

## Original Article

**Determinants of Hospital Stay Duration Post-Colorectal Surgery**

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## ARTICLE INFO

## ABSTRACT

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**Introduction:** Hospital length of stay (LOS) remains a vital metric for assessing patient outcomes and healthcare resource utilization. Given the substantial financial impact of diagnosing and treating colorectal anomalies, coupled with an increased susceptibility to postoperative complications, it is crucial to understand the factors affecting LOS following colorectal surgery. Our primary objective was to investigate the preoperative, intraoperative, and postoperative risk factors that have substantial influence over LOS following a colorectal procedure.

**Methods:** This study analyzed data from a retrospective study of adults who underwent various colorectal surgeries (colostomy, ileostomy, small bowel resection, etc.) at Cleveland Clinic Foundation (January 2005 - December 2014). Predictor variables were categorized into preoperative (patient demographics, medical history, comorbidities, lifestyle factors), intraoperative, and postoperative factors. LOS was grouped into short-term (SLOS) ( $\leq 7$  days), medium-term (MLOS) (8-30 days), and long-term (LLOS) ( $> 30$  days) stays. Multinomial logistic regression models assessed predictor effects on LOS.

**Results:** Among the 7874 patients, 50.7% were females, with a minimum age of 20 years. SLOS were observed in 61.1%, MLOS in 37.6%, and LLOS in 1.3% of patients. Advanced age correlated with prolonged LOS, possibly due to age-related health challenges like weak immune systems. Coagulopathy, and fluid and electrolyte disorders raised MLOS and LLOS risk, likely due to complications like significant bleeding and electrolyte imbalances. Surgery duration predicted longer LOS, elevating LLOS and MLOS by 52% and 42%. Postoperative infections were associated to extended stays, possibly due to subsequent interventions, monitoring and recovery delays.

**Conclusion:** Our study revealed that key preoperative predictors of LOS included Age, coagulopathy, fluid and electrolyte disorders, severe weight loss, and drug abuse. Notably, intraoperative factors such as surgical approach (open vs laparoscopic) and surgery duration, alongside postoperative complications including superficial and serious infections, significantly influenced LOS. By incorporating these insights into the preoperative planning, clinicians could potentially develop tailored interventions to mitigate risk factors and enhance postoperative recovery, thus potentially reducing LOS and improving patient outcomes.

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## Introduction

Colorectal surgeries are essential procedures conducted to address diverse colorectal ailments. Some of the common colorectal ailments which necessitates surgery include colorectal cancer (1.93 million new cases in 2020<sup>1</sup>), inflammatory bowel disease (4.9 million cases in 2019<sup>2</sup>), intestinal atony, Chron's disease, and many others. This field of medical intervention has experienced a notable surge in demand due to the escalating prevalence of colorectal disorders. Furthermore, certain investigations predict a rise in colorectal disorders over the coming decades.<sup>1, 2, 3</sup>

One crucial metric in evaluating patient outcomes and healthcare efficiency is the hospital length of stay (LOS) for in-patients, defined as the number of days a patient remains hospitalized during a single admission event.<sup>4</sup> Studies have associated LOS with healthcare costs<sup>5</sup> and the occurrence of hospital-acquired complications, such as infections and medication side effects.<sup>6, 7</sup> Reducing LOS not only mitigates the risk of complications but also contributes to cost savings, given the expensive nature of diagnosing and treating colorectal anomalies. For instance, in 2019, the median cost of diagnosing and treating colorectal cancer in New Zealand was \$14,697 for patients without complications and \$28,485 for patients with complications.<sup>8</sup> This highlights the financial burden associated with different patient scenarios, offering valuable insights into the economic implications of the treatment and management of colorectal ailments. While recent attention has focused on reducing LOS through enhanced recovery protocols,<sup>9-14</sup> very few research has delved into identifying perioperative factors influencing

LOS post-colorectal procedures, a critical pursuit for recognizing modifiable elements, optimizing resource management, and enabling personalized care for colorectal surgery patients. .

