[2,8,16,17] In addition, disparities in treatment may arise because of inadequate access to high-quality health care services, which may be caused by financial constraints that hinder the adoption of certain treatment options or a lack of awareness regarding the availability of alternative treatments. Consequently, these patients may receive less efficacious treatments of their condition, further exacerbating the disparity in outcomes.

Furthermore, comorbidities such as diabetes, heart disease, or other chronic conditions are more prevalent among lower-SES patients. These comorbidities can complicate the treatment regimen for HNC, leading to poorer outcomes. The intersection of late-stage diagnosis, treatment disparities, and higher rates of comorbidities among lower-SES patients underscores the multifaceted challenge of managing HNC in these populations.[17] It is imperative to address these concerns to enhance the overall prognosis for all individuals diagnosed with HNC, irrespective of their socioeconomic background.

Recognizing these varied postoperative needs, the necessity for augmented resources becomes apparent. Enhanced nursing care, encompassing vigilant postoperative monitoring and thorough patient education on wound management, is crucial. Ensuring that patients are well

informed about early signs of complications is also vital. Previous studies have demonstrated that socioeconomic inequalities can have a negative impact on patient outcomes, highlighting the need for additional support mechanisms.[7–10,24,25] A dedicated clinic for preoperative assessments and nutritional optimization could serve as a valuable resource, improving both preoperative and follow-up care and facilitating prompt management of any complications, as well as implementing specific nutritional intervention programs designed to promote wound healing and minimize complications, as nutrition is a crucial factor in postsurgical recovery. These patient-centric interventions have the potential to mitigate the effects of socioeconomic disparities on postoperative outcomes and elevate the standard of patient care in FFF reconstruction.

Although the study provides valuable insights into the relationship between SES and postoperative complications after FFF head and neck reconstruction, it is important to acknowledge several limitations. It is worth noting that the study was conducted at a single center and used a retrospective design, which may limit the generalizability of its findings. In addition, the study did not have data on other potential confounding factors, such as comorbidities and lifestyle factors, which could influence postoperative outcomes. The study may have needed to be adequately powered to detect significance in other socioeconomic factors, such as education and occupation, potentially impacting postoperative outcomes. Despite these limitations, this study provides valuable insights into the factors associated with postoperative complications after FFF reconstruction.

CONCLUSIONS

This study analyzed outcomes for patients undergoing FFF reconstruction, revealing pronounced disparities in surgical complications across different MHI categories. Patients in the lower MHI bracket (<$55,000) faced significantly higher odds of postoperative complications, including wound dehiscence and surgical site infections, as well as a greater likelihood of requiring flap takeback. Median household income was an independent factor that played a significant role in determining postoperative outcomes. Hence, there is an urgent need for targeted interventions to address the existing disparities. In addition, neoadjuvant radiation was linked to higher postoperative complications, particularly in the 3- to 6-month postoperative period. These findings emphasize the impact of socioeconomic factors and neoadjuvant treatments on the surgical outcomes of HNC patients. Therefore, it is crucial to implement comprehensive policy modifications and design tailored interventions that focus on improving health care accessibility and providing specialized perioperative support for lower-income individuals.

By addressing these understudied areas, this study contributes significantly to the ongoing discourse on the multifaceted determinants of health outcomes in HNC reconstruction, enhancing understanding and guiding future interventions. Understanding this relationship is crucial for developing patient care strategies that extend beyond clinical treatments to address broader socioeconomic factors affecting recovery and quality of life after surgery. Future research should focus on devising strategies to improve treatment sequencing and access to quality care, particularly for those at heightened risk of adverse outcomes due to socioeconomic constraints.

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