A Multi-center Observational Cohort Study of Dialysis Patients' Prognostic Factors: Evidence from Pakistan

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Abstract

Objective: Chronic kidney disease has emerged as a devastating global health crisis. This cohort study identifies predictive factors for the survival prognosis of patients receiving dialysis.

Methods: This retrospective observational cohort study uses data on 1,137 patients undergoing hemodialysis for at least 3 months at multiple clinics in the Punjab Province of Pakistan, from January 2015 to December 2019. Semi-parametric Cox Regression and parametric Accelerated Failure Time models were used to detect predictive factors associated with the survival of the patients.

Results: Factors significantly associated with dialysis survival prognosis included dialysis duration (in months) (HR 0.075;95% CI:0.017-0.332), inter-dialytic weight gain (HR 0.775; 95% CI:0.582-1.032), serum potassium (HR 0.883;95% CI:0.730-1.068), serum hemoglobin (HR 1.734;95% CI:1.446-2.081), serum albumin (HR 1.293;95% CI:0.566-2.955).

Conclusion: We propose a prognosis score which is a practical and easily adaptable tool based on readily available clinical variables. Our findings present an overall survival advantage at levels of high serum albumin, high serum hemoglobin, low inter-dialytic weight gain, and large dialysis duration at the recommended range of potassium level for a patient. Results report established primary prognosis factors that are clinically useful and can offer insights to clinicians that may provide better treatment and improved survival of dialysis patients.

Introduction

Chronic kidney disease (CKD) has emerged as a global health crisis due to escalating risk factors such as deteriorating quality of water, increasing burden of co-morbidities (such as hypertension, diabetes, and other chronic conditions), and poorly resourced healthcare systems (George et al. 2017; Swartling et al. 2021). According to the World Health Organization (WHO), 7 of the 10 leading causes of death globally include chronic conditions such as heart disease, diabetes, and kidney disease (WHO, 2020). CKD, the 10th leading cause of death, accounts for 1.3 million deaths annually (WHO, 2020). It is expected that the incidence rate of CKD in developing countries will rise to four times higher than those in developed countries (George et al. 2017). The prevalence of CKD patients is projected to disproportionately increase in developing countries, including those on the Indian subcontinent, presenting additional challenges for struggling public health and healthcare systems (Abraham et al. 2016; Jha et al. 2013). The number of patients receiving renal replacement therapy around the globe is also expected to double in 10 years (Liyanage et al. 2015; Swartling et al. 2021). Among approximately 500 million individuals with CKD, 78% live in low-income to middle-income countries (George et al. 2017). Given the poor distribution of wealth and large proportions of the population living below poverty in developing countries, affordability and accessibility of hemodialysis (aka dialysis) treatment are likely to result in poor outcomes for the patients (Javed et al. 2021; Sakhuja and Sud, 2003). Already, untreated kidney failure results in deaths of over 1 million people annually, and dialysis patients have an alarmingly high risk of death, ranging from 25–30% globally (Couser et al. 2011). Effective policies to prevent the progression of chronic renal disease in developing countries have faced more challenges in implementation (Barsoum, 2009)

Specifically in Pakistan, chronic renal failure prevalence rates range from 12.5–29.9% (Jessani et al. 2014). Like other developing countries, a rise in CKD levels in Pakistan has been attributed to poor quality of water and diet. For example, Imtiaz and colleagues (2020) found that in Pakistan, high levels of arsenic, cadmium, lead, and other harmful heavy metal toxins in poultry become a significant cause of CKD. Researchers have advocated for the need to understand the etiology of CKD in Pakistan and other neighboring countries in South Asia (Feng et al. 2019).

Past studies reported a significant positive association between a CKD diagnosis and: age (Ahmed et al. 2021; Jessani et al. 2014; Alam et al. 2014), sex (Ahmed et al. 2021), smoking status (Ahmed et al. 2021), duration of end-stage renal disease (ESRD) (Ahmed et al. 2021), diabetes mellitus (Type 2 diabetes) (Ahmed et al. 2021; Imran et al. 2015; Jessani et al. 2014; Jafar et al. 2004), hypertension (Imran et al. 2015; Jessani et al. 2014; (Jafar et al. 2003), raised triglyceride levels (Jessani et al. 2014), obesity (Jafar et al. 2003), proteinuria (Jafar et al. 2003) and history of stroke (Jessani et al. 2014). The Hypertention and Diabetis millites were found as the major causes of CKD in urban areas while glomerulonephritis and kidney stones were dominant risk factors in the rural areas (Rizvi & Manzoor, 2002; Salman et al. 2017). Existing literature revealed unclear findings regarding age and gender significance on CKD in Pakistan. Alam et al. (2014); Jessani et al. (2014) and Ahmed et al. (2021) reported the highest prevalence of CKD among older patients of age more than 50 years. However, none of the other studies reported about significant effect of age on CKD in the region. Siddiqa et al. (2012) and Imran et al. (2015) observed statistically insignificant effects of age and sex on CKD. Alam et al. 2014 and Ahmed et al. 2021 identified a higher prevalence of CKD among men, however, Jessani et al. (2014) reported women suffered more frequently from CKD.

