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Predictors of All-cause Mortality among Hospitalized HIV Patients in Kazakhstan: a Retrospective Study

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Abstract

Aim: This paper examines the predictors of all-cause mortality among hospitalized HIV-positive patients in Kazakhstan.

Material and methods: The study uses baseline data from patient hospital discharge records derived from the Unified Electronic Healthcare System of Kazakhstan (UNEHS) between 2014 and 2019. Artificial intelligence technology was utilized to extract data from the discharge records. Patients were included based on their first hospitalization, and they were subsequently monitored until their discharge or occurrence of death.

Results: The study revealed that females had a 2.06-fold higher risk of all-cause mortality compared to males. After adjustments in the Cox proportional hazard model, age, intravenous drug use (IDU), and anemia were observed as independent predictors of mortality within the patient cohort.

Conclusions: Findings of this study emphasize the need to enhance efforts to prevent late HIV diagnosis by improving access to testing and treatment for those affected, and to strengthen potential for developing risk factors reduction strategies.

Keywords: HIV, predictors of mortality, all-cause mortality, comorbidity, regression analysis.

Introduction

Human Immunodeficiency Virus (HIV), which is responsible for Acquired Immune Deficiency Syndrome (AIDS), is a threatening communicable zoonotic infection with profound social consequences [1]. An estimated 38 million people are living with HIV, with 1.7 million new HIV infections, and 690,000 deaths associated with AIDS [2]. Although HIV infection is preventable, significant HIV transmission continues across the world.

Despite recent improvements in health care as a result of government policy reforms, Kazakhstani health care facilities still face challenges in treating blood-borne infections such as HIV/AIDS, tuberculosis and other similar diseases [3]. According to UNAIDS (2019), the number of new HIV infections in Kazakhstan has increased by 39% since 2010 [4]. It was also forecasted that the prevalence of HIV infection in Kazakhstan will double from 2021 by 2030 [5]. Given the rising incidence of newly contracted HIV cases and predicted prevalence of the disease in the future, it is essential to accurately assess the current situation and the real magnitude of the HIV epidemic in Kazakhstan. This evaluation is necessary to implement public health procedures that can effectively prevent and control the anticipated spread of HIV infection.

When focusing on data collection from HIV patients, it becomes imperative to trace the relationship between mortality and associated factors of patients, which predominantly stem studies conducted in developed nations, leaving a significant data gap in developing countries. Especially, demographic, behavioral, clinical, and laboratory data obtained at hospital admission engage significant attention as independent predictors of adverse outcomes, given their accessibility and potential for developing strategies for risk factor reduction that may have an impact on mortality rates. Consequently, despite existing research

on demographic determinants and the impact of concurrent illnesses on HIV mortality, this research represents the first effort to highlight the significance of clinical and laboratory data sourced from patients within the Unified National Electronic Health System (UNEHS) system to establish their association with mortality rates in Kazakhstan.

Hence, the objective of this retrospective cohort study is to discern predictors of mortality in patients with HIV admitted to tertiary care hospitals between 2014 and 2019, utilizing comprehensive patient-level clinical data.

Methodology

Study design

This retrospective study utilized hospital admission data from HIV-positive individuals between January 1, 2014, and December 31, 2019, obtained from the UNEHS database in Kazakhstan. A total of 152 medical discharges were analyzed with the assistance of a custom-designed data mining application using artificial intelligence. To eliminate risk of inaccurate data, the information extracted by the AI application underwent additional manual verification. The dataset included information on demographic characteristics, clinical findings upon admission, laboratory test results (general blood testing and biochemical blood testing), comorbidities, behavioral factors, and outcomes. Age was categorized into four categories: <18 years, 18–34 years, 35–50 years, and >50 years. Ethnicity was categorized into Kazakhs, Russians, and others (including 11 ethnicities). Laboratory data, including, but not limited to, hemoglobin, red blood cells (RBC), leukocytes (WBC), platelets (PLT), erythrocyte sedimentation rate (ESR), bilirubin, albumen, urea, creatinine, and cholesterol were gathered within the first day of admission. Quantitative variables were analyzed using interval scales, whereas qualitative variables were categorized as binary (yes/no).

Additionally, to evaluate all-cause mortality, we incorporated data on deaths occurring outside the hospital for the same 152 patients up to the conclusion of 2023, with any additional observations beyond these parameters excluded from the analysis. Duplicate entries were eliminated by employing the unique population registry ID (RPN ID) utilized in the UNEHS registry, confirming that every patient was included in the analysis once.

