Clinical and Sociodemographic Predictors of Mortality in End-Stage Renal Disease Inpatients in Rural Areas of the USA: Evidence From the Nationwide Inpatient Sample

Emmanuel Adeyemi 1, Andrew Okpe 1, Chinedum Enete 1, Kim Dixon 1

1. Internal Medicine, Saint Peter’s University Hospital, New Brunswick, USA

Corresponding author: Andrew Okpe, aokpe@saintpetersuh.com

Abstract

Background: End-stage renal disease (ESRD) has been associated with an increase in all-cause mortality among patients. The accumulation of comorbidities appears to be a contributing factor. This study set out to identify the effect of comorbidity severity and other predictors of mortality among ESRD inpatients in rural America.

Methods: This is a cross-sectional study that used the 2016-2018 Nationwide Inpatient Sample (NIS) from the Healthcare Cost and Utilization Project (HCUP). The study included patients aged 18 years or older with ESRD hospitalized in rural hospitals in America. Independent variables used in the survey include age, gender, race, type of admission (elective versus nonelective), type of hospital control, expected primary payer, and severity of comorbidities. The dependent variable was death during hospitalization. All analyses were weighted. Univariate (frequencies), bivariate (Chi-square), and logistic regression analyses were done using the SAS Studio (SAS Institute Inc., Cary, NC, USA).

Results: There were 144,575 weighted ESRD hospitalizations, and 5% of the hospitalized patients died. In the bivariate analysis, significant variables include age group, race, type of hospital admission, expected primary payer, type of hospital control, and severity of comorbidities, and all had a significant P-value of <0.0001. On multivariable logistic regression analysis, middle-aged and elderly patients had 40% (adjusted odds ratio (aOR): 1.40, 95% confidence interval (CI): 1.20-1.62) and 201% (aOR: 3.01, 95% CI: 2.61-3.48) more odds of mortality while hospitalized, respectively, compared to the young. Compared to whites, blacks had 19% (aOR: 0.81, 95% CI: 0.77-0.86) reduced odds of mortality, Hispanics had 47% (aOR: 0.53, 95% CI: 0.46-0.61) reduced odds of mortality, Native Americans had 27% (aOR: 0.73, 95% CI: 0.65-0.84) reduced odds of mortality, and Asian or Pacific Islanders had 50% (aOR: 0.50, 95% CI: 0.45-0.90) reduced odds of mortality. ESRD patients on nonelective hospitalizations had 16% (aOR: 0.84, 95% CI: 0.79-0.90) reduced odds of mortality while hospitalized versus those on elective hospitalization. ESRD patients with severe comorbidities had 40% (aOR: 1.40, 95% CI: 1.26-1.54) more odds of mortality compared to those with mild comorbidities, and those with moderate comorbidities had 22% (aOR: 1.22, 95% CI: 1.10-1.36) compared to those with mild comorbidities. Compared to patients on Medicare, ESRD hospitalizations on Medicaid had 19% (aOR: 1.19, 95% CI: 1.06-1.32) higher odds of mortality, hospitalizations on private insurance had 26% (aOR: 1.26, 95% CI: 1.15-1.37) higher odds of mortality, self-pay patients had 99% (aOR: 1.99, 95% CI: 1.61-2.45) higher odds of mortality, and no charge patients had over 1400% (aOR: 15.61, 95% CI: 7.09-34.35) higher odds of mortality. The area under the curve (AUC) for the model was 62%.

Conclusion: The severity of comorbidities and expected primary payer are the modifiable predictors identified to predict ESRD inpatient mortality. From this study, the findings suggest that strategies aimed at preventing the severity of comorbidities and ensuring universal health coverage might help reduce ESRD inpatient mortality in rural America.