Serious gaps exist in the existing body of scientific research evidence about factors associated with the prognosis of CKD, and predictive factors for the prognosis of end-stage renal (ESRD) patients. The main objective of the present research is to identify the combined effect of factors affecting the survival of ESRD patients receiving hemodialysis in a developing country and analyze survival times of dialysis patients to assess the risk of mortality for the period of 5 years.

Material And Methods

This research used a quantitative, observational cohort study design. Data were collected retrospectively from public sector hospitals in Punjab Province, Pakistan.

Study population and data collection method

Drawing from their medical records, this study uses data of all eligible hemodialysis patients at six Punjabi dialytic centers for the 5-year period from January 2015 to December 2019. Dialysis patients of 25 districts of Punjab (out of 36), and 12 districts of Khyber Pakhton Khah (KPK), Northern Areas, and Azad Kashmir were covered by these dialysis units of Rawalpindi and Lahore divisions of Punjab. In this study, patients have been included from six participating centers. The size of the centers varies between 266 patients (the smallest one) and 1,261 (the largest one).

A structured questionnaire was used for extracting data from hospital records on patients' demographic, clinical, and laboratory variables with particular criteria for inclusion. All patients undergoing hemodialysis for

at least 3 months and treated by in-center hemodialysis in government hospitals of Punjab were eligible for inclusion in the present study. Patients referred to another dialysis unit or lost to follow-up within 1 month of entry in the study were excluded later from the study. A total of 1507 patients met the initial inclusion criteria, and 310 were later transferred out or lost to follow-up. Finally, 1137 patients remained in the study with 757 events (deaths) among patients over the five-year study period. For the current study, ethical clearance was obtained from the Ethical Committee of the Department of Mathematics & Statistics, International Islamic University, Islamabad.

Measures

The key outcome variable of interest for this study is survival time in months which began after a patient completed three months of dialysis and ended at death or the end of follow-up. The clinical patients in this retrospective follow-up study covering 2015–2019 were followed through their medical charts until death or the 30th of December 2019; whichever came earlier. Inter-dialytic weight gain (IDWG) was measured as the difference of pre-dialysis and post-dialysis weight between consuctive dialysis sessions. Incidence of hepatitis was the status of hepatitis recorded at the start of the study. In hospital records, all serum values are updated monthly, and in this study, clinical variables have been observed from the start of study at time 0 to the last contact. All time-varying variables for each patient were recorded for every 3rd month to minimize the measurement variability and reduce the bulk of data.

The independent predictive variables tested included age in completed years, date of the first treatment, age at the start of dialysis (≤ 29, 30–39, 40–49, ≥ 50), status (dead/alive), frequency of dialysis (once, twice, thrice in a week), duration of dialysis at the entry of study (months), duration of dialysis/hour, gender (male or female), the incidence of hepatitis (no, B+, C+), the hospital-acquired incidence of hepatitis (no, B+, C+), causes of ESRD (diabetes, hypertension, obstructive uropathy, congenital diseases, drug-induced, chronic renal failure and polycystic diseases), co-morbidities (cardiovascular disease, tuberculosis, hypertension (HTN), diabetes mellitus (DM), chronic heart failure (CHF), chronic liver disease(CLD), interdialytic weight gain (pre-dialysis and post-dialysis weight), pre-dialysis urea, pre-dialysis creatinine, serum potassium, serum phosphate, serum hemoglobin, and serum albumin. Uniformly all the dialysis centers have the same treatment modality with almost the same frequency of dialysis, duration of dialysis/hour, types of dialysates, type of dialysis membrane, and usage of auxiliary medication.