Study population

The cohort consisted of patients recognized according to the following ICD-11 (The International Classification of Diseases, 11th revision) codes: B20.0 (HIV disease resulting in mycobacterial infection), B20.1 (HIV disease resulting in other bacterial infections), B20.3 (HIV disease resulting in other viral infections), B20.8 (HIV disease resulting in other infectious and parasitic diseases), and B20.9 (HIV disease resulting in unspecified infectious or parasitic disease). Patients were included based on their first hospitalization, and they were subsequently monitored until their discharge or occurrence of death.

Statistical analysis

Statistical analysis, data cleaning and data management were conducted using Stata SE 18.0 version. Data analysis (percentage for categorical variables and mean ± standard deviation (SD) or median (interquartile range – IQR) for continuous variables) were performed to describe the characteristics of the research population. The cohort was categorized into two groups as alive and dead patients. Two-sided t-tests for parametric and Mann-Whitney U tests for non-parametric data were implemented for comparison of means. Pearson's chi-square and Fisher's exact tests were used to compare proportions.

For all-cause mortality risk assessment of hospitalized HIV patients, the Cox proportional hazard regression analysis was performed to evaluate unadjusted (univariable) and adjusted (multivariable) hazard functions. The potential confounders introduced in the multivariable-adjusted model were derived from data availability in the cohort and theoretical considerations based on the statistical significance of unadjusted analysis. These are the models of multivariate Cox regression analysis: Model 1: age, gender, ethnicity, intravenous drug use (IDU); Model 2: in addition to variables from model 1 contained laboratory data as ESR and anemia; Model 3: in addition to variables from model 2 contained bilirubin and creatinine. The Kaplan-Meier survival function with log-rank test for statistical significance was used to estimate survival probabilities among hospitalized HIV patients.

Proportional hazards assumptions were tested using Schoenfeld residuals, Akaike's (AIC) and Schwarz's Bayesian (BIC) information criteria. Magnitude of hazard ratios (HR) and the width of their 95% confidence intervals (CI) were evaluated to determine the statistical and clinical significance of the associations. P-value are two-sided and reported as significant at <0.05 for all analyses.

Results

Table 1 illustrates the socio-demographic, clinical, laboratorial, and behavioral characteristics along with immunology data, comorbidities, and outcomes by death in the hospitalized HIV cohort. The cohort included 152 patients diagnosed with HIV in their first hospital admissions over a 6-year period (2014–2019). There were 77 alive patients (50.7%) and 75 deceased patients (49.3%). 67.1% of the cohort (n = 102) were women (p = 0.041). The median age of hospitalized HIV patients was 31 years (IQR 12–39; p <0.0001). 67 people (44.1%) of the cohort were young, aged <18 years. Nearly half (45.3%) of the cohort within the age range of 35–44 years experienced death. The majority of HIV-infected patients (47.0%) were ethnic Kazakhs (n = 71).

The mean heart rate for cohort was observed to be 97.8±15.7 bpm (p = 0.039). Upon admission, non-survivors had lower levels of hemoglobin, lymphocytes, and monocytes count, alongside elevated erythrocyte sedimentation rate (ESR). Moreover, the deceased patients had significantly abnormal urea parameter. Regarding albumin and cholesterol levels, deceased individuals had lower values compared to alive patients. A comparable pattern was witnessed for CD4 cells. The cohort analysis displayed a median CD4+ T lymphocyte count of 540 cells/mm^3 (IQR 220–844), while the median CD4 cells count in deceased patients was almost 5 times lower (p < 0.0001).

More non-survivors had tachycardia, cholecystitis, unspecified operations, cachexia, and meningitis. Nearly 55% of deceased patients (n = 41) had viral hepatitis C (p =0.001). No significant results were identified for diffuse liver change, cirrhosis, oral candidiasis, viral hepatitis B, and anemia. Concerning behavioral factors, 44.0% (n = 33) of deceased patients reported alcohol abuse, 35 (46.7%) reported intravenous