How to cite this article

Adeyemi E, Okpe A, Enete C, et al. (June 03, 2022) Clinical and Sociodemographic Predictors of Mortality in End-Stage Renal Disease Inpatients in Rural Areas of the USA: Evidence From the Nationwide Inpatient Sample. Cureus 14(6): e25624. DOI 10.7759/cureus.25624

Introduction

Chronic kidney disease (CKD) is defined as the presence of kidney damage manifested by hematuria, albuminuria (albumin > 30 mg in 24 hours), or structural abnormalities, with an estimated glomerular filtration rate < 60 mL/minute/1.73 m² persisting for more than three months [1]. End-stage renal disease (ESRD) is the terminal stage of CKD with an estimated glomerular filtration rate < 15 mL/minute/1.73 m² and often requires renal replacement therapy such as dialysis and/or kidney transplant [1]. In the United States, the prevalence of CKD is estimated at 37 million [2]. Of this number, the prevalence of ESRD is estimated at more than 700,000 among American adults with the majority being on renal replacement therapy.
therapy with 71% on dialysis and 29% with a kidney transplant [2]. The burden of CKD/ESRD gulsps 35.8% of Medicare’s total fee-for-service spending and contributes to premature mortality in the United States.

Unfavorable clinical outcomes such as dialysis dependence, cardiovascular events, and all-cause mortality have been associated with the progression of CKD to ESRD [3,4]. A meta-analysis that included over 1.3 million participants showed that with decreasing kidney function, mortality among ESRD patients increased exponentially [5]. Some of the factors predicting mortality include age [6], absence of arteriovenous fistula [7], lack of early nephrology care [8], and comorbidities [9].

This study set out to identify the effect of comorbidities on mortality among ESRD inpatients in rural America. Our initial hypothesis was that the severity of comorbidities among ESRD inpatients is a predictor of mortality while adjusting for other potential confounders. The goal is that our study alongside others done on this subject will provide the background for building a model that may help predict mortality among ESRD inpatients. We also hope that the findings from this study could help institutions to address modifiable predictors of mortality identified in this study.

**Materials And Methods**

This is a cross-sectional study that used the 2016-2018 Nationwide Inpatient Sample (NIS) from the Healthcare Cost and Utilization Project (HCUP). The study included patients aged 18 years and older with ESRD hospitalized in rural hospitals in America. Independent variables from the survey included age (categorized into young, middle age, and elderly), gender, race, type of admission (elective versus nonelective), expected primary payer, type of hospital control, and severity of comorbidity (extrapolated from the Charlson Comorbidity Index with a score of 1-2 being mild, 3-4 being moderate, and greater than 4 being severe). The dependent variable was death while on admission. Univariate analysis was done using weighted and unweighted frequencies. Weighted bivariate analysis was done using Chi-square to see the significance of the association between independent and dependent variables. Only variables that were significant (P<0.05) on bivariate analysis were included in the logistic regression analysis. Regression analysis was also weighted. Both univariate and multivariate logistic regression analyses were done with the univariate logistic regression yielding the crude odds ratio and multivariate logistic regression yielding the adjusted odds ratio (AOR), with stepwise selection with entry and stay P-values of ≤0.05. The predictive validity of the model was assessed using the C-statistic. All analyses were done using the SAS Studio (SAS Institute Inc., Cary, NC, USA).