Statistical Analyses

To model the outcome variable and survival time, this study used the semi-parametric Cox proportional hazards model, which is a flexible multivariable survival analysis procedure. After assessing the adequacy of the fitted Cox model for proportionality, linearity, influential diagnostics, and goodness of fit, the prediction model has been obtained stratified by centers. Significant prognostic factors were identified separately by fitting a Cox model and Accelerated failure time (AFT) model in both univariate and multivariate analysis. Parametric accelerated failure time (AFT) models offer a useful substitute to the PH model for statistical modeling of survival time data. In contrast to the hazard rates of a PH model, in AFT formation survival time models generate the summary measure, interpreted in terms of the speed of progression of a disease. These models are evenly good for time-dependent covariates and can accommodate the left censoring as well. All

analyses were performed using SAS Software, version 9.4, of the SAS System for Windows, by SAS Institute Inc, Cary, North Carolina.

Results

Patient Characteristics

Description of the continuous and categorical factors used in the statistical analysis are specified in Table 1.

Table 1
Descriptive statistics for characteristics of Dialysis Patients (N = 1137)

Variables (Categorical)	Frequency	Percent
Gender		
Male	715	62.9
Female	422	37.1
Age at start of dialysis		
less than 29	232	20.4
30–39	177	15.6
40–49	269	23.7
greater than 50	462	40.6
Frequency of dialysis per week		
Once	3	0.3
Twice	998	87.8
Thrice	136	12.0
Incidence hepatitis		
No	907	79.8
C+	188	16.5
B+	42	3.7
Hospital-acquired hepatitis		
No	709	62.4
C+	320	28.1
B+	113	9.9
Causes of dialysis		
Diabetes	409	36.0
Hypertension	367	32.3
Obstructive uropathy	189	16.6
Congenital	73	6.4
Drug-Induced	58	5.1
CRF (any cause)	19	1.7
Polycystic	16	1.4

Variables (Categorical)	Frequency	Percent
any other	9	0.8
Comorbidities		
None	44	3.9
Cardiovascular	21	1.8
Hypertension	652	57.3
Diabetes mellitus	165	14.5
Chronic liver disease	44	3.9
Tuberculosis	217	19.1
Variables (Continuous)	**Frequency**	**Mean (SD)**
Age	1137	44.266 (14.776)
Dialysis duration(months)	1137	5.176(0.591)
Inter-dialytic Weight Gain (kg)	1137	3.552 (1.3821)
Blood Urea Nitrogen (BUN) (mg/dl)	1137	108.758 (46.755)
Serum Creatinine (mg/dl)	1137	6.764 (3.225)
Serum Potassium (mg/dl)	1137	5.221 (1.591)
Serum Phosphate (mg/dl)	1137	6.19 (2.265)
Serum Hemoglobin (g/dl)	1137	9.548 (2.301)
Serum Albumin (g/dl)	1137	3.204 (0.876)

Univariate analysis based on Cox regression model depicted 11 factors having significant effect on survival time of patients after being dialyzed: Gender (*p-value*: 0.048), Age (*p-value*: 0.002), Hospital acquired hepatitis(*p-value*: <0.001), Causes of ESRF(only significant drug-induced category *p-value*: 0.003), Inter-dialytic weight gain (IDWG) (*p-value*: < 0.001), Serum Creatinine (*p-value*: 0.010), Serum Potassium (*p-value*: < 0.001), Serum Phosphate (*p-value*: < 0.001), Serum Hemoglobin (*p-value*: < 0.001), Serum Albumin (*p-value*: < 0.001), Dialysis duration at entry of study (*p-value*: < 0.001). Simultaneous study of variables through multivariate analysis would clarify the consequences of significant variables that have influenced the survival.

Multivariate Analysis: Identification of prognostic factors of dialysis patient's survival data

The Cox regression semi parametric model is a widely applied model for time to event data. The approach of purposeful selection of covariates to a proportional hazards model was followed to search out a set of statistically and clinically significant covariates. Multivariate analysis for identification of prognostic factors by Cox Regression model is summarized in Table 2.