The primary objective of this study is to identify preoperative, intraoperative, and postoperative risk factors significantly affecting LOS after colorectal procedures. Unlike many existing studies that primarily concentrate on enhancing recovery protocols to reduce LOS, our research delves into a broader scope which would provide a holistic perspective on LOS determinants that extends beyond protocol-driven interventions alone. These determinants can guide the development of targeted interventions, personalized treatment strategies, and refined perioperative protocols. Furthermore, this knowledge can serve as a foundation for future investigations into optimizing surgical approaches, postoperative management, and patient outcomes. Clinically, the study's outcomes have the potential to inform evidence-based decision-making, enable risk assessment, and facilitate proactive measures to mitigate LOS and improve overall quality of care for colorectal surgery patients.

## Methods

### Data source and study design

The data for this research was derived from a retrospective study conducted by Walters et al. in 2020.<sup>15</sup> Their study aimed to investigate the relationship between time-weighted average core temperature and the occurrence of serious wound and systemic infections within 30 days after colorectal surgery. To achieve this, they utilized a comprehensive dataset sourced from

the Colorectal Surgery Database and Cleveland Clinic Perioperative Health Documentation System of the Cleveland Clinic Foundation. This dataset has been made publicly available and can be accessed on the Teaching Statistics in the Health Sciences database.<sup>16</sup> The dataset includes preoperative, intraoperative, and postoperative factors, including the duration of hospital stay, documented during the perioperative phase of the surgery, making it suitable to address our research objectives.

### **Setting and Participants**

The participants in this study comprised adults who underwent colorectal surgery at the Cleveland Clinic Foundation between January 2005 and December 2014. The inclusion criteria were as follows:

- 1) Age greater than 18 years;
- 2) Surgery duration exceeding 1 hour;
- 3) Administration of general anesthesia;
- 4) Esophageal core temperature monitoring for at least 30 minutes (with no interruptions exceeding 30 minutes); and
- 5) First surgery during the hospital visit.

Initially, 7908 participants met these inclusion criteria. However, patients who died before their discharge might have unique medical conditions, complications, or treatment trajectories that could disproportionately influence the LOS analysis, hence they were excluded from this study, resulting in a final participant count of 7874.

### **Variables**

This study aimed to investigate the factors influencing hospital LOS following colorectal surgery, with LOS being the primary outcome

variable of interest. To facilitate comparison, the LOS variable was categorized into three classes: short-term hospital stays (SLOS) for  $LOS \leq 7$  days, medium-term hospital stays (MLOS) for LOS between 8 and 30 days, and long-term hospital stay (LLOS) for LOS exceeding 30 days.

Various predictor variables were considered in this analysis, organized into distinct categories. The predictor variables have been outlined in Table 1. None of the predictor variables of this study underwent any data transformations.

### **Statistical Analysis**

In this study, descriptive statistics were employed to characterize the primary outcome variable and all other predictor variables. Frequencies and percentages were used to describe the nominal variables, while mean, median, maximum, and minimum values were calculated to describe numeric variables, like LOS, age, and surgery duration. Given the categorization of the primary outcome variable (LOS) into three distinct classes (SLOS, MLOS, and LLOS), the utilization of multinomial logistic regression stood as the most fitting approach to evaluate the impacts of the predictor variables on LOS. As such, multinomial logistics regression was employed to assess the effects of predictor variables on LOS.

The study employed odds ratios from a multinomial logistic model to analyze predictor variable effects on LOS. An odds ratio represents how much the odds of an outcome change relative to a reference category, for a unit change in the predictor while other variables are held constant. An odds ratio over 1 indicates higher odds for the specific category,

Table 1. Predictor variables included in our study.

Postoperative Factors	Intraoperative Factors	Postoperative Factors
Demographics <ul style="list-style-type: none"> <li>• Age</li> <li>• Gender</li> </ul>	Manner of surgery (Open vs Laparoscopic)	Serious infections (having at least one of surgical site infections, pelvic abscess, intra-abdominal abscess, clostridium difficile, pneumonia, or sepsis)
Medical History <ul style="list-style-type: none"> <li>• History of Congestive Heart Failure (CHF)</li> <li>• History of Renal Failure (RF)</li> <li>• History of Liver Disease (LD)</li> <li>• History of Diabetes</li> </ul>	Surgery duration in hours	Superficial infections (having at least one of skin infections, wound infections, fascial dehiscence, or perineal wound problems)
Comorbidities <ul style="list-style-type: none"> <li>• Coagulopathy</li> <li>• Chronic Blood Loss Anemia (CBA)</li> <li>• Fluid and Electrolyte Disorders (FED)</li> </ul>		
Lifestyle Factors <ul style="list-style-type: none"> <li>• Obesity</li> <li>• Weight loss</li> <li>• Drug Abuse</li> <li>• Immunosuppressive drug use</li> </ul>		