Table 1 Demographic data

Characteristic	Total (n=152)	Alive (n=77)	Dead (n=75)	P value
Age, year (median [IQR])	31 [12–39]	12 [11–14]	38 [32–44]	p < 0.0001
< 18	67 (44.1)	61 (79.2)	6 (8.00)	
18–34	25 (16.5)	6 (7.80)	19 (25.3)	
35–44	41 (27.0)	7 (9.10)	34 (45.3)	
45–50	12 (7.90)	1 (1.30)	11 (14.7)	
> 50	7 (4.50)	2 (2.60)	5 (6.70)	
Gender, n (%)				0.041
Male,	50 (32.9)	33 (42.9)	17 (22.7)	
Female,	102 (67.1)	44 (57.1)	58 (77.3)	
Ethnicity, n (%)				0.001
Kazakh	71 (47.0)	43 (55.8)	28 (37.8)	
Russian	46 (30.5)	20 (26.0)	26 (35.1)	
Other	35 (22.5)	14 (18.2)	20 (27.1)	
Clinical findings at admission				
Heart rate bpm (mean ± SD)	97.8±15.7	93.2±15.6	99.1±15.6	0.039
General blood analysis				
Haemoglobin g/L (median [IQR])	115 [94.0–126]	122 [115–129]	98.0 [81.0–115]	p < 0.0001
RBC × 10^{12}/L (mean ± SD)	3.65±0.82	3.84±0.68	3.44±0.93	0.002
WBC × 10^{9}/L (median [IQR])	6.30 [4.50–8.90]	6.10 [4.60–7.80]	7.00 [4.40–10.4]	0.169
PLT × 10^{2}/L (mean ± SD)	266±117	301±92.7	219±130	0.142
Lymphocytes % (median [IQR])	27.0 [13.0–43.0]	35.0 [24.0–45.0]	18.0 [9.00–30.0]	0.004
Neutrophils % (median [IQR])	56.5 [45.0–74.0]	36.3 [34.5–37.8]	38.0 [32.0–57.0]	0.039
NLR (median [IQR])	1.90 [1.00–4.20]	1.60 [1.00–2.67]	4.49 [1.14–9.86]	0.030
Monocytes % (median [IQR])	8.00 [4.10–10.0]	10.0 [7.00–11.0]	5.00 [3.00–7.50]	p < 0.0001
Eosinophils % (median [IQR])	2.00 [1.00–2.00]	2.00 [1.00–2.00]	2.00 [1.00–5.00]	0.034
ESR mm/hour (median [IQR])	33.0 [15.0–54.0]	20.0 [9.50–32.5]	52.0 [35.0–64.0]	p < 0.0001
Blood chemistry				
Bilirubin µmol/L (median [IQR])	10.7 [7.00–15.7]	9.40 [6.75–13.2]	12.0 [7.20–17.9]	0.141
Total protein g/L (median [IQR])	68.3 [61.6–74.0]	69.1 [65.5–73.8]	67.4 [58.0–74.0]	0.051
Albumin g/L (mean ± SD)	40.3±9.19	41.7±6.30	35.8±14.7	p < 0.0001
Urea µmol/L (median [IQR])	4.10 [3.30–5.74]	3.82 [2.90–4.50]	5.00 [3.56–8.64]	p < 0.0001
Creatinine µmol/L (median [IQR])	61.0 [45.5–85.0]	56.0 [45.0–64.0]	79.2 [49.5–120]	0.062
Cholesterol µmol/L (mean ± SD)	3.65±1.20	3.86±0.96	3.20±1.51	0.0122
Triglyceride µmol/L (median [IQR])	1.10 [0.80–1.82]	1.10 [0.78–1.57]	1.45 [0.99–2.44]	0.135
Immunology				
CD4 cells/mm^3 (median [IQR])	540 [220–844]	664 [483–911]	118 [45.0–504]	p < 0.0001
CD8 cells/mm^3 (median [IQR])	640 [466–856]	652 [534–1021]	639 [377–856]	0.637
CD3 cells/mm^3 (median [IQR])	1618 [934–2226]	2103 [1610–2387]	934 [758–1320]	0.157
PTI % (mean ± SD)	80.4±22.9	112±15.1	76.3±20.5	0.766
Fibrinogen g/L (median [IQR])	3.40 [3.10–4.68]	4.80 [2.50–7.10]	3.40 [3.10–4.64]	0.511
Comorbidities				
Tachycardia, n (%)	54 (35.5)	19 (24.7)	35 (46.7)	p < 0.0001
Diffuse liver change, n (%)	69 (45.4)	35 (45.5)	34 (45.3)	0.046
Cirrhosis, n (%)	11 (7.24)	4 (5.19)	7 (9.33)	0.279
Cholecystitis, n (%)	37 (24.3)	16 (20.8)	21 (28.6)	p < 0.0001
Pancreatitis, n (%)	37 (24.3)	13 (16.8)	24 (32.0)	0.007
Oral candidiasis, n (%)	31 (20.4)	17 (22.1)	14 (18.7)	0.857
Hepatitis C, n (%)	63 (41.5)	22 (28.6)	41 (54.7)	0.001
Hepatitis B, n (%)	17 (11.2)	7 (9.09)	10 (13.3)	0.322
Any surgery, n (%)	22 (14.6)	3 (3.95)	19 (25.3)	0.002
Cachexia, n (%)	48 (31.6)	9 (11.7)	39 (52.0)	p < 0.0001
Meningitis, n (%)	11 (7.24)	2 (2.60)	9 (12.0)	0.002
Anemia	106 (70.2)	52 (67.5)	54 (73.0)	0.249
Behavioural factors				
Alcohol abuse, n (%)	40 (26.3)	7 (9.09)	33 (44.0)	p < 0.0001
IDU, n (%)	39 (25.7)	4 (5.19)	35 (46.7)	p < 0.0001
Smoking, n (%)	47 (30.9)	10 (13.0)	37 (49.3)	p < 0.0001
Outcomes				
Hospital stay duration, day median [IQR]	11 (8–19)	11 (9–16)	10 (5–32)	0.100
Years of illness, years median [IQR]	8 (2–10)	9 (4–10)	2 (0–5)	p < 0.0001