**Results**

There were 144,575 hospitalizations in the study. Most (63.2%) ESRD admissions in the study were aged 60 years or more. More than half (58.5%) of all ESRD admissions were males. More than half (57.3%) were whites, and close to a third were blacks (32.3%). The majority (85.9%) of the admissions were nonelective. Medicare was the expected primary payer for 81% of the admissions. More than two-thirds (66.8%) of the hospitalizations were in private, not-for-profit hospitals. Just over half (52.4%) of the admissions had severe comorbidities (Table 1).
| Characteristics | Unweighted frequency (N=28,915) | Weighted frequency (N=144,575) | Weighted percentage |
|-----------------|---------------------------------|--------------------------------|---------------------|
| Age             |                                 |                                |                     |
| 18-39           | 2,153                           | 10,765                         | 7.4                 |
| 40-59           | 8,497                           | 42,485                         | 29.4                |
| ≥60             | 18,265                          | 91,325                         | 63.2                |
| Sex             |                                 |                                |                     |
| Female          | 14,018                          | 70,090                         | 41.5                |
| Male            | 14,897                          | 74,485                         | 58.5                |
| Race            |                                 |                                |                     |
| White           | 16,579                          | 82,895                         | 57.3                |
| Black           | 9,330                           | 46,650                         | 32.3                |
| Hispanic        | 1,416                           | 7,080                          | 4.9                 |
| Asian or Pacific Islander | 297 | 1,485 | 1.0 |
| Native American | 1,036                           | 5,180                          | 3.6                 |
| Other           | 257                             | 1,285                          | 0.9                 |
| Type of admission |                               |                                |                     |
| Elective        | 4,082                           | 20,410                         | 14.1                |
| Nonelective     | 24,833                          | 124,165                        | 85.9                |
| Expected primary payer |                           |                                |                     |
| Medicare        | 23,415                          | 117,075                        | 81.0                |
| Medicaid        | 2,255                           | 11,275                         | 7.8                 |
| Private insurance | 2,200                          | 11,450                         | 7.9                 |
| Self-pay        | 335                             | 1,675                          | 1.2                 |
| No charge       | 6                               | 30                             | 0.0                 |
| Other           | 614                             | 3,070                          | 2.1                 |
| Type of hospital control |                       |                                |                     |
| Government, nonfederal | 4,538                          | 22,690                         | 15.7                |
| Private, not-for-profit | 19,318                          | 96,590                         | 66.8                |
| Private, invest-owned | 5,059                          | 25,295                         | 17.5                |
| Comorbidities   |                                 |                                |                     |
| Mild            | 2,589                           | 12,945                         | 9.0                 |
| Moderate        | 11,183                          | 55,915                         | 38.7                |
| Severe          | 15,143                          | 75,715                         | 52.4                |
| Death during hospitalization |                 |                                |                     |
| Yes             | 1,437                           | 7,185                          | 5.0                 |
| No              | 27,478                          | 137,390                        | 95.0                |

**TABLE 1: Characteristics of the participants**
On bivariate analysis analyzing the characteristics of respondents by death during hospitalization, there was a difference between the groups for the following characteristics: age group (P<0.0001), race (P<0.0001), type of hospital admissions (P<0.0001), expected primary payer (P<0.0001), type of hospital control (P<0.0001), and severity of comorbidities (P<0.0001). There was no difference between groups for gender (P=0.6577) (Table 2).
## TABLE 2: Characteristics of the respondents by death during hospitalization