Medical History involves previous medical conditions that the patients have had in the past but are no longer present as such they cannot be regarded as comorbid conditions; Comorbidities include the medical conditions that were present during the preoperative phase of the surgery.

while below 1 suggests lower odds compared to the reference. An odds ratio of 1 indicate no change. Percentage interpretation involves calculating the odds change percentage for a one-unit predictor change. For instance, an odds ratio of 1.20 suggests a 20% increase in odds for the outcome, and an odds ratio of 0.85 signifies a 15% decrease for each predictor unit change, with other variables constant.

Furthermore, likelihood ratio chi-square tests were utilized to determine the overall significance of the final model and the individual significance of each predictor variable. The chosen level of significance throughout the study was set at 0.05. All statistical analyses were carried out using the Statistical Package for the Social Sciences (SPSS) version 25.

## Results

### Descriptives

From Table 2, the study's marginally elevated

representation of females (50.7%) suggests an equitable distribution of both male and female patients within the context of colorectal surgery. The distribution of ages, with a mean and median around 55-56 years, observed in Table 3, might reflect the common age range for colorectal surgeries, where conditions tend to manifest more frequently in middle-aged and older individuals.

From Table 3, the wide range of LOS (1 to 144 days) might be due to variations in surgical complexity, patient conditions, and potential complications. Likewise, the high frequency of SLOS cases (61.1%) suggests that many patients experience relatively quick recoveries, possibly due to less invasive procedures or efficient postoperative care protocols. Coagulopathy's low prevalence (7.1%) indicates the rarity of such cases even in the general population. Contrastingly, the higher incidence of FED (40.3%) could be a consequence of the impact of electrolyte

*Determinants of Hospital Stay Duration Post-Colorectal Surgery*

Table 2. Frequency distribution of perioperative characteristics of the participants

Variables	Classes	Frequency	%
Length of Stay	LLOS	103	1.3%
	MLOS	2957	37.6%
	SLOS	4814	61.1%
Gender	Female	3990	50.7%
	Male	3884	49.3%
Congestive Heart Failure	Yes	262	3.3%
	No	7612	96.7%
Diabetes	Yes	882	11.2%
	No	6992	88.8%
Renal Failure	Yes	333	4.2%
	No	7541	95.8%
Liver Disease	Yes	205	2.6%
	No	7669	97.4%
Coagulopathy	Present in Patient	559	7.1%
	Absent	7315	92.9%
Fluid and Electrolyte Disorders	Present in Patient	3174	40.3%
	Absent	4700	59.7%
Chronic Blood Loss Anemia	Present in Patient	182	2.3%
	Absent	7692	97.7%
Obesity	Present in Patient	1313	16.7%
	Absent	6561	83.3%
Weight Loss	Present in Patient	2073	26.3%
	Absent	5801	73.7%
Drug Abuse	Yes	157	2.0%
	No	7717	98.0%
Immunosuppressive Drugs	Yes	246	3.1%
	No	7628	96.9%
Manner of Surgery	Open	6475	82.2%
	Laparoscopic	1399	17.8%
Serious Infection	Present	657	8.3%
	Absent	7217	91.7%
Superficial Infection	Present	635	8.1%
	Absent	7239	91.9%

LLOS, Long-term length of stay; MLOS, Medium-term length of stay; SLOS, Short-term length of stay.

Table 3. Summary statistics of participant's characteristics

Variables	Minimum	Mean	Median	Maximum
Age (years)	20.00	55.67	56.10	102.00
Surgery Duration (hours)	1.22	3.56	3.25	14.17
Length of Stay (days)	1	8	6	144

imbalances on colorectal health. Additionally, the predominance of open surgeries (82.2%) as seen in Table 2, might reflect the severity of cases, necessitating more invasive approaches. Finally, the low occurrence of postoperative complications (8.3% serious infections, 8.1% superficial infections) might be indicative of effective infection control measures, stringent surgical protocols, and attentive wound care.

