PREDICTORS OF IN-HOSPITAL MORTALITY AMONG LIVER DISEASE PATIENTS: A LOGISTIC REGRESSION APPROACH

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ARTICLE INFO

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Vol: 3 | Issue: 4
ISSN Print: 2960-2580
ISSN Online: 2960-2599

Publisher:
Medical Research and Statistical Consultancy Training Centre (SMC-PRIVATE) Limited

Contributions
Chikezie Onyeka Okonkwo: main author and write up
Timilehin Adeniji: Analysis and ethical approval

Keywords: In-hospital mortality, death, cirrhosis, liver disease, regression

ORIGINAL ARTICLE

ABSTRACT

Background: Liver disease constitutes a major cause of morbidity and mortality in Nigeria. In-hospital outcomes are influenced by demographic, clinical, and therapeutic factors. Accurate identification of mortality predictors is essential for risk assessment and optimized resource utilization. Objective: This study aimed to identify independent predictors of in-hospital mortality among patients admitted with liver disease at a Nigerian tertiary hospital, viz University of Ilorin Teaching Hospital (UITH) using logistic regression modeling. **Methods**: A retrospective hospital-based study analyzed 295 complete records of liver disease admissions at the University of Ilorin Teaching Hospital, Ilorin, from the study period until 2024. Data included age, sex, body mass index (BMI), length of stay, and outcome (discharged or deceased). Normality was assessed via the Anderson-Darling test; group differences were evaluated using the Wilcoxon rank-sum test and chi-square test. Binary logistic regression was employed to estimate crude odds ratios (ORs) for mortality predictors. **Results**: Numerical variables (age, BMI, length of stay) were non-normally distributed. Wilcoxon tests revealed significant differences in length of stay between survivors and non-survivors ($p < 0.05$). A chi-square test indicated borderline association between sex and outcome. Logistic regression identified length of stay as the only significant predictor (OR = 0.944, 95% CI: [0.920, 0.968], $p < 0.001$), with each additional day reducing mortality odds by approximately 5.6%. Age, sex, and BMI were non-significant. **Conclusion**: Prolonged hospital stay emerged as a strong protective factor against in-hospital mortality in liver disease patients, highlighting the critical role of timely admission and sustained management. These findings underscore the need for early intervention and improved 'in-patient' care to improve survival
Keywords: Liver disease, In-hospital mortality, Logistic regression, Length of stay.

INTRODUCTION

Liver disease remains a significant health burden in the world in general, and Nigeria in particular. It contributes substantially to morbidity and mortality across diverse populations. The burden of chronic liver disease has intensified due to rising prevalence of alcoholic liver disease, viral hepatitis, and metabolic dysfunction-associated steatotic liver disease, necessitating reliable prognostic tools to stratify patient risk and guide clinical decision-

making. Among hospitalized patients with advanced liver disease, accurate prediction of in-hospital mortality remains a critical clinical challenge that directly influences resource allocation and treatment strategies [1].

The ability to identify high-risk patients at admission enables clinicians to implement more intensive monitoring protocols and optimize therapeutic interventions, ultimately improving patient outcomes and reducing preventable complications [2]. Logistic regression modeling has emerged as a fundamental statistical approach in medical research for identifying independent predictors of adverse outcomes and generating individualized risk estimates that facilitate evidence-based clinical practice [3]. The complexity of liver disease patho-physiology necessitates multifactorial approaches to mortality prediction, as no single laboratory parameter or clinical finding can reliably forecast patient outcomes. Previous investigations have identified numerous clinical and biochemical predictors associated with increased in-hospital mortality in cirrhotic patients, these factors include advanced age, renal dysfunction, coagulopathy, and systemic inflammatory markers. The Model for End-Stage Liver Disease (MELD) score and its modified variants, including MELD-Na and MELD 3.0, have been extensively validated as independent predictors of mortality in patients with end-stage liver disease [4]. However, recent evidence suggests that novel biomarkers and inflammatory indices may enhance the discriminatory ability of traditional scoring systems, warranting comprehensive reassessment of mortality predictors in contemporary patient cohorts [5].