ESR – Erythrocytes sedimentation rate; IDU – Intravenous drug abuse; NLR – Neutrophils-to-lymphocytes ratio; PLT – platelets; PTI – Prothrombin index; RBC – Red blood cells; WBC – White blood cell.

Table 2

The association between demographic, clinical, laboratory, behavioral related variable and risk of all-cause mortality using unadjusted Cox proportional hazard model

Characteristics	Number of observations / number of deaths	Unadjusted HR [95% CI]	P value
Age+5	152 / 75	1.42 [1.30; 1.55]	<0.0001
Gender			
Male		ref	
Female	102 / 58	2.06 [1.11; 3.80]	0.021
Ethnicity			
Kazakhs		ref	
Russians	46 / 26	1.36 [0.74; 2.49]	0.088
Others	34 / 20	1.71 [0.92; 3.17]	0.324
Tachycardia	54 / 35	2.23 [1.35; 3.68]	0.002
Diffuse liver change	69 / 34	0.83 [0.50; 1.38]	0.470
Cirrhosis	11 / 7	2.89 [1.37; 6.09]	0.005
Cholecystitis	37 / 21	1.19 [0.68; 2.09]	0.544
Pancreatitis	37 / 24	1.72 [1.01; 2.93]	0.044
Oral candidiasis	31 / 14	1.34 [0.75; 2.40]	0.327
Non-hepatitis C		ref	
Hepatitis C	63 / 41	3.66 [2.14; 6.26]	<0.0001
Hepatitis B	17 / 10	2.63 [1.42; 4.86]	0.002
Any surgery	22 / 19	3.90 [2.23; 6.81]	<0.0001
Non-cachexia		ref	
Cachexia	48 / 39	5.65 [3.35; 9.54]	<0.0001
Meningitis	11 / 9	1.53 [0.66; 3.56]	0.321
Anaemia	106 / 54	2.52 [1.28; 4.98]	0.008
Non-alcohol abuse		ref	
Alcohol abuse	40 / 33	3.11 [1.87; 5.16]	<0.0001
Non-IDU		ref	
IDU	39 / 35	5.70 [3.41; 9.51]	<0.0001
Non-smoking		ref	
Smoking	47 / 37	3.30 [1.99; 5.49]	<0.0001
Haemoglobin^{-10}	146 / 75	1.52 [1.37; 1.69]	<0.0001
WBC	150 / 73	1.03 [0.99; 1.06]	0.143
PLT^{-50}	122 / 70	1.46 [1.25; 1.71]	<0.0001
Lymphocytes	134 / 75	0.97 [0.95; 0.99]	0.002
Neutrophils^{+5}	102 / 36	1.17 [1.05; 1.30]	0.004
NLR^{+2}	102 / 57	1.15 [1.08; 1.22]	<0.0001
Monocytes	135 / 60	1.00 [0.99; 1.02]	0.611
Eosinophils	112 / 66	1.11 [1.03; 1.19]	0.004
ESR^{+10}	149 / 73	1.42 [1.26; 1.60]	<0.0001
Bilirubin	140 / 72	1.01 [1.00; 1.01]	0.011
Total protein	138 / 72	0.99 [0.97; 1.02]	0.470
Albumin	55 / 42	0.89 [0.81; 0.96]	0.004
Urea^{+5}	136 / 72	1.49 [1.21; 1.84]	<0.0001
Creatinine^{+20}	107 / 45	1.05 [1.02; 1.09]	0.005
Cholesterol^{-2}	84 / 57	4.67 [1.95; 11.16]	0.001
Triglyceride	55 / 41	1.97 [1.00; 3.87]	0.050
CD4^{-100}	87 / 63	1.84 [1.38; 2.47]	<0.0001
Hospital stay duration	152 / 75	1.00 [1.00; 1.01]	0.447
Years of illness	109 / 40	0.89 [0.81; 0.97]	0.009