Table 2
Multivariate analysis- Cox Stratified Regression Model and Loglogistic regression model in an AFT formulation for identification of prognostic factors of dialysis patients

Variables	Categories	Cox Regression Model			AFT Loglogistic regression model		
		B	P-value	Hazard ratios (95% CI)	B	P-value	Time ratios (95% CI)
Age	None	0.005	0.270	1.005(1.001–1.010)	-0.004	**0.008**	.995 (.992-.998)
IDWG	None	0.108	**0.001**	1.114(1.044–1.188)	-0.094	**< 0.001**	.909 (.869-.951)
Serum Potassium	None	0.091	**< 0.001**	1.096(1.052–1.141)	-0.006	**0.014**	.993 (.810-1.219)
Serum Hemoglobin	None	.016	**< 0.001**	.984(.807-.993)	0.048	**0.012**	1.050 (.974-1.131)
Serum Albumin	None	0.337	**< 0.001**	.713(.632-.805)	0.028	**0.004**	1.028 (.985-1.074)
Serum Creatinine	None	.007	0.541	.992(.969-1.016)	− .020	0.122	.980(.963-.997)
Serum Phosphate	None	.002	0.891	.997(.964-1.032)	− .001	0.098	0.999(0.862–1.001)
Dialysis duration	None	-2.584	**0.001**	.075(.017-.332)	-1.992	0.297	.136(.123-.150)
Gender	male*						
	female	.002	0.976	1.002(.858-1.169)	.043	0.197	1.044(1.028–1.061)
Age at start of dialysis	≤ 29 yr*						
	30–39 yr	.026	0.859	.973(.726-1.304)	.048	0.711	1.049(.812-1.356)
	40–49 yr	.201	0.255	.817(.577-1.156)	.291	.150	1.3387(1.074–1.668)
	≥ 50 yr	.379	0.128	.683(.419-1.115)	.313	.100	1.367(1.119–1.671)
Frequency of dialysis weekly	once*						
	Twice	.665	0.355	.514(.125-2.105)	.272	0.760	0.761(.186 – 3.100)
	Thrice	.372	0.607	.688(.166-2.847)	.044	0.950	1.045(.2607 – 4.188)
Hospital-acquired hepatitis	No*						

Note: B-regression coefficient; CI-confidence interval; AFT-accelerated failure time; IDWG = Inter-dialytic weight gain

Variables	Categories	Cox Regression Model			AFT Loglogistic regression model		
		B	P-value	Hazard ratios (95% CI)	B	P-value	Time ratios (95% CI)
	C+	−.040	0.663	.960(.802 – 1.150)	− .684	0.162	0.504(.403-.607)
	B+	−.011	0.925	.988(.781 – 1.250)	− .639	0.535	0.527(.415-.643)
Comorbidities	None*						
	Tuberculosis	−.115	0.749	.891(.440-1.804)	.166	0.639	1.180(.589-2.365)
	Hypertension	.062	0.749	1.064(.725-1.561)	−.126	0.509	.880(.604-1.283)
	Diabetes Miletus	.243	0.249	1.275(.843-1.929)	.032	0.876	1.032(.688-1.549)
	Chronic Liver Disease	−.078	0.777	.924(.536-1.592)	.522	0.073	.593(.349-1.007)
	Cardio-vascular disease	.313	0.133	1.367(.909-2.056)	.079	0.697	1.082(.726-1.613)

Note: B-regression coefficient; CI-confidence interval; AFT-accelerated failure time; IDWG = Inter-dialytic weight gain

Effects of Regression coefficients of Log-logistic distribution are similar and comparable to those produced by Cox Regression. Higher level of IDWG (HR 0.775; 95% CI:0.582–1.032) and serum_K (serum potassium) (HR 0.883;95% CI:0.730–1.068) exposed lower survival time. However, longer dialysis duration in months (HR 0.075;95% CI:0.017–0.332) and higher levels of serum hemoglobin (HR 1.734;95% CI:1.446–2.081) and serum albumin (HR 1.293;95% CI:0.566–2.955) presented beneficial impact on patients' survival time and were associated with increased average survival time. Further explanation of covariates at combinations of different levels, can provide clinically interesting comparisons. To explain the interaction effects of covariates at different levels 3^5factorial design was applied, in which the five independent covariates were crossed with one another. The intent of presenting combined effects of covariates at each level provided a full insight of good and bad prognosis of patient population, which is essential for the assessment of outcomes of renal replacement therapy. Complete set of different interaction combinations at low, medium, and high level of five variables in terms of hazard ratios are given in Table S1 (provided as digital content of supplementary material).