Logistic regression analysis provides a methodologically sound framework for quantifying the relative contribution of multiple predictor variables while adjusting for potential confounders, thereby establishing the independent association between specific factors and in-hospital mortality. The growing recognition of sex-based and ethnic disparities in liver disease outcomes underscores the importance of developing population-specific mortality prediction models. Recent studies utilizing large administrative databases and prospective cohorts have demonstrated that logistic regression models incorporating demographic variables, physiological markers, and laboratory parameters achieve superior discriminatory performance compared to traditional clinical scoring systems alone [6].

The sequential organ failure assessment (SOFA) score, albumin-bilirubin (ALBI) grade, and neutrophil-to-lymphocyte ratio (NLR) represent emerging prognostic markers that capture distinct pathophysiological mechanisms underlying acute decompensation and organ dysfunction in advanced liver disease. Integration of machine learning approaches with logistic regression has enabled identification of novel predictive patterns that may not be apparent through conventional statistical analysis, improving risk stratification accuracy and clinical applicability. Furthermore, dynamic assessment of laboratory parameters and clinical trajectories during hospitalization provides superior prognostication compared to static baseline measurements alone [7].

Contemporary international guidelines recommend risk stratification of hospitalized patients with liver disease utilizing multiple validated prognostic tools to facilitate appropriate allocation of intensive care resources and guide timing of liver transplantation referral. The hierarchical integration of clinical severity scores, laboratory parameters reflecting synthetic hepatic function and renal reserve, and markers of systemic inflammation provides comprehensive risk assessment in this high-mortality population. Logistic regression methodology enables systematic evaluation of variable contributions to mortality risk while quantifying the magnitude of association and generating individual probability estimates that inform patient counseling and treatment planning [8].

Prospective validation of logistic regression-derived mortality prediction models in geographically diverse patient populations with variable healthcare infrastructure remains essential to establish the external generalizability and clinical utility of identified predictors [9]. The present study aimed to develop and validate a logistic regression-based model for in-hospital mortality prediction in liver disease patients, incorporating readily available demographic, clinical, and laboratory variables to establish a practical bedside tool for risk stratification.

Recent advances in understanding sepsis-associated organ dysfunction in cirrhotic patients have identified several pathways through which systemic inflammation drives acute decompensation and mortality [10]. Advanced age, baseline renal impairment, and elevated inflammatory biomarkers represent consistent independent predictors across multiple prospective and retrospective cohorts of hospitalized cirrhotic patients. The prognostic significance of specific laboratory parameters such as serum bilirubin, serum creatinine, international normalized ratio, and arterial ammonia concentration reflects different aspects of hepatic and renal functions that collectively determine clinical trajectory. Implementation of logistic regression models in real-time clinical decision support systems has demonstrated feasibility in acute care settings, enabling evidence-based triage and resource utilization optimization [8]. The cumulative evidence base demonstrates that mortality prediction in liver disease benefits from incorporation of multiple biomarkers and severity scores into integrated logistic models that account for interactive effects between predictor variables and provide individualized risk estimates [9].

MATERIAL AND METHOD

Study Design: This retrospective hospital-based study was conducted at the University of Ilorin Teaching Hospital (UITH), Ilorin, Nigeria. The Teaching Hospital is a tertiary healthcare institution that serves as center for chronic (including liver) disease management in the North-Central region of Nigeria. The data utilized in the study were extracted from the Records department of the hospital over the study period. Statistically, most of the cases of liver diseases in the North-central region of the country are referred to this hospital, so the conclusion drawn from this hospital is expected to mirror the generality of liver disease cases in the region.

Population and Inclusion Criteria

The study population consists of patients who were diagnosed with liver disease and injuries and admitted to, or referred to UITH during the review period. These group of patients include patients with confirmed diagnosis of liver disease, their ages, their sexes, their heights and weight$\left[BMI = \frac{Weight\ (kg)}{(Height)^2 (m^2)}\right]$, and their survival outcome (i.e. whether the patient died or was discharged). The observations were taken as reported from the hospital records. As a way of dealing with missing values, other patients with indeterminate outcomes were not considered in the research.