ESR – Erythrocytes sedimentation rate; IDU – intravenous drug abuse; NLR – Neutrophils-to-lymphocytes ratio; PLT – platelets; WBC – White blood cell.

drug use (IDU) and 37 (49.3%) dead patients smoked (p < 0.0001). The median duration of the disease from first diagnosis to death was 8 years. (IQR 2–10; p < 0.0001), with deceased patients having a significantly shorter length of illness.

Table 2 shows the association of socio-demographic, clinical, laboratorial, and behavioral characteristics along with immunology data, comorbidities, and outcomes with all-cause mortality in the unadjusted Cox proportional regression analysis. Every 5-year increment in age was linked to a 42% increase in the hazard of death (Undj. HR 1.42; 95% CI 1.30–1.55; p <0.0001). Moreover, females had a 2.06-fold increased risk of experiencing death in comparison to males (95% CI 1.11–3.80; p = 0.021). Patients with tachycardia had 2.23-fold higher hazard of death (95% CI 1.35–3.68; p = 0.002). Similarly, hospitalized HIV-positive patients with viral hepatitis B, cirrhosis, and anemia had high hazard ratios of 2.63 (95% CI 1.42–4.86; p = 0.002), 2.89 (95% CI 1.37–6.09); p = 0.005), and 2.52 (95% CI 1.28–4.98; p = 0.008), respectively. Whereas people coinfected with diffuse liver change, cholecystitis, pancreatitis, and oral candidiasis showed non-significant results. Each decrement in hemoglobin for 10 g/L was associated with a 52% unadjusted greater risk of all-cause mortality (Unadj. HR 1.52; 95% CI 1.37–1.69; p <0.0001). Opposingly, increase of neutrophils by 5% raised risk of all-cause mortality by 17% (Undj. HR = 1.17; 95% CI 1.05–1.30; p = 0.004). Every 2 increment in neutrophil-to-lymphocyte ratio (NLR) was associated with 15% greater hazard of death (Undj. HR 1.15; 95% CI 1.08–1.22; p <0.0001). Moreover, with each additional increase of 10 mm/hour in ESR, the risk of all-cause mortality was raised by 42% (Unadj. HR 1.42; 95% CI 1.26–1.60; p <0.0001). Elevated by 5 µmol/L urea (Undj. HR 1.49; 95% CI 1.21–1.84; p <0.0001) and reduced by 100 cells/mm3 CD4 (Undj. HR 1.84; 95% CI 1.38–2.47; p<0.0001) also increase hazard of death. Furthermore, each decrement in cholesterol for 2 µmol/L was associated with almost 5-fold increase hazard of death (Undj. HR 4.67; 95% CI 1.95–11.16; p<0.0001). With each 20 µmol/L increase in creatinine, there was corresponding 5% rise in the hazard of death (Undj. HR 1.05; 95% CI 1.02–1.09; p = 0.005).

In Kaplan-Meier survival analysis, patients diagnosed with viral hepatitis C had almost 4 times lower probability of survival (Undj. HR = 3.66; 95% CI 2.14–6.26; p <0.0001), compared with patients without viral hepatitis C (Figure 1).

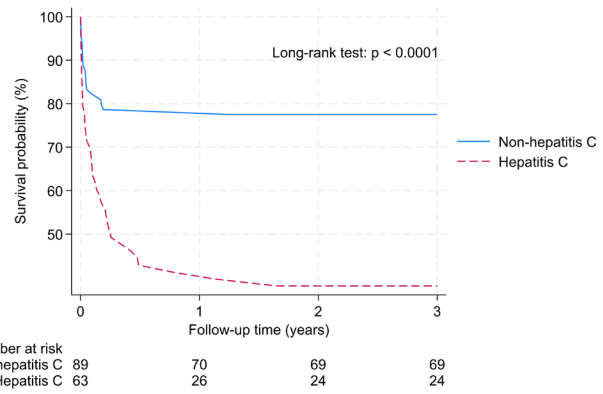

Figure 1 – Kaplan-Meier survival analysis among HIV-positive patients adjusted for viral hepatitis C