On multivariable logistic regression analysis, middle-aged and elderly patients had 40% (AOR: 1.40, 95% CI: 1.20-1.62) and 201% (AOR: 3.01, 95% CI: 2.61-3.48) more odds of mortality while hospitalized, respectively, compared to the young. Compared to whites, blacks had 19% (AOR: 0.81, 95% CI: 0.77-0.86) reduced odds of mortality.
mortality, Hispanics had 47% (AOR: 0.53, 95% CI: 0.46-0.61) reduced odds of mortality, Native Americans had 27% (AOR: 0.73, 95% CI: 0.63-0.84) reduced odds of mortality, and Asian or Pacific Islanders had 30% (AOR: 0.70, 95% CI: 0.54-0.90) reduced odds of mortality. ESRD patients on nonelective hospitalization had 16% (AOR: 0.84, 95% CI: 0.79-0.90) reduced odds of mortality while hospitalized versus those on elective hospitalization. Compared to patients on Medicare, ESRD hospitalizations on Medicaid had 19% (AOR: 1.19, 95% CI: 1.06-1.32) higher odds of mortality, hospitalizations on private insurance had 26% (AOR: 1.26, 95% CI: 1.15-1.37) higher odds of mortality, self-pay patients had 99% (AOR: 1.99, 95% CI: 1.61-2.45) higher odds of mortality, and no charge patients had over 1400% (AOR: 15.61, 95% CI: 7.09-34.35) higher odds of mortality. Patients hospitalized in private, not-for-profit hospitals had 19% (AOR: 0.81, 95% CI: 0.76-0.86) reduced odds of mortality compared to those hospitalized in government hospitals, and those admitted in private, investor-owned hospitals had 24% (AOR: 0.76, 95% CI: 0.70-0.83) reduced odds of mortality compared to those admitted in government hospitals. ESRD patients with severe comorbidities had 40% (AOR: 1.40, 95% CI: 1.26-1.54) more odds of mortality compared to those with mild comorbidities, and those with moderate comorbidities had 22% (AOR: 1.22 95% CI: 1.10-1.36) more odds compared to those with mild comorbidities (Table 3).
| Characteristics          | Crude OR (95% CI)       | P-value | Adjusted OR | P-value |
|-------------------------|-------------------------|---------|-------------|---------|
| **Age**                 |                         |         |             |         |
| 18-39                   | 1 (ref)                 | <0.0001 | 1 (ref)     |         |
| 40-59                   | 1.49 (1.09-2.05)        |         | 1.40 (1.20-1.62) | <0.0001 |
| ≥60                     | 3.27 (2.44-4.39)        |         | 3.01 (2.61-3.48) |         |
| **Race**                |                         |         |             |         |
| White                   | 1 (ref)                 | <0.0001 | 1 (ref)     |         |
| Black                   | 0.73 (0.65-0.82)        |         | 0.81 (0.77-0.86) |         |
| Hispanic                | 0.51 (0.38-0.69)        |         | 0.53 (0.46-0.61) | <0.0001 |
| Asian or Pacific Islander| 0.76 (0.45-1.29)       |         | 0.70 (0.54-0.90) |         |
| Native American         | 0.63 (0.46-0.87)        |         | 0.73 (0.63-0.84) |         |
| Other                   | 0.67 (0.34-1.32)        |         | 0.71 (0.53-0.94) |         |
| **Type of admission**   |                         |         |             |         |
| Elective                | 1 (ref)                 | 0.0278  | 1 (ref)     | <0.0001 |
| Nonelective             | 0.82 (0.69-0.98)        |         | 0.84 (0.79-0.90) |         |
| **Expected primary payer** |                       |         |             |         |
| Medicare                | 1 (ref)                 | <0.0001 | 1 (ref)     |         |
| Medicaid                | 0.73 (0.58-0.92)        |         | 1.19 (1.06-1.32) |         |
| Private insurance       | 1.06 (0.85-1.32)        |         | 1.26 (1.15-1.37) | <0.0001 |
| Self-pay                | 1.24 (0.78-1.97)        |         | 1.99 (1.61-2.45) |         |
| No charge               | 9.74 (1.09-87.20)       |         | 15.6 (7.09-34.35) |         |
| Other                   | 2.63 (1.95-3.55)        |         | 2.61 (2.33-2.93) |         |
| **Type of hospital control** |                      |         |             |         |
| Government, nonfederal  | 1 (ref)                 | 0.1037  | 1 (ref)     |         |
| Private, not-for-profit | 0.89 (0.75-1.05)        |         | 0.81 (0.76-0.86) | <0.0001 |
| Private, investor-owned | 0.80 (0.64-0.98)        |         | 0.76 (0.70-0.83) |         |
| **Comorbidities**       |                         |         |             |         |
| Mild                    | 1 (ref)                 | <0.0001 | 1 (ref)     |         |
| Moderate                | 1.30 (1.04-1.63)        |         | 1.22 (1.10-1.36) | <0.0001 |
| Severe                  | 1.61 (1.28-2.03)        |         | 1.40 (1.26-1.54) |         |

**TABLE 3: Predictors of inpatient mortality among ESRD inpatients in rural America**

Predictive validity of the model assessed using the C-statistic: 0.62

**Discussion**

Among ESRD inpatients in rural America, the following variables have been identified as predictors of mortality: age, race, type of admission, expected primary payer, type of hospital control, and severity of comorbidities.

Expectedly, as patients age, the odds of mortality in ESRD inpatients increase. This could be explained by factors such as comorbidities that tend to accumulate as patients age, but even with adjustment for...
comorbidities, the effect of age as a predictor of mortality in ESRD inpatients remains. This effect of age on mortality in ESRD inpatients has been seen in another study [6,10].

