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Predictors of length of stay for patients undergoing percutaneous intervention

By

Ammin Rajab Abu El-Shaer¹, Ali Suleiman Harbi², Raghad Waleed Al-Harazneh³

¹Deputy Hospital Director, Istiklal Hospital

²School of Nursing, Applied Science Private University, Amman, Jordan.

³Department of Nursing education, Istiklal Hospital



Abstract

Cardiovascular disease (CVD) is the leading cause of death worldwide. The majority of deaths occur in low- and middle-income countries (LMIC). Among cardiovascular conditions coronary artery disease (CAD) is the most common. Percutaneous coronary intervention (PCI) is a widely implemented nonsurgical technique management for treating obstructive or narrowing coronary artery disease. Despite technology development in PCI procedure and post-procedural management, some patients are still complaining of complications that may result in extended length of stay. This study aims to identify the predictors of length of stay for patients undergoing percutaneous intervention. **Methods:** the study was conducted employing prospective observational design at Istiklal Hospital in Amman, Jordan. The convenience sampling method was used to select the participants in this study. Data was collected through interviews and utilizing patient medical records. **Results:** the sample consisted of 122 participants. LOS ranged from 1-5 days with a mean of 1.64 ($SD \pm 1.053$). The average age was 58.66 ($SD \pm 11.960$). The majority of the sample 110 (90.2%) were males and 113 (92.6%) were married. The final multiple linear regression model explained 58.7% of the variance in LOS ($Adjusted R^2 = 0.32$). The overall model was statistically significant $F(7, 114) = 25.56, p < 0.001$, indicating that the predictor variables significantly explained LOS. **Conclusion:** length of stay post-PCI can be predicted by several demographic and clinical factors. Advanced age, female gender, increased weight, having a history of HTN, DM, or CKD were identified in the present study as predictors for LOS. Identifying these predictors allows healthcare providers to priority recognize patients with high risk. Therefore, they can provide focused care plan to avoid unnecessary prolonged hospital stay and allocate health resources.

Keywords: Length of stay, Predictors, coronary artery disease, Percutaneous coronary intervention

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Corresponding author
Ammin Rajab Abu El-Shaer

Introduction

Cardiovascular disease (CVD) is the leading cause of death worldwide. The majority of deaths occur in low- and middle-income countries (LMIC). Among cardiovascular conditions coronary artery disease (CAD) is the most common (Di Cesare et al., 2024). According to global cardiovascular disease statistics produced by the American Heart Association (AHA), CAD is responsible for more than 9 million deaths globally (Martin et al., 2024). Additionally, it was estimated that in 2020 nearly 244 million people were living with CAD with a prevalence rate of 112.37 per 100,000 (Martin et al., 2024).

Percutaneous coronary intervention (PCI) is a widely implemented nonsurgical technique management for treating obstructive or narrowing coronary artery disease (CAD) (Hoole & Bambrough, 2020). It offers an efficient and less invasive treatment option that can replace surgical procedures such as coronary artery bypass grafting (CABG) (Sabatine et al., 2021; Stone et al., 2020). Despite technology development in PCI procedure and post-procedural management, some patients are still complaining of complications that may result in extended length of stay (LOS) (Firman Sugiharto et al., 2023).



Length of stay LOS is the duration counted from the day of admission to the hospital until the day of discharge (Eskandari et al., 2022). It is a critical indicator of the quality of care in healthcare systems (Siddique et al., 2021). The financial burden of LOS cannot be ignored. Extended LOS significantly increases treatment costs, affecting both providers and patients (Minhas et al., 2022). Therefore, shortening LOS, while maintaining high quality of care, can result in substantial reductions in healthcare costs. Additionally, effective post-procedural care and discharge planning are essential practices that can minimize unnecessary delays, thereby saving resource utilization within healthcare facilities (Bautista, 2021; Lauck et al., 2020). Moreover, LOS is an important factor in influencing patient outcomes, reducing LOS has been linked with decreased risks of hospital-acquired infections and related medication side effects. It is also associated with improved treatment outcomes and lower mortality rates (Jang et al., 2020; Zhang et al., 2020).