Sampling technique: A census was carried out for all the recorded cases of liver diseases as found in the hospital records. All documented cases of liver disease and injuries were included within the study period were included in the dataset. This ensured full coverage of available records and minimized the possibility of sampling bias. The key variables include: **Age (years), Sex** [Female (F), Male(M)], BMI (kg per mm^2), Length of stay (days)(i.e. from the day the patient was admitted until when they die or are discharged), Outcome [discharged , Deceased]

Inclusion criteria

- All cases of liver diseases and liver injuries were included from the records, a total of 295 cases.
- Records containing complete information on gender, age, height, weight, length of stay, and final outcome; i.e. whether patient was discharged or deceased.

Exclusion criteria

- Cases unrelated to liver disease or liver injuries.

Ethical approval

Ethical clearance for the study was granted by the Records Unit, University of Ilorin Teaching Hospital (UITH), Ilorin. Anonymity of patients was ensured to protect patient's confidentiality.

DATA ANALYSIS

All analyses were conducted using R version 4.5.0. Statistical significance was set at a two-sided $p < 0.01$ for the numerical variables and $p < 0.05$ for categorical variables. Continuous variables were assessed for normality using the Anderson-Darling test. Data were summarized as mean standard deviation (SD) for normally distributed variables or median (inter-quartile range, IQR) for non-normally distributed variables. Categorical variables were presented as frequencies and percentages.

RESULTS

The result show that the numerical variables, Age, BMI and length of stay are not normally distributed. Having established that the numerical variables are not all from a Normal distribution, in order to test their contribution to whether a patient survives (discharged) or deceased, we employ the *Wilcoxon Ranked sum test.* The Wilcoxon Ranked-Sum Test results are summarized in table 2 below. The chi-square test results concludes that there is significant association between sex and outcomes. Therefore whether a patient is discharged or dies depends on

their sex. This was further tested using the binary logistic regression. The results are summarized in the table below in table 5. Intercept ($\beta_0 = 0.2847$) is the value of the log odds when all other variables are zeros (i.e. age = 0, female sex, length of stay = 0, BMI = 0). Upon considering the other variables, we observe that a negative estimate of the sex variable indicates that there is a protective effect that affects male patients but not female patients, this is so because in the variable 'Sex' was coded as male = 1, and female = 0. Moreso, the odds ratio indicate that (0.723) indicate that males have $(1 - 0.723)\% = 27.7\%$ lower odds of death than females. However, the variable 'Sex' is borderline non-significant (0.06) $\alpha = 0.05$ level of significance. On age, the regression coefficient $\beta = 0.0074$ indicates increased risk of liver disease with age. This is further explained by the Odds ratio, such that for every one year increase in age, there is 7%(0.007) chance of developing a kidney disease, fortunately, this value is not significant at 5%. In the same vein, the odds ratio of BMI indicates an almost negligible effect (0.8%) of developing liver disease. The BM, just like the Sex does not significantly determine the outcome of patients with liver disease, whether they are discharged or die. The clinical implication of this is that BMI show no association with outcomes of liver disease after controlling for other factors. The length of time a patient stays in the hospital seems to be the main variable that determines whether a patient lives or dies while controlling for other factors. The negative coefficient $\beta = -0.0575$ indicates protective effects of longer stay at the hospital. With Odds ratio of 0.944, the odds of death decrease by$(1 - 0.944) = 0.056(5.6\%)$, there is an over five and half percent chance of being discharged with every additional day spent at the hospital for treatment. In other words. This variable is highly significant in determining who is discharged from the hospital. This is further confirmed by the confidence interval. By implication, patients who were taken early to hospital are five and half times more likely to be recover than patients who do not go early to the hospital for treatment.

Table 1: Summary of Anderson-Darling Test for Normality

Variable	**A-D statistic**	**p-value**	**Decision**	**Interpretation**
Age	0.9241	0.01869	Reject H_0	Not Normal
BMI	1.1803	0.004354	Reject H_0	Not Normal
Length of stay	9.0319	2.2e-16	Reject H_0	Not Normal

Table 2: Summary of Wilcoxon Ranked-Sum Test

Variable	**W statistic**	R_1	**Z-score**	**p-value**	**Remark**
Age	9655.50	20,919.50	-1.7840.0744	0.0744	Not significant
BMI	10696.00	21,971.00	-0.243	0.8080	Not significant
Length of stay	8783.00	19,058.00	2.905	0.0037	significant

Table 3: Chi-square Contingency table

Variable	**Discharged**	**Deceased**	**Total**
Male	98	84	182
Female	52	61	133
Total	150	145	295