Patients with cachexia had almost 6 times higher hazard of death (Undj. HR = 5.65; 95% CI 3.35–9.54; p <0.0001) in comparison to those patients without cachexia (Figure 2). Figure 3 shows that individuals with IDU had a 5.7-fold higher risk of dying than those who did not report IDU (Undj. HR = 5.70; 95% CI 3.41–9.51; p <0.0001). Finally, patients with such behavioral characteristics as alcohol abuse and smoking showed 3 times decreased survival probability (Undj. HR = 3.11; 95% CI 1.87–5.16; p <0.0001, and Undj. HR = 3.30; 95% CI 1.99–5.49;

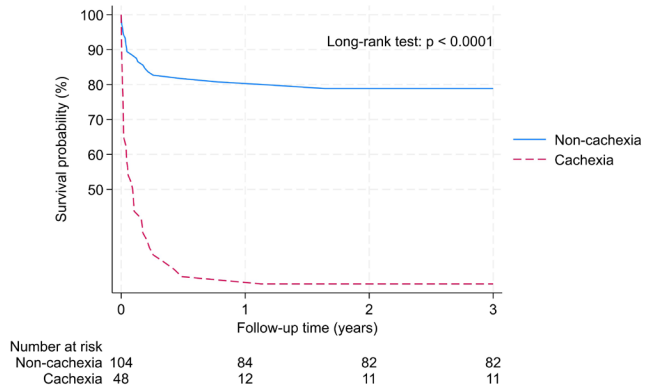

Figure 2 – Kaplan-Meier survival analysis among HIV-positive patients adjusted for cachexia

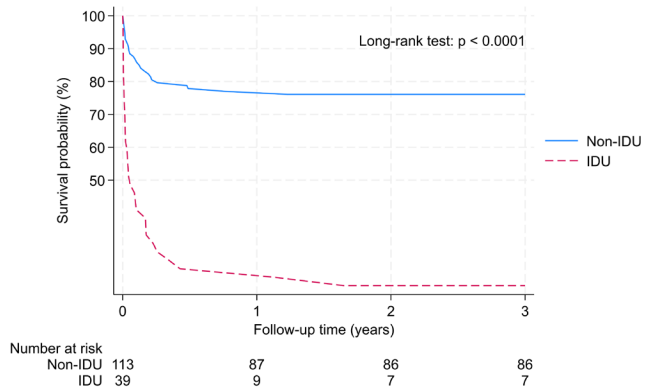

Figure 3 – Kaplan-Meier survival analysis among HIV-positive patients adjusted for intravenous drug use (IDU)

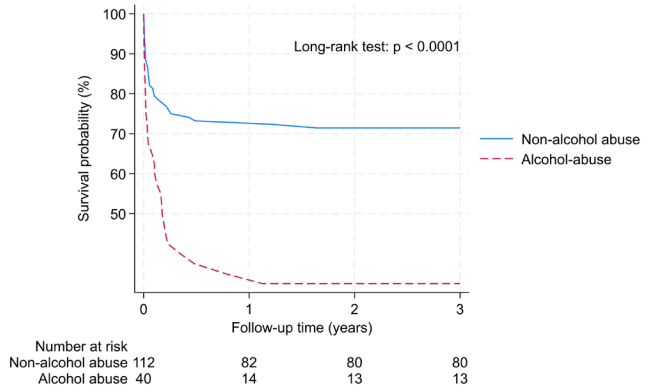

Figure 4 – Kaplan-Meier survival analysis among HIV-positive patients adjusted for alcohol abuse

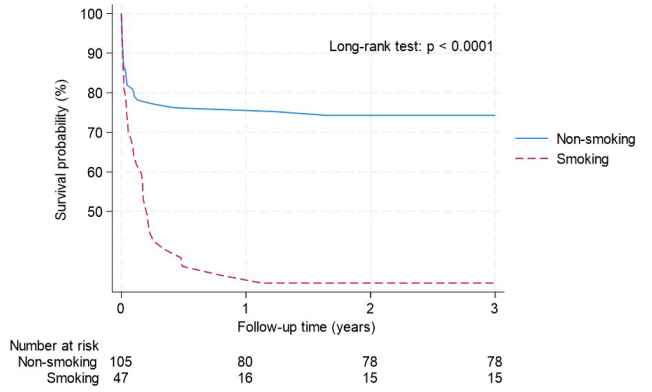

Figure 5 – Kaplan-Meier survival analysis among HIV-positive patients adjusted for smoking

p <0.0001, respectively) when compared with HIV patients without those habits (Figure 4 and Figure 5).