Traditionally, LOS is associated with many factors, including patient demographics such as gender and advanced age, clinical characteristics such as being diabetic or hypertensive, procedural details, and post-procedural complications (Alexandrescu et al., 2021; Firman Sugiharto et al., 2023). However, in many clinical settings, particularly in the pre-procedural phase, some data regarding these factors may not be readily available. In such contexts, relying on easily available data, such as demographic characteristics and the presence of comorbidities, becomes important. These basic variables can still provide valuable information about the potential LOS for PCI patients.

Although prior studies have provided valuable insights, healthcare systems vary significantly across countries. Cultural differences, resource availability, and patient demographics characteristics can impact LOS. Therefore, examining and validating sociodemographic and comorbid predictors in different settings is paramount. It can yield important findings that reflect the specific challenges and needs of a given population. This study aims to investigate whether LOS can be predicted by sociodemographic factors such as age, gender, and marital status and comorbidities such as diabetes mellitus, hypertension, and chronic kidney disease for patients post-PCI.

Methods

Design, Sampling, and Siting

This study adopted a prospective observational design to retrieve data related to patients planned for PCI and tracking them until discharge. The study was conducted at *Istiklal Hospital* in Amman, Jordan. The convenience sampling method was used to select the participants in this study. The sample size was calculated using the G* power software calculator (version 3.1.9.7) based on the following values; an alpha of 0.05, power of 0.95, and an effect size of .015. The final required sample size was 120 participants.

Data Collection

A group of trained nurses were assigned to collect the data. Patients were interviewed and provided with information regarding the study. During the interview sociodemographic data such as age,

gender, and marital status are collected and saved in special forms. Additionally, return to patients' medical records to retrieve clinical data. The date of admission for every patient was recorded and patients were followed until the date of discharge. All patients' data were computerized and prepared for statistical analysis.

Statistical Analysis

Exploratory data analysis (EDA) and inferential statistics were used to analyze the data. Continuous variables were described by means and standard deviations and categorical variables were presented as frequency and percentage. A multiple linear regression model was used to determine whether LOS can be predicted by sociodemographic characteristics (i.e. age, gender, marital status, smoking status) and comorbidities (i.e. diabetes mellitus, hypertension, and chronic kidney disease). The results were considered statistically significant at alpha < 0.05. confidence interval was set at 95%.

Ethical Considerations

This study prioritized respondents' rights and privacy. All data were handled confidentially, and participation was entirely voluntary. No risks were associated with participation, and ethical approval was obtained before the study began.

Results

The sample consisted of 122 participants. LOS ranged from 1-5 days with a mean of 1.64 (SD ± 1.053). The average age was 58.66 (SD ± 11.960). The majority of the sample 110 (90.2%) were males and 113 (92.6%) were married. Nearly half of the sample were smokers 62 (50.8%). Hypertension was the most frequent comorbid disease with 66 (54.1%) of the sample were hypertensive, followed by DM with 48 (39.3%) of the sample were diabetic, whereas 18 (14.8%) had CKD. (See table 1&2).

Table 1: descriptive analysis of categorical variables

		Frequency	Perce nt	Valid Percent	Cumulativ e Percent
Gende r	Femal e	12	9.8	9.8	9.8
	Male	110	90.2	90.2	100.0
Marita l Status	Single	5	4.1	4.1	4.1
	Marrie d	113	92.6	92.6	96.7
	Divor ced	3	2.5	2.5	99.2
	Wido wed	1	.8	.8	100.0
Smoki ng Status	Non-smoke r	60	49.2	49.2	49.2
	Smok er	62	50.8	50.8	100.0



Have HTN	No	56	45.9	45.9	45.9
	Yes	66	54.1	54.1	100.0
Have DM	No	74	60.7	60.7	60.7
	Yes	48	39.3	39.3	100.0
Have CKD	No	104	85.2	85.2	85.2
	Yes	18	14.8	14.8	100.0

HTN: hypertension, DM: diabetes mellitus, CKD: chronic kidney disease

The residuals of the final model were inspected for normality and homoscedasticity. A plot of residuals versus fitted values showed no obvious patterns, indicating that the assumptions of homoscedasticity were met. The Durbin-Watson statistic was 1.62, suggesting no autocorrelation issues.