### **Multinomial Logistic Regression Analysis for LLOS vs SLOS (reference)**

The findings presented in Table 4 provide insights into the various factors influencing the likelihood of LLOS compared to SLOS following colorectal surgeries.

The increase of 3.4% in the odds of LLOS with each one-year increase in age could be due to older patients possibly having more complex health issues, leading to longer recovery periods. Patients with coagulopathy or FED exhibited an approximate 325% and 299% higher likelihood of experiencing LLOS. This reflects the potential complications (profuse bleeding and electrolyte imbalances) these conditions pose during recovery, necessitating extended hospital stays.

A medical history of CHF or diabetes was not significantly enough to affect LLOS. This is likely a result of the relatively low prevalence of such cases in the study's cohort. Conversely, a substantial impact of severe weight loss before surgery on LLOS was observed, which might stem from these patients having severe medical conditions or compromised nutritional statuses which increase their likelihood of experiencing LLOS.

Furthermore, the increase in the likelihood of LLOS by 52% for every additional hour of

surgery indicates that longer surgeries tend to result in extended recovery times, possibly due to the invasiveness of the procedure. The lack of significant effect on LLOS from open (versus laparoscopic) surgeries might indicate that other factors play a more prominent role in determining prolonged recovery duration.

A substantial increase in likelihood of LLOS for patients with serious or superficial infections was observed, suggesting that infections significantly prolong recovery times, possibly due to additional treatment requirements.

### **Multinomial Logistic Regression Analysis for MLOS vs SLOS (reference)**

The findings from the multinomial logistic regression analysis in Table 5 provide insights into the factors influencing the likelihood of MLOS compared to SLOS following colorectal surgeries.

An increase in the likelihood of MLOS by 1.4% for every 1-year increase in age was observed, suggesting that older patients might face more complex postoperative recovery needs, impacting their LOS. The significantly higher likelihood of MLOS observed for patients with coagulopathy (49%) and FED (78%) highlights how these conditions contribute to postoperative complications, potentially leading to extended recovery periods.

A 61% increase in MLOS likelihood for patients who are drug addicts was observed. This suggests that a drug abuse history might be associated with weakened immune systems, influencing surgical outcomes, potentially leading to more demanding recovery requirements. Furthermore, the substantial impact of severe weight loss (181%) before surgery on MLOS could be a

*Determinants of Hospital Stay Duration Post-Colorectal Surgery*

Table 4. Summary of the findings from the multinomial logistic model of SLOS (reference) VS LLOS

Predictors	OR	p-value	95% CI
Age	1.034	0.000	[1.020, 1.048]
Gender: Female	1.024	0.913	[0.667, 1.571]
CHF: Yes	1.822	0.110	[0.872, 3.807]
Diabetes: Yes	1.011	0.972	[0.555, 1.841]
RF: Yes	0.922	0.825	[0.451, 1.887]
LD: Yes	0.762	0.605	[0.272, 2.133]
Coagulopathy: Yes	4.249	0.000	[2.617, 6.898]
FED: Yes	3.986	0.000	[2.020, 7.865]
CBA: Yes	1.083	0.885	[0.366, 3.204]
Obesity: Yes	0.840	0.515	[0.496, 1.421]
Weight Loss: Yes	33.267	0.000	[14.853, 74.510]
Drug Abuse: Yes	2.030	0.146	[0.781, 5.276]
Immunosuppressants: Yes	0.683	0.610	[0.158, 2.954]
Surgery Duration	1.523	0.000	[1.373, 1.690]
Manner of Surgery: Open	0.986	0.967	[0.506, 1.922]
Serious Infection: Yes	10.909	0.000	[6.843, 17.389]
Superficial Infection: Yes	1.890	0.039	[1.034, 3.452]

OR, Odds ratio; CI, Confidence interval; CHF, Congestive heart failure; RF, Renal failure; LD, Liver disease; FED, Fluid and electrolyte disorders; CBA, Chronic blood loss anemia

Table 5. Summary of the findings from the multinomial logistic model of SLOS (reference) VS MLOS