Discussion

Globally there is a huge rise in the incidence of treated End Stage Renal Disease (ESRD) which urges us to pay attention to this devastating social, economic, and health problem. The annual mortality rate remains stubbornly high in ESRD patients and awareness of ESRD remains limited in developing countries. Most individuals with ESRD in developing countries go undetected at early stages. So, it comes out to be a critical

health issue of developing countries like Pakistan. While recommendations on ESRD progression are generally based on data from developed nations and may not necessarily apply to settings of low-resource developing countries, the strength of this study lies in the fact that it is a first cohort study to investigate the joint prognostic influence of covariates for dialysis patients in the respective population of low-resource settings. In this study, we inspected the joint prognostic influence of demographic and biochemical variables, to ascertain the prognostic information for best and worst survival of dialysis receiving patients.

In our study, dialysis duration (months) (*p-value*:0.027), inter-dialytic weight gain (*p-value*: 0.001), serum potassium (*p-value*: <0.001), serum hemoglobin (*p-value*: <0.001), and serum albumin (*p-value*: <0.001) appeared as significant prognostic factors. These are clinically adjustable prognostic factors where increased dialysis duration time reflects a lower risk of death in dialysis patients. These reduced chances of death over the course of time can be explained by the stability of clinical variables attributed to dialysis. Moreover, it may be because most patients opt for dialysis at a very late stage. The maximum number of deaths in the initial period can be due to worse clinical conditions at the time of presentation, thereby decreasing the chances of death by stabilizing clinical variables over time. Studies concerning the duration of dialysis of patients lead to conflicting conclusions. Contrary to our findings, some studies found no significant relationship of dialysis duration on the survival and quality of life of patients (Barzegar et al. 2017; Parvan et al. 2012; A. L-Jumaih et al. 2011). Gerasimoula et al. (2015), Anees et al. (2011), and Taheri et al. (2013) reported that increased duration of disease by combining supplementary diseases and aging could negatively impact patients' quality of life. Inconsistent with the aforementioned studies, Guerra et al. (2012) and Santos et al. (2007) compared hemodialysis patient's mental function scores for less and more than 3 years, and it was believed that elapsed onset of hemodialysis might increase the patient's adaptation to hemodialysis and by improving the uremic symptoms can enhance their performance, similar to the results which we observed (Morsch et al. 2006). The dissimilarities between these studies likely underscore the different social and health support systems in different countries.

Zhang et al. (2019) reported hypoalbuminemia was associated with a worse renal prognosis in dialysis patients with type 2 diabetes mellitus and diabetic nephropathy. Lang et al. (2018) found low serum albumin levels were associated with declined kidney function. Whereas contradictory conclusion had been made by Alves et al. (2018) that mortality risk increased in ESRD patients with low serum albumin and high C-reactive protein (CRP), but it was not observed the same, with low serum albumin and normal CRP. Minatoguchi et al. (2018) reported hypoalbuminemia as a strong predictor of infection-related in-hospital death and for poor prognosis of hemodialysis patients. Gama-Axelsson et al. (2012) stated that low serum albumin levels are found to be strongly associated with inflammation in dialysis patients. Naves et al. (2011) reported that low levels of serum albumin are associated with an increased mortality rate. Iseki et al. (1993) identified serum albumin as a strong predictor of mortality among chronic hemodialysis patients and suggested that the low level of serum albumin should be cautiously treated, confirming our current findings.

Our findings confirmed the several past investigations which found increased Inter-dialytic weight gain (IDWG) harmful for the survival of CKD patients. Kalantar-Zadeh et al. (2009) concluded that higher Inter-dialytic weight gain (IDWG) proved to be related to a higher risk of death. Lopez et al. (2005) concluded that higher pre-dialysis IDWG had negative aspects, albeit the beneficial impact of IDWG upon nutritional status has the better long-term prognosis of patients. Rodriguez et al. (2005) reported that an IDWG less than 1.5 to 2.0 kg was the

most favorable target for the survival of patients. Kimmel et al. (2000) had also observed a similar type of relationship, observing the increase in IDWG was associated with a high risk of mortality.

Pirklbauer, M. (2020) discussed hypokalemia and hyperkalemia that severe hyperkalemia can cause electrocardiogram abnormalities, muscle weakness, and ascending paralysis, in line with the findings of Abuelo (2018) and An et al. (2012), contrariwise reported that hypokalemia was not associated with all-cause mortality. Karaboyas et al. (2017) reported a higher level of serum_potassium (serum_k) associated with worse survival and related outcomes. In prior studies, similar results were drawn about Hyperkalemia that requires intent monitoring. Kovesdy et al. (2007) and Bleyer et al. (2006) examined the association between pre-dialysis serum_k levels and mortality. Pre-dialysis serum_k between recommended range 4.6 to 5.3 mEq/L was reported to be associated with the higher survival of patients, while serum_k < 4.0 or > 5.6 mEq/L resulted in association with increased mortality, consistent with our study findings.