Table 2: descriptive analysis of continuous variables

	N	Minimum	Maximum	Mean	Std. Deviation
Age	122	32	96	58.66	11.960
Weight	122	60	130	83.47	11.416
LOS	122	1	5	1.64	1.053

LOS: length of stay

The initial model included all eight predictor variables. Backward elimination was used to remove non-significant predictors ($p > 0.05$). After refinement, marital Status and smoking Status were excluded from the final model, as they did not significantly contribute to predicting LOS.

The final multiple linear regression model explained 58.7% of the variance in LOS (Adjusted $R^2 = 0.32$). The overall model was statistically significant $F(7, 114) = 25.56, p < 0.001$, indicating that the predictor variables significantly explained LOS. (See Table 3).

Table 3: linear regression model of predictors of LOS

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-1.226	.660		-1.858	.066
AGE	.013	.006	.153	2.105	.037
Gender	-.697	.216	-.198	-	.002

				3.220	
Weight	.026	.006	.284	4.438	.000
HTN	.467	.148	.222	3.161	.002
DM	.308	.138	.143	2.231	.028
CKD	.995	.199	.337	4.993	.000

HTN: hypertension, DM: diabetes mellitus, CKD: chronic kidney disease.

Discussion

The present study explored the predictors of LOS in patients undergoing PCI. The findings underscored many demographic and clinical factors influencing LOS, including age, gender, weight, HTN, DM, and CKD. The results of the present study provide an understanding regarding the multifactorial nature of LOS post-PCI. It highlights the need to take into account patient's characteristics and medical history while planning for optimizing patient care and resource utilization.

Advanced age is a proven predictor of LOS. Older patients are likely to stay longer in hospital post-PCI as a result of age-related physiological factors that interfere with the recovery process. (Chin et al., 2011; Rajesh V Swaminathan et al., 2015). Previous research reported that patients with an average age of >68 years have a longer LOS (Isik et al., 2016). Pathophysiological changes such as impaired endothelial function, increased calcification, and a history of cardiac disease associated with extended LOS among elderly patients (Lv et al., 2021; Mirbolouk et al., 2020; Velagapudi et al., 2018). Correspondingly, the findings of the present study revealed that age is an independent predictor of LOS. This result was in agreement with previous studies; Velagapudi et al Conducted a retrospective study on 678,545 patients to inspect contemporary trends in LOS and to identify the predictors associated with prolonged LOS in patients undergoing PCI. They divided the patients into 3 groups according to the LOS: <2 days, 2 to 3 days, and >3 days. They found that older age was associated with longer LOS (Velagapudi et al., 2018). Similarly, Burton et al conducted a retrospective study to develop a predictive model consisting of factors associated with extended hospital stay among PCI patients. In their study age was identified also as a predictor of prolonged length of stay (Burton et al., 2019).

Women with ACS present with different symptoms compared to men (van Oosterhout et al., 2020). Previous research has suggested that women have a longer time from symptom onset to presentation and are less likely to have diagnostic testing such as electrocardiogram and troponins. Not recognizing symptoms often delays the diagnosis of ACS (Costello & Younis, 2020). The extent of lesion depends on the duration of ischemia, (Bugiardini et al., 2017; Cenko et al., 2018; D'Onofrio et al., 2015). These findings could interpret the worse outcomes after PCI for women compared to men.