Predictors	OR	p-value	95% CI
Age	1.014	0.000	[1.011, 1.018]
Gender: Female	0.925	0.137	[0.834, 1.025]
CHF: Yes	1.296	0.089	[0.961, 1.749]
Diabetes: Yes	1.006	0.949	[0.849, 1.191]
RF: Yes	0.953	0.721	[0.730, 1.243]
LD: Yes	0.954	0.775	[0.689, 1.321]
Coagulopathy: Yes	1.485	0.000	[1.201, 1.837]
FED: Yes	1.783	0.000	[1.591, 1.998]
CBA: Yes	1.256	0.180	[0.900, 1.754]
Obesity: Yes	0.948	0.461	[0.824, 1.092]
Weight Loss: Yes	2.814	0.000	[2.486, 3.186]
Drug Abuse: Yes	1.607	0.014	[1.102, 2.342]
Immunosuppressants: Yes	1.125	0.436	[0.837, 1.512]
Surgery Duration	1.469	0.000	[1.420, 1.520]
Manner of Surgery: Open	1.758	0.000	[1.525, 2.028]
Serious Infection: Yes	2.928	0.000	[2.395, 3.580]
Superficial Infection: Yes	1.677	0.000	[1.384, 2.032]

OR, Odds ratio; CI, Confidence interval; CHF, Congestive heart failure; RF, Renal failure; LD, Liver disease; FED, Fluid and electrolyte disorders; CBA, Chronic blood loss anemia

result of compromised health status, which might make recovery more challenging. Immunosuppressive drug use and obesity on MLOS are observed to be non-significant predictors of MLOS, implying that their influence on LOS is less pronounced in this context.

The higher likelihood of MLOS for patients undergoing open surgeries (76%) underscores the potential complexity and invasiveness of open procedures, which might result in extended recovery times. Likewise, the increase in the odds of MLOS by 47% for every additional hour of surgery emphasizes the effect of surgical duration on recovery since longer surgery durations are associated with severe medical conditions.

Finally, the strong association between postoperative complications and MLOS suggests that patients experiencing serious or superficial infections face substantially longer recovery periods, possibly due to the added challenges of managing such complications.

### Likelihood Ratio Chi-Square Tests

The findings from the likelihood ratio chi-square tests in Table 6 reveal clinically relevant insights into the factors influencing LOS following colorectal surgeries.

The significant p-value associated with the final model (p-value = 0.000) underscores the overall effectiveness of the predictive model, indicating that the inclusion of all predictors significantly improves the model's performance compared to a null model.

Age emerged as a significant predictor of LOS, suggesting that older patients might experience longer stays due to potential age-related complications. Gender, however, did not have

Table 6. Summary results of the likelihood ratio chi-square tests of significance the relationship of each predictor variable and LOS

Predictor	Chi-Square	p-value
Final Model	2053.178	0.000
Age	86.995	0.000
Gender	2.356	0.308
CHF	4.068	0.131
Diabetes	0.005	0.998
RF	0.142	0.931
LD	0.304	0.859
Coagulopathy	35.816	0.000
FED	108.632	0.000
CBA	1.820	0.402
Obesity	0.809	0.667
Weight Loss	358.706	0.000
Drug Abuse	6.576	0.037
Immunosuppressive Drugs	1.056	0.590
Manner of Surgery	64.142	0.000
Surgery Duration	560.871	0.000
Serious Infection	160.158	0.000
Superficial Infection	28.358	0.000

CHF, Congestive Heart Failure; RF, Renal Failure; LD, Liver Disease; FED, Fluid and Electrolyte Disorders; CBA, Chronic Blood Loss Anemia

a significant effect on LOS, suggesting its limited influence in this context. Additionally, medical history factors like CHF, diabetes, RF, and LD did not show significant effects on LOS, possibly due to the very low prevalence of such conditions.

A significant influence of comorbidities like coagulopathy and FED on LOS was observed, suggesting that patients with these conditions undergo more intricate postoperative recoveries, possibly due to heightened risks of severe bleeding and imbalances in fluids and electrolytes.