Karaboyas et al. (2020) reported that hemodialysis commencement with anemia was observed to be associated with increased mortality risk. Management of anemia in ESRD patients can improve the survival of these patients on dialysis therapy. By conducting a short-term study Kawamoto et al. (2018) stated that low hemoglobin (Hb) level at the beginning of dialysis did not prove harmful for the short-term prognosis of patients. Mimura et al. (2015) recommended maintaining the target Hb level of dialysis patients reliant on their ages, which offered beneficial survival of patients. Gilbertson et al. (2008) verified that a longer time duration with a Hb below the target range can be a primary driver of the improved risk of mortality. Regidor et al. (2006) explored associations between stable Hb levels 12 to with the greatest survival and the lower range of the hb (11 to 11.5 g/dl) found to be associated with a higher death risk. Despite of, in previous studies (Locatelli et al., 2004; Collins, 2002; Collins et al., 2000) had examined the associations between baseline hb levels and survival without bothering about the changes in hb levels over time. Ofsthun et al. (2003) established the findings that higher hb level has no association with increased risk of death. Also, Positive link between survival and high Hb level reported by Collins et al. (2001) supported the results of our study.

To study possible interaction effects, it was assessed whether different conditions for a covariate produce variant results, depending on the conditions considered for a second covariate. We have looked forward to the combined effects of covariates, as there is more to consider than simply the marginal effect of each covariate. The lowest hazard ratio (0.0066) explained a 99.34% reduction in hazard risk for the patient who achieved a lower level of IDWG, lower level of serum_k, higher level of Hb, and higher level of serum_alb with less age group. Such a lower hazard risk value of 99.34% would be the best possible condition for the current population under study. The possible worst condition of a patient under dialysis would be with the highest hazard ratio of 6.74 times more hazard risk with higher IDWG, higher serum_k level, lower Hb level, and lower serum_alb level regardless of age. Overall, at a high level of serum_alb and Hb, low level of IDWG, and medium serum_k, all together, with three age groups of patients (low, medium, and high resp.) demonstrated better survival condition and good prognosis for such patients, reducing hazard risk by (99.34%, 99.09%, 98.80% resp). Overall, it has been observed that shift towards high levels of serum_alb and Hb within the recommended range of IDWG and serum_k, all together, irrespective of the age of the patient (low, medium, and high resp.) demonstrated better survival condition and good prognosis for such patients.

All international guidelines as well as the European Best Practice Guidelines (EBPG) and the United States Kidney Disease Outcomes Quality Initiative (KDOQI) (2012) advised that individuals should achieve the specific target status of clinical covariates within the mentioned time of being seen by nephrologists. The current study immediately after the initiation of dialysis of ESRF patients demonstrated the worst survival. Since dialysis is itself invasive therapy with its own complications therefore maintenance of significant clinical covariates in recommended target ranges is the main concern for better prognosis of these patients.

This study has a possibility for further research with other medical conditions such as obesity, cigarette smoking measured in pack/years, the daily quantity of alcohol consumption, or prohibited drug consumption which may also ultimately contribute to poor survival. Current data is deficient in these fine details. Secondly, patients' characteristics in this study can be further discussed in comparison to other studies, those who have a high prevalence of chronic kidney failure patients, such as in liver and cardiovascular diseases.

Conclusions

Demographic and biochemical variables predicted dialysis patients' survival prognosis. These results explained the combined survival advantage at low/medium inter-dialytic weight gain, low/medium serum potassium, medium/high serum hemoglobin, high level of serum albumin, and longer dialysis duration. Simultaneously, the effect of low levels of serum albumin, serum hemoglobin and dialysis duration, high level of interdialytic weight gain, and serum potassium predicted lower survival times. Moreover, increased levels of both serum albumin and serum hemoglobin provided a lower hazard risk for dialysis patients.

Declarations

Ethics approval and consent to participate:

Ethical clearance was obtained from the Ethical Committee of the Department of Mathematics & Statistics, International Islamic University, Islamabad. **All methods were carried out in accordance with relevant guidelines and regulations. Informed consent was obtained from all subjects and/or their guardians.**

Consent for Publication:

Not applicable

Availability of Data and Materials:

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing Interests:

none to report

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none to report

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Analysis: Drs. Saddiqa and Shah, Writing: Drs. Saddiqa, Shah, and Jones

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