The traditional risk factors of CAD (HTN, DM, dyslipidemia, obesity, and smoking) have become more prevalent among modern

women. Moreover, women are at risk for several specific conditions such as gestational HTN or DM, menopause, use of contraceptives, and polycystic ovary syndrome, which contribute to CVD (Araújo et al., 2018; Lin et al., 2022). In the present study, the female gender was identified as an independent predictor for prolonged LOS. Being female is associated with a 0.70-day increase in the LOS. Likewise, prior research has demonstrated that females are at higher risk of prolonged LOS compared to men (Isik et al., 2016; F. Sugiharto et al., 2023).

Obesity plays a critical role in the development of CAD due to metabolic, hemodynamic, inflammatory factors, and oxidative stress (Lassale et al., 2018; Patlolla et al., 2021). Despite these, the relationship between body weight and adverse outcomes post-PCI is not fully understood, obesity paradox phenomenon implies that overweight and obese patients have better outcomes than normal and underweight patients (Mehta et al., 2021). While several studies supported this phenomenon, some studies have shown that Patients with extreme body mass index (underweight and class III obesity) are susceptible to prolonged LOS (Lv et al., 2021; Patlolla et al., 2021). However, the results of the present study revealed that the risk of prolonged LOS increases with increased weight. The lack of consensus warrants further research to understand the exact mechanism by which body weight affects LOS post-PCI.

Additionally, the findings of the present study demonstrated that the traditional comorbid diseases HTN, DM, and CKD can significantly predict LOS after PCI. These findings were in concordance with previous studies that reported that patients with longer LOS had more comorbid diseases than those with shorter LOS (Rajesh V. Swaminathan et al., 2015). Studies reported that DM is a predictor for adverse outcomes post-PCI (Megaly et al., 2022; Shalaby et al., 2024). The hypercoagulable predisposition state, atherosclerosis and inducing endothelial dysfunction in patients with DM could be the cause of these unfavorable outcomes (Goel et al., 2021). Other studies demonstrated that extended duration of LOS is more common in patients with a history of HTN. This might be driven by several pathophysiological factors, such as atherosclerosis, left ventricular hypertrophy, arrhythmias, and endothelial damage that will influence the LOS (Frak et al., 2022; Rezaianzadeh et al., 2020; Zeitouni et al., 2020). Moreover, patients with CKD also experience longer LOS, this can be a consequence of vascular and circulatory complications post-PCI including bleeding, loss of distal pulse, occlusion site access, dissection and pseudo aneurysm that will indeed affect LOS in patients with CKD (Jankowski et al., 2021; Prasad et al., 2020).

Some encountered limitations during the study should be acknowledged. First, this study was conducted in a single site, which may limit the generalizability of the results to other regions with different healthcare systems, cultural, and demographic and characteristics. Additionally, the study relied only on pre-procedural data and lacked intra and post-procedural data which might involve some cofounders that influence the results. Finally, data related to variation in clinical decision-making were not available, this variation could impact the LOS.

Conclusion

length of stay post-PCI can be predicted by several demographic and clinical factors. Advanced age, female gender, increased weight, having a history of HTN, DM, or CKD were identified in the present study as predictors for LOS. Identifying these predictors allows healthcare providers to priority recognize patients with high risk. Therefore, they can provide focused care plan to avoid unnecessary prolonged hospital stay and allocate health resources.

Implication and Recommendation

The results of this study offer valuable insights into the key predictors of LOS for patients undergoing PCI, which may guide both healthcare delivery and hospital administration plans. Recognizing predictors of LOS allows healthcare providers to improve patient care pathways, potentially reducing preventable prolonged stays and controlling resource utilization. Furthermore, the results underscore the importance of considering demographic and clinical factors when managing post-PCI patients. Future studies are recommended to focus on validating these findings across multiple healthcare settings to boost their generalizability. It is also recommended that future studies include detailed data on procedural, clinical decision-making, and post-discharge care, as these potential predictors may add further clarification to the variation in LOS.

Conflict of interest

The authors declare no conflict of interest

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