Patients’ gender seems not to matter as a predictor of ESRD inpatient mortality as there was no difference between males and females on bivariate analysis; hence, gender was not included in the model of regression. The nonsignificance of gender has also been seen in other studies [11].

One of the highlights of our study is the paradoxical finding of lower odds of mortality among black and other minority patients with ESRD compared to their white counterparts. Given the better social determinants of health among whites compared to other minorities, it would be expected that the risk of mortality will be higher in minorities compared to whites. The opposite is however the case. This finding has been seen in other studies. Reasons to explain this paradox include survival bias, selection of healthier white patients for kidney transplantation, and a higher likelihood of renal replacement therapy in minorities with less severe comorbidities versus those with more severe comorbidities [12]. Other reasons that have been used to explain this paradox include the emigration of immigrant minorities to their countries of origin to die and differences in inflammation and nutrition [13], among others.

In terms of expected payer for the hospitalization, it appears that as patients receive less help in terms of organized health financing, the odds of mortality increase. It also appears that patients on government-financed insurance/assistance such as Medicare and Medicaid had reduced odds of mortality compared to self-pay/private insurance/no charge (largely charity) patients. In our study, after adjusting for other variables, Medicare and Medicaid patients had reduced odds of mortality compared to their counterparts who had private insurance, self-pay, or are supported by charities (no charge). This could be that the higher out-of-pocket cost (for private insurance or self-pay) or uncertainty of how to finance care (as in no charge patients) could cause less access to care, delay in seeking care, and other factors that could raise both morbidity and mortality in these patients. As a matter of fact, one study found that uninsured patients with end-stage renal disease begin dialysis later than insured patients and have poorer clinical outcomes by the time they start dialysis [14]. The implication of this is that measures aimed at achieving universal health coverage may greatly reduce inpatient mortality among ESRD patients.

Our study also showed that even after adjusting for age, as the severity of comorbidities among ESRD inpatients increases, the odds of mortality increase. The reason for this seems self-explanatory as severe comorbidities will have a more significant negative effect on the body physiology of patients compared to less severe comorbidities. This has been found in other studies [15,16]. The implication of this is that institutions should focus on developing strategies to reduce the accumulation of comorbidities as this may help in reducing mortality among ESRD inpatients.

Our study also showed that patients admitted into private hospitals (both investor-owned and not-for-profit) had reduced odds of mortality compared to those admitted into government, nonfederal hospitals. The reason for this is not exactly clear as there is a dearth of studies examining this subject in the literature. Possible reasons for this difference could be the resources available in terms of both humans and technology in caring for these patients, which may be better in private hospitals compared to government, nonfederal hospitals. This would be an interesting subject for future studies to examine.

Unexpectedly, patients with ESRD on nonelective admission had reduced odds of mortality compared to patients with elective admission. Again, there is a dearth of information in the literature on the effect of type of hospital admission (elective versus nonelective) on mortality in ESRD patients. This would constitute an interesting subject for future studies on this subject especially given that this finding goes against intuition.

Although the area under the curve (AUC) for our model is only 0.62, we hope that some of the variables used in our model can be used by other researchers in the future to create even more predictive models for mortality in ESRD inpatients.

Our study does have some limitations. First, although our study has found some association or relationship between the variables examined, this may not necessarily mean causation. Second, we only assessed the effect of variables that could be obtained in the NIS dataset; there are other variables such as the type of renal replacement therapy a patient is getting and the type of dialysis access that will predict mortality among ESRD inpatients, and this study did not adjust for all other variables. Third, this study only included the rural population of the United States, and caution should be applied in applying the findings from this study to a different population.

**Conclusions**

We hope that our research on this subject will provide the background for building a model that may help predict mortality among ESRD inpatients. We also hope that the findings from this study could help institutions address modifiable predictors of mortality identified in this study.
In conclusion, the NIS dataset provides a valuable tool for studying variables and mortality patterns among ESRD inpatients in the USA. We should bear in mind that not all variables are available for analysis from the NIS dataset, and this is a drawback of our study. We hope that other researchers will be able to use this concept in completing further research in this area, considering the racial differences in mortality comparing rural versus urban settings in the USA.