Following adjustments in the Cox proportional hazard regression model (as shown in Table 3), age+5 (Model 3: HR 1.35; 95% CI 1.17–1.57; p < 0.0001), IDU (Model 3: HR 1.90; 95% CI 1.83–10.23; p = 0.001), and anemia (Model 3: HR 2.50; 95% CI 1.63–13.36; p = 0.004) remained as independent predictors of all-cause mortality across Models 1, 2, and 3. The greatest risk of death was associated with the IDU.

Table 3

The association between demographic, clinical, laboratory, behavioral related variable and risk of all-cause mortality using adjusted Cox proportional hazard model

Covariates	Model 1 HR (95% CI)	P value	Model 2 HR (95% CI)	P value	Model 3 HR (95% CI)	P value
Age+5	1.37 [1.24–1.51]	< 0.0001	1.37 [1.21–1.55]	< 0.0001	1.28 [1.10–1.50]	0.002
Gender						
Female						
Male	1.41 [0.68–2.89]	0.352	0.87 [0.41–1.86]	0.715	0.83 [0.30–2.26]	0.714
Ethnicity						
Kazakhs						
Russians	1.15 [0.65–2.53]	0.663	1.19 [0.61–2.31]	0.617	0.94 [0.43–2.07]	0.882
Others	1.28 [0.65–2.54]	0.469	1.53 [0.75–3.11]	0.239	1.48 [0.63–3.51]	0.371
IDU	2.43 [1.40–4.24]	0.002	3.30 [1.84–5.91]	< 0.0001	4.80 [1.85–10.52]	< 0.0001
Anemia	-	-	4.03 [1.88–8.64]	< 0.0001	4.41 [1.85–10.52]	0.001
ESR	-	-	1.00 [0.99–1.02]	0.467	1.01 [0.99–1.03]	0.316
Bilirubin	-	-	-	-	1.01 [1.00–1.02]	0.008
Creatinine	-	-	-	-	1.00 [0.99–1.00]	0.268

ESR – erythrocytes sedimentation rate; IDU – intravenous drug abuse.

Discussion

This retrospective study was intended to provide an evaluation of all-cause mortality among HIV-positive patients and related risk factors in the population of Kazakhstan on the basis of the UNEHS data between 2014 and 2019. Previous studies have demonstrated a relationship between advancing age and heightened susceptibility to HIV-related mortality [6]. This trend aligns with the findings of this research, where older age was identified as an independent predictor of HIV-associated mortality. The increase in mortality risk with age could be attributed to various factors including limited access to effective antiretroviral therapy and other obstacles encountered by older individuals such as chronic illnesses, cognitive and psychological comorbidities, and deterioration in physical condition [7]. In this research, common HIV coinfections included tachycardia, pancreatitis, viral hepatitis C, and cachexia were identified as significant determinants of all-cause mortality using unadjusted Cox hazard regression analysis.

In studies from the USA and China, HIV-positive males comprise the majority of the patient cohort [8, 9]. In these countries, male HIV mortality exceeds that of females due to their involvement in high-risk behaviors that lead to increased transmission of the disease [10]. However, the larger proportion

of participants in this research was females (67.1%), resulting in divergent outcomes where females exhibit a twofold higher hazard of all-cause mortality as compared with males. This outcome could potentially be due to the limited sample size in this study.

In addition to laboratory observations, the neutrophil-to-lymphocyte ratio (NLR) was calculated, which is considered to demonstrate the balance between innate and adaptive immune responses and serves as a dependable marker of inflammation. Due to insufficient data on neutrophil count, its number was recalculated based on available data from lymphocytes, monocytes, and eosinophils counts which collectively constitute the total leukocytes count in the blood. In this research, the NLR was observed to be above 4 (IQR 1.14–9.86) for non-survivors. According to previous studies, there is a linear relationship between increased NLR values and heightened risk of death [11]. Therefore, high NLR value may be related to an increased risk of developing AIDS, as well as other non-AIDS-defining infections, including oncological and cardiovascular diseases in HIV-positive people [12].

In the research, non-survivors had elevated levels of alcohol and smoking abuse. This agrees with the results of former studies [13, 14]. Given that the study population of this research is predominantly female, it is notable that tobacco use among women rose from 4.5% to 10.1% between 2014 and 2019 [15]. This behavior should be addressed early in the beginning of treatment, and approaches for dealing with this problem should be discussed with the patient. Notably, smoking has been linked to heightened risks of chronic lung disease, cardiovascular disease, and cancer development in HIV-infected patients [16].