Table 4: Chi-square test results

	Statistic	**Degree of freedom**	**p-value**	**Interpretation**
Chi-square	4.227	1	0.0398*	Significant association exist
Cramer V	1.120	-	-	Weak association

Table -5 Binary Logistic Regression Test Result

Variables	***β*** **Estimate**	**Std Error**	**Wald Z**	**p-value**	**99% C.I.**	**Odds Ratio**	**Interpretation**
Intercept	0.2847	1.2156	0.234	0.8147	-	1.329	Not significant
Sex (M)	-0.3244	0.1748	-1.856	0.0653	[0.478,1.094]	1.007	Not significant
Age	0.0074	0.0052	1.423	0.1547	[0.994,1.021]	0.723	Not significant
BMI	0.0081	0.0494	0.164	0.8699	[0.887,1.146]	0.944	Not significant
Length-of-stay	-0.0575	0.0144	-3.993	0.00067**	[0.904,0.986]	1.008	Significant

DISCUSSION

The fibrotic replacement of liver tissue resulting in any chronic liver disease (CLD) is considered as cirrhosis [11]. It is among the primary causes of hepatic mortality in the world. In 2019, cirrhosis in the world was estimated to cause 1.47 million deaths, which constituted 2.4% of the total deaths. After 2010, this figure rose by 10% [12]. The low survival rates in patients with cirrhosis and the worsening prognosis associated with such complications as hepatic encephalopathy (HE), gastrointestinal bleeding (GIB), spontaneous bacterial peritonitis (SBP), hepatorenal syndrome (HRS), and ascites make researchers develop corrective approaches to predict outcomes in patients with chronic liver disease [13].

This research was aimed at the application of a logistic regression method to identify predictors of in-hospital mortality among patients with liver disease. The key variables analyzed included age, sex, BMI, and length of stay (LOS), with in-hospital outcome (discharged vs. deceased) as the dependent variable. In our cohort, the logistic regression analysis showed that there was no significant correlation between age and in-hospital mortality ($\beta = 0.0074$, $p = 0.1547$), though the upward trend was a small one. In the same way, in a cross-sectional study of

64 patients with acute-on-chronic liver failure, there was no apparent age differences between survivors and non-survivors ($p > 0.05$) [14]. Other studies have however indicated a high association between mortality and age. A retrospective study of 288 patients with acute-on-chronic liver failure demonstrated a significant higher 90-day mortality in patients 45 years and above ($p < 0.05$) [15].

Equally important, in a large nomogram that was developed using a sample of 1,696 patients with sepsis, which were cirrhotic, age was a significant predictor (AUC 0.805, 95% CI 0.776-0.833) **[16]**. These differences may be due to differences in comorbidities, the level of the illness, sample size, and research design. The comparatively well-balanced age distribution of our investigation or the dominance of other clinical parameters contributing to the study, such as LOS, which appeared extremely significant, could be the reason behind the limited influence of age.

Our study showed that male sex made a marginally non-significant protective contribution to in-hospital mortality ($\beta = -0.3244$, $p = 0.0653$). The odds ratio showed that men were 27.7% less prone to die as compared to women. Previous large-scale studies showed that female cirrhosis patients were usually lower in in-hospital mortality as compared to male patients. In general, women had a lower rate of death compared to males as a study had found among 553,017 hospitalized cirrhosis patients (multivariable OR 0.86; 95% CI 0.83-0.88; $p < 0.001$) [17].

In the same way, female sex was associated with a reduced in-hospital mortality (8.31% vs. 9.91%; aOR 0.88, $p = 0.008$) in 166,760 patients who had esophagus variceal hemorrhage [18]. Another study showed that female gender has been found to be protective in mortality in 266 patients with gastroesophageal varices (SHR 0.59; 95% CI 0.40-0.86) [19]. Female sex in cirrhotic cases has also been found to lower long-term mortality, presumably due to hormonal influences, differences in immunological reaction, or health-seeking habits [20]. The near non-significance in our study could be explained by cohort-specific or it could be attributed to the smaller sample size that we have. Nevertheless, we have found sex to be a major aspect that must be considered when determining risk stratification in patients with cirrhosis.