Furthermore, the significant effects of drug abuse and severe weight loss prior to surgery as predictors of LOS could suggest



that these factors might contribute to heightened postoperative complications or more challenging recoveries. Likewise, the significant influence of both surgery approach (open vs laparoscopic) and surgery duration on LOS highlights the importance of these factors in determining recovery duration.

Finally, significant individual effects of postoperative complications, including serious and superficial infections were observed. This underscore their role in prolonging LOS, indicating that addressing and managing complications effectively is crucial for minimizing hospital stays.

## Discussion

This study aimed at identifying preoperative, intraoperative and postoperative factors that affect LOS following a colorectal surgery and the nature of these effects. In this study, we made the following discoveries:

- a) For preoperative factors age, coagulopathy, FED, drug abuse and severe weight loss prior to surgery were identified as significant predictors of LOS,
- b) For intraoperative factors, surgery approach (open vs laparoscopic) and surgery duration were both discovered to be significant predictors of LOS, and
- c) For postoperative factors, serious infections and superficial infections were also found to be significant predictors of LOS.

## Preoperative Factors

In our investigation, among the demographic factors considered, age emerged as the sole significant determinant of LOS. With every year increase in age, the likelihood of

experiencing LLOS and MLOS increased by 3.4% and 1.4%, respectively. This observation indicates that advanced age is associated with an increased risk of prolonged LOS following colorectal surgery. These findings are consistent with prior research studies,<sup>17, 18, 19, 20</sup> which collectively substantiate our identified relationship between age and LOS. Conversely, our study showed that gender did not have a significant impact on LOS. This outcome aligns closely with the findings reported by Kelly et al.,<sup>17</sup> Faiz et al.,<sup>19</sup> and Li et al.,<sup>21</sup> where in their respective investigations similarly indicated that gender did not serve as a significant predictor nor was it associated with LOS. However, a contrasting perspective emerges from Lobato et al.'s 2013 study,<sup>22</sup> which identified gender as a significant predictor of LOS following colorectal surgery, attributing prolonged LOS to males as compared to females. The difference in our study's findings regarding the role of gender as a predictor of LOS after colorectal surgery, compared to the research by Lobato et al.,<sup>22</sup> could be explained by variations in how the primary outcome variable, LOS, was defined. In their study, they considered extended LOS as any hospital stay surpassing the 75th percentile. Our findings, in relation to existing research, emphasize the complexity and variability of gender's role in influencing LOS outcomes in the context of colorectal surgery.

Regarding medical history, our analysis revealed that CHF, diabetes, RF, and LD were not significant predictors of LOS. This observation is consistent with certain research findings while differing from others. For instance, our results do not agree with Lobato et al.'s study,<sup>22</sup> which indicated that a history of CHF significantly impacted LOS, resulting

in a 205% increased risk of prolonged LOS. Similarly, multiple studies have established the significance of disease history, whether RF, LD, or diabetes, in having significant influence on patient LOS, resulting in increased risks of postoperative complications and extended LOS.<sup>23, 24</sup> Discrepancies in findings could be attributed to factors such as cohort differences. For instance, in the research conducted by Ho et al.,<sup>23</sup> their study exclusively focused on patients aged 65 and older, while Levy et al.<sup>24</sup> restricted their study to patients diagnosed solely with rectal neoplasms. Nevertheless, our findings are consistent with the study conducted by Leichtle et al.,<sup>25</sup> which similarly found that a medical history of any cardiovascular disease had no significant effect on LOS. Additionally, the study by Reddy et al.<sup>26</sup> aligns with our results, as they identified diabetic history as a nonsignificant predictor of LOS following colorectal surgery. The lack of significance of these medical histories within our study may stem from the significantly low prevalence of such cases among our study's participants. As a result, the study might not have possessed enough statistical power to identify their significant impacts on LOS.