This study revealed that deceased patients had a shorter duration of illness from the onset of the disease to experiencing death compared to survivors. This could be attributed to delayed diagnosis of HIV, which reduces life expectancy [17]. Unfortunately, approximately half of HIV patients worldwide are diagnosed in later stage of the disease, as defined by a CD4+ T-cell count below 350 cells/mm3 or with advanced HIV infection (AHP) with a CD4+ T-cell count below 200 cells/mm3 [18]. In this research, non-surviving patients had a median CD4 count of 118 cells/mm3 (IQR 45.0–504; $p<0.0001$), indicating the possibility for late diagnosis among the deceased cohort. Moreover, diagnosing the disease in more advanced stages or at terminal phases may stem from inadequate population testing coverage among HIV-positive individuals in Kazakhstan. This is a result of patients failing to attend check-ups due to social or psychological aspects, and the HIV-related stigma. This draws attention to the importance of early diagnosis, monitoring, and prioritizing patients to prevent adverse outcomes.

Alongside age, intravenous drug abuse (IDU) was observed as an independent predictor of all-cause mortality in both univariate and multivariate Cox proportional hazard analysis. Given that existing evidence suggests HIV transmission primarily through IDU, these findings have important implications for prevention and policy change [19]. It is imperative that the Kazakh government and international non-governmental organizations (NGOs) prioritize addressing structural barriers that restrain intravenous drug users from accessing HIV treatment. Policy reforms are essential to curb high arrest rates and discrimination against drug users. Failure to address these obstacles will likely perpetuate low utilization of needle exchange programs, HIV testing, and uptake of HIV services among drug users [20].

According to the World Health Organization (WHO), mild to moderate anemia is defined as hemoglobin levels <13.0 g/dL in males and <12.00 g/dL in females. Anemia was identified in this study based on hemoglobin levels from a general blood test. Given that anemia is one of the most frequent blood disorders among people with HIV infection, it was included in the multivariate Cox regression analysis [21]. In line with previous studies, anemia was identified as an independent predictor of all-cause mortality in HIV-positive patients in this research [22]. Thus, regular hematological screening and treatment are crucial for HIV-positive patients to potentially slow down the progression of HIV infection and its associated hematological complications.

In this study, HIV-infected patients exhibited elevated erythrocyte sedimentation rate (ESR) levels, which aligns with previous research demonstrating significantly higher ESR in HIV-positive patients compared to controls [23]. This elevation in ESR is typical of infectious and inflammatory conditions such as HIV. Therefore, ESR was included as a parameter in the multivariate Cox hazard model analysis. Although it was not identified as an independent predictor of all-cause mortality in HIV-infected individuals which may be explained by the limited sample size of the study. Similarly, bilirubin and creatinine, both recognized as indicators of renal function, did not show significant findings in the adjusted Cox hazard ration models. They were included in the model because, in addition to aging, various risk factors such as the viral infection itself, antiretroviral therapy, HIV-related opportunistic illnesses (diabetes mellitus and heart disease), and co-infection (such as viral hepatitis C, viral hepatitis B, and tuberculosis) significantly influence the development of kidney disease in the HIV-positive patients [24].

This study also has limitations that should be mentioned. First, as was noted earlier, the research is limited by the small sample size and missing data on some variables. In addition, the AI application developed to extract patient data from their hospital discharges may have made errors. Considering the human factor during the manual re-evaluation of the extracted information is also essential. Second, the lack of comprehensive HIV epidemiological data may introduce bias in this study. Data are incomplete on other social aspects of patients, such as employment status, additional comorbidities, and medication usage, which are significant factors in assessing the mortality of HIV patients. Finally, the majority of the patients were women, so the results may not be generalized to men.

Despite these limitations, to the best of our knowledge, this research represents the first analysis of hospitalized patients with HIV that looks beyond epidemiological data and focuses on laboratory and clinical observations. An additional unique feature of the study is its adaptation of artificial intelligence to extract specific data from hospital records of HIV patients.

Conclusions

In conclusion, the study revealed a mortality rate of 49.3% among HIV patients from all causes of death. Poor outcomes were linked to many abnormal clinical and laboratory findings upon admission. Age, intravenous drug use (IDU), and anemia were identified as independent predictors of all-cause mortality. These findings provide valuable insights for healthcare practitioners in assessing mortality risk factors. Future research with larger cohorts is warranted to validate these results.

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