Additional Information

Disclosures

**Human subjects:** All authors have confirmed that this study did not involve human participants or tissue.

**Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue.

**Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

1. Vaidya SR, Areddula NR: Chronic renal failure. StatPearls Publishing, Treasure Island, FL; 2022.
2. Centers for Disease Control and Prevention: Chronic kidney disease in the United States, 2021. https://www.cdc.gov/kidneydisease/publications-resources/ckd-national-facts.html.
3. van der Velde M, Matsushita K, Coresh J, et al.: Lower estimated glomerular filtration rate and higher albuminuria are associated with all-cause and cardiovascular mortality. A collaborative meta-analysis of high-risk population cohorts. Kidney Int. 2011, 79:1541-52. 10.1038/ki.2010.536
4. Matsushita K, Coresh J, Sang Y, et al.: Estimated glomerular filtration rate and albuminuria for prediction of cardiovascular outcomes: a collaborative meta-analysis of individual participant data. Lancet Diabetes Endocrinol. 2015, 3:514-25. 10.1016/S2213-8587(15)00040-6
5. Tonelli M, Wiebe N, Culleton B, et al.: Chronic kidney disease and mortality risk: a systematic review. J Am Soc Nephrol. 2006, 17:2034-47. 10.1681/ASN.2005101085
6. Noh J, Yoo KD, Baek W, et al.: Prediction of the mortality risk in peritoneal dialysis patients using machine learning models: a nation-wide prospective cohort in Korea. Sci Rep. 2020, 10:7470. 10.1038/s41598-020-64184-0
7. Hod T, Patibandla BK, Vin Y, Brown RS, Goldfarb-Rumyantsev AS: Arteriovenous fistula placement in the elderly: when is the optimal time? J Am Soc Nephrol. 2015, 26:448-56. 10.1681/ASN.2015030336
8. Gillespie BW, Morgenstern H, Hedgeman E, et al.: Nephrology care prior to end-stage renal disease and outcomes among new ESRD patients in the USA. Clin Kidney J. 2015, 8:772-80. 10.1093/ckj/sfv103
9. Miskulin DC, Martin AA, Brown R, et al.: Predicting 1 year mortality in an outpatient hemodialysis population: a comparison of comorbidity instruments. Nephrol Dial Transplant. 2004, 19:413-20. 10.1093/ndt/gfg571
10. Landray MJ, Emberson JR, Blackwell L, et al.: Prediction of ESRD and death among people with CKD: the Chronic Renal Impairment in Birmingham (CRIB) prospective cohort study. Am J Kidney Dis. 2010, 56:1082-94. 10.1053/j.ajkd.2010.07.016
11. Gonçalves FL, Elias RM, dos Reis LM, et al.: Serum sclerostin is an independent predictor of mortality in hemodialysis patients. BMC Nephrol. 2014, 15:190. 10.1186/1471-2369-15-190
12. Gaylin DS, Held PJ, Port FK, et al.: The impact of comorbid and sociodemographic factors on access to renal transplantation. JAMA. 1993, 269:605-8.
13. Desai N, Lora CM, Lash JP, Ricardo AC: CKD and ESRD in US Hispanics. Am J Kidney Dis. 2019, 73:102-11. 10.1053/j.ajkd.2018.02.354
14. Institute of Medicine (US) Committee on the Consequences of Uninsurance: Care without coverage: too little, too late. National Academies Press (US), Washington, DC; 2002.
15. Di Iorio B, Cillo N, Cirillo M, De Santo NG: Charlson Comorbidity Index is a predictor of outcomes in incident hemodialysis patients and correlates with phase angle and hospitalization. Int J Artif Organs. 2004, 27:330-6. 10.1177/039139880402700409
16. Rattanasompattikul M, Ferouz U, Molnar MZ, et al.: Charlson comorbidity score is a strong predictor of mortality in hemodialysis patients. Int Urol Nephrol. 2012, 44:1815-20. 10.1007/s11255-011-0883-9