In terms of comorbid conditions, our investigation found that coagulopathy emerged as a significant predictor for both LLOS and MLOS, increasing the associated risks by 325% and 49%, respectively. This underscores the elevated risk of patients with coagulopathy to a prolonged LOS following colorectal surgery. Previous studies have found coagulopathy to significantly increase the risk of postoperative complications, which in turn prolongs LOS, and mortality,<sup>23, 24</sup> as prolonged LOS have been associated with increased risk of death.<sup>24</sup> Likewise, our study revealed that FED had

a significant effect on LLOS and MLOS, increasing the related risks by 299% and 78%, respectively. This suggests a tendency for patients with FED to experience prolonged hospital stays, possibly due to complications like electrolyte imbalances. This discovery aligns with the outcomes reported by Ho et al.<sup>23</sup> and Levy et al.,<sup>24</sup> who similarly recognized FED as a significant factor contributing to postoperative complications. This, in turn, increases the potential for extended hospital stays and, ultimately, an increased risk of death. Conversely, our analysis demonstrated that CBA did not have a significant impact on LOS. This contrast with Leichtle et al.'s conclusions,<sup>25</sup> where they established anemia, encompassing varying degrees of severity, as a significant contributor to prolonged hospital stays after colon surgery. This contrast can be rationalized by the relatively low prevalence of CBA cases (2.3%) in our study, along with the disparity in study methodologies. For instance, Leichtle et al.'s<sup>25</sup> research incorporated confounder controls, unlike our study, which lacked such adjustments.

Additionally, in terms of lifestyle and medication factors, our investigation revealed that although obesity displayed lower likelihood of a prolonged LOS, it did not have a statistically significant effect on LOS. This diverges from the findings reported by Gendall et al.<sup>27</sup> and Lee et al.,<sup>28</sup> whose respective studies indicated a significant negative impact of obesity on postoperative outcomes, including LOS. This discrepancy could be attributed to the distinct research designs employed: Gendall et al.<sup>27</sup> conducted a review study, whereas our study followed a retrospective approach. In our study, we observed a significant effect of drug abuse in predicting MLOS, with an elevated

risk of 61%. However, drug abuse did not yield significance in predicting LLOS. These findings align partially with certain studies, where drug abuse demonstrated a lack of significant effect on LOS following colorectal surgery. For instance, Levy et al.<sup>24</sup> reported similar results, where it was discovered that drug abuse, alcohol abuse, and tobacco usage did not significantly affect postoperative complications, LOS, or mortality. Furthermore, we discovered a highly significant association between severe preoperative weight loss and both LLOS and MLOS, with increased risks of 3227% and 181%, respectively. The significant magnitudes of these risks could be attributed to severe and unexplained weight loss frequently indicating grave medical conditions, like end-stage cancers. This finding is, consistent with the findings of previous studies.<sup>22</sup>

### **Intraoperative Factors**

Concerning intraoperative factors, our investigation found that surgery duration played a significant role in predicting both MLOS and LLOS, resulting in increased risks of 47% and 52%, respectively for each additional hour of surgery. This finding corresponds with the results of a study by Eagye et al.,<sup>20</sup> which identified an association between surgical durations exceeding 3 hours and an increased susceptibility to postoperative infections, leading to prolonged hospital stays. Likewise, Guidolin et al.<sup>29</sup> arrived at a similar conclusion, stating that each additional 30 minutes of surgical duration corresponded with a 10% increase in the risk of encountering postoperative complications. Similar to these findings, Evans et al.<sup>30</sup> observed similar outcomes.

Moreover, with regard to the surgical approach, we observed that undergoing open surgery procedures significantly increased the likelihood of having MLOS, while having no significant influence on LLOS. Specifically, compared to laparoscopic procedures, patients undergoing open surgery faced a 76% increased risk of MLOS. This conclusion aligns with the findings of previous studies by Faiz et al.<sup>19</sup> and Lobato et al.,<sup>22</sup> both of which identified the manner of surgery as a significant predictor of LOS. This discovery emphasizes the importance of promoting laparoscopic surgeries, as their benefits extend beyond mere LOS. These advantages include faster recovery owing to minimized trauma to adjacent tissues, improved aesthetics due to smaller incisions, and a decreased likelihood of postoperative complications, such as wound infections. However, it's essential to recognize that although laparoscopy offers numerous benefits, certain patient-specific factors or surgical complexities might make open surgery a more suitable choice in some instances.

### **Postoperative Factors**

Lastly, in the terms of postoperative complications, our study found that patients encountering either superficial infections or serious infections faced increased risks of prolonged hospital stays. Specifically, for cases of superficial infections, the odds of experiencing MLOS and LLOS increased by 68% and 89%, respectively. For instances of serious infections, the odds of having MLOS and LLOS increased by 193% and 991%, respectively. These findings indicate the substantial adverse impact that postoperative infections, particularly those of a serious nature,

impose on LOS.