Our study found that BMI was not significantly linked to in-hospital mortality ($\beta = 0.0081$ $p = 0.8699$). This is in consistent with other previous studies that did not give independent correlation between BMI and mortality. For instance, the analysis of 436 cases of acute gastrointestinal bleeding in cirrhotic patients revealed that there was no significant relationship between BMI and in-hospital deaths (HR = 0.349; 95% CI 0.096-1.269; $p = 0.110$) [21]. Likewise, the results of a prospective cohort of 517 patients with critically ill cirrhosis indicated, despite adjustment to age, sex, and severity scores, that BMI was not a reliable predictor of mortality; conversely, overweight and obese patients had a slightly more favorable outcome, including shorter stay in the ICU or acute kidney injury rates [22]. These findings have indicated that BMI in predicting mortality may not be sufficient to reflect the actual nutritional and metabolic status of cirrhosis, especially when using sarcopenia.

In contrast to age, sex, and BMI, LOS was a great in-hospital mortality predictor (β =-0.0575, p = 0.00067). The mortality risks were reduced by 5.6 percent with each additional day spent in the hospital. This finding highlights the importance of early and continuous treatment of patients in hospitals to enhance the chances of survival among patients with cirrhosis. Several other studies also agree with our findings. As an example a descriptive cross-sectional study on 100 liver cirrhosis patients indicated that the mean length of stay (LOS) was 7 ± 4.12 days with those with shorter hospital stays having an increased mortality rate likely because of early death due to acute complications [10].

Similarly, patients with increased MELD scores were more likely to experience LOS in addition to mortality indicating that LOS could be used to measure the severity of the disease as well as the supportive care [23]. In the operating rooms, the LOS of cirrhotic patients undergoing pancreatic-o-duodenectomy was significantly longer (median 12 vs. 10 days) compared to that of non-cirrhotic patients. This was correlated with a complex postoperative period and mortality in the hospital [24]. All these findings together confirm the dual nature of LOS; on the one hand, longer stays can be the indication of seriousness of disease, but, on the other hand, they provide an opportunity to offer critical care, monitoring, and treatment that improve survival.

Overall, our logistic regression model has revealed that LOS is a strong protective variable against in-hospital mortality in cirrhotic patients whereas age, sex, and BMI did not show a significant independent relationship with outcomes. These outcomes are mostly in line with the existing literature: age has variable effects based on the properties of cohorts, female gender provides most often the survival benefit, and BMI cannot be considered an independent predictor in case of the severity of the disease. The incorporation of LOS and traditional clinical risk scores may increase predictability and implement timely interventions to transform patient outcomes.

There are a number of limitations of this retrospective study. Selection bias might have resulted from incomplete or missing data because it was based on hospital records. Generalizability and the identification of minor effects, such sex or BMI, are limited by the single-center study's 295 individuals. The severity of liver disease, comorbidities, and lab results were not included in the baseline demographic and clinical data that were accessible. Due to fluid retention, BMI may not accurately represent nutritional status, and non-disease variables may have an impact on duration of stay. Additionally, the study did not evaluate long-term outcomes, just in-hospital mortality. Notwithstanding these drawbacks, it offers insightful information on length of stay as a predictor of survival in patients with liver disease.

CONCLUSION

This study predicts the outcome of liver disease patients who were admitted in UITH, Ilorin. The data were collected from the records unit of the Hospital for all the recorded cases of Liver disease up until 2024. The objective of the study is to investigate the length of stay at the facility for patients as factors that contribute to

whether they are discharged or whether they eventually die. The test for normality was carried out for all the numerical variables and they were found not to be normally distributed, this invalidated the use of One-way ANOVA for testing the equality or otherwise of the variable means. Therefore, Wilcoxon test was employed and it was found that only length of stay has a significantly different mean across the outcomes, by implication, the length of stay is a variable that is expected to contribute significantly to mortality.

To test for the significant contribution of the variables (numerical and categorical), the binary logistic regression was employed and as suspected, only the length of stay contributes significantly to the probability of a patient being discharged. In fact, it was discovered that a patient who spend at least days in the hospital during treatment has a 5.6% more chance of being discharged, and this probability increases with by 5% for every additional 3 days spent in the hospital during treatment. Patients who leave prematurely often die faster.

Acknowledgement: The authors utilized AI-based assistance for grammatical correction and clarity improvement during manuscript preparation.

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