These findings align with Lobato et al.'s<sup>22</sup> findings, who similarly identified the significant effects of postoperative complications such as sepsis (OR = 2.54), organ space infections (OR = 2.34), and superficial wound infections (OR = 1.74) on LOS following colorectal surgery in their study. Moreover, our findings align with the research findings of Schmelzer et al.,<sup>18</sup> Reddy et al.,<sup>26</sup> and Leung et al.,<sup>31</sup> further emphasizing the significant impact of postoperative infections on LOS following colorectal surgery. Likewise, postoperative complications extend beyond just prolonging LOS. These complications can also lead to increased medical costs, reduced quality of life for patients, and complication related readmissions. Therefore, efforts to minimize such complications are crucial as they help reduce LOS and healthcare costs, and optimize resource allocation within the healthcare system.

### Limitations

In undertaking this research, it is important to acknowledge certain limitations that may impact the scope and generalizability of our findings. Foremost among these limitations is the secondary nature of the data utilized. As a result, the current dataset may have undergone modification to protect the privacy and identities of the participants, thereby potentially introducing variations to the original data. Furthermore, an inherent limitation of this study pertains to the assumption that all colorectal procedures are uniformly influenced by the identified factors. In reality, the diverse spectrum of colorectal procedures may be subject to different variables and dynamics, which our study did not explicitly account for. This

aspect may contribute to an oversimplification of the complex interplay between patient characteristics, surgical procedures, and their subsequent effects on hospital length of stay. Also, a possible survivorship bias in our study arises from excluding patients who died before discharge. This might underestimate LOS and impact assessments of factors influencing LOS, particularly for patients with severe complications or poorer outcomes. Additionally, while meticulous efforts were made to include a comprehensive range of preoperative, intraoperative, and postoperative factors, other pertinent variables that could influence LOS may not have been fully considered within the scope of this research. Likewise, it is important to note that our study did not account for potential confounding variables such as race, hospital practices, disease complexity, anesthesia management, and surgeon expertise. Therefore, the implications of these uncontrolled variables could introduce variability in our findings and potentially affect the accuracy of the identified factors influencing LOS.

### Conclusions

In summary, our study revealed significant insights into predictors of LOS after colorectal surgery. Preoperative factors like age, coagulopathy, FED, severe weight loss, and drug abuse emerged as important predictors, while gender, immunosuppressive drugs, and certain medical histories had negligible effects on LOS. Intraoperative factors such as surgical approach and duration of surgery were identified as significant predictors of LOS. Likewise, postoperative factors which include both serious and superficial infections, also played significant roles in predicting LOS.

In light of our study's findings, specific interventions could address predictors of longer LOS after colorectal surgery. For preoperative factors, proactive measures such as tailored preoperative optimization for older patients and those with coagulopathy, FED, severe weight loss, or a history of drug abuse could help minimize LOS. Optimizing surgical approach and duration could involve employing minimally invasive techniques and refining surgical protocols. Also, rigorous infection prevention protocols and timely management could mitigate the impact of both serious and superficial postoperative infections on LOS. These focused interventions hold potential to improve postoperative outcomes and reduce LOS. Shorter hospital stays directly result in reduced utilization of hospital resources, including bed occupancy, staff time, and consumables which in turn decreases the overall cost of care per patient and enhance postoperative recovery.

Given the complexity of LOS determinants, we encourage further granular research that delves into specific subtypes of colorectal surgeries or stratifies by patient characteristics such as overall health, socio-economic status, and age groups. This granular analysis could provide nuanced insights, enabling tailored interventions that optimize surgical outcomes and resource utilization.

### Availability of Data

The data that support the findings of this research are available under the Creative Commons Attribution 4.0 International License (CC BY 4.0). The dataset is accessible through the Teaching Statistics in the Health Sciences database, which provides unrestricted access

to the collected data, allowing for its reuse and redistribution. Researchers and interested parties are encouraged to explore and utilize the dataset while adhering to the terms of the Creative Commons license.

### Conflict of Interests

The authors declare that they have no conflict of interests.

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