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The Prevalence of Liver Enzyme Abnormalities Among Adult Patients with Non-Communicable Diseases in Rwanda: A Gender-Stratified Analysis

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Background: Liver enzyme abnormalities are early indicators of hepatic dysfunction and are increasingly observed in individuals with non-communicable diseases (NCDs). Globally, liver diseases cause approximately 2 million deaths every year (≈4% of all deaths). In Rwanda, data on liver health and its gender-based stratification among adults with NCDs are scarce. This study assessed the prevalence and gender-specific patterns of liver enzyme abnormalities in this population to inform targeted interventions.

Methods: A descriptive cross-sectional study was conducted at the NCD outpatient clinic of the University Teaching Hospital of Butare (CHUB), involving 185 adult patients with documented NCDs. A structured and pretested questionnaire was used to collect sociodemographic, behavioral, and clinical data. Serum levels of alanine aminotransferase (ALT), aspartate aminotransferase (AST), and gamma-glutamyl transferase (GGT) were measured using the HumaLyzer 3500 semi-automated analyzer. Gender-stratified analyses were performed to assess prevalence and clustering of liver enzyme abnormalities.

Results: Out of the 185 participants, liver enzyme abnormalities were observed in 51 (27.6%), with isolated GGT elevation being the most common pattern (18, 9.7%). Females exhibited significantly higher De Ritis ratios with median = 1.04, interquartile range (IQR) = 0.83–1.4, $p = 0.019$. Females showed relatively elevated GGT levels, possibly linked to non-alcoholic fatty liver disease or environmental exposures.

Conclusion: Liver enzyme abnormalities are prevalent among older Rwandan adults with NCDs, with gender and occupational disparities. These findings underscore the need to integrate liver health into NCD care strategies in Rwanda.

Keywords: adults, ALT, dietary fat intake, liver enzymes, metabolic syndrome, non-communicable diseases, Rwanda

Introduction

Liver diseases remain a significant global health challenge, contributing to approximately 2 million deaths every year and accounting for nearly 4% of all global deaths.[1] Chronic liver conditions such as cirrhosis, hepatitis B and C infections, alcohol-related liver disease, and metabolic-associated steatotic liver disease (MASLD) are among the leading causes of liver-related morbidity and mortality.[2] While high-income countries have made substantial progress in liver disease management through early screening, non-invasive diagnostics, and advanced therapeutics, low- and middle-income countries (LMICs) continue to face disproportionate burdens due to limited healthcare infrastructure, low awareness, and inadequate surveillance systems.[2,3]

In sub-Saharan Africa (SSA), the burden of liver disease is particularly acute, with the region reporting some of the highest liver-related death rates globally, especially among males.[3] The region faces a complex interplay of risk factors including viral hepatitis, alcohol use, aflatoxin exposure, and emerging metabolic disorders such as MASLD, type 2

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diabetes mellitus (T2DM) and hypertension.[4] A recent meta-analysis estimated the prevalence of MASLD in SSA at 29.2%, with higher rates reported among individuals with diabetes mellitus (DM), hypertension, and elevated body mass index (BMI).[2] Despite this growing burden, liver diseases in the region remain underdiagnosed and underreported, largely due to limited access to liver function testing and specialist care.[5]

In East Africa, liver disease patterns mirror broader regional trends but are further complicated by sociocultural practices and environmental exposures. For instance, a study in rural Uganda involving over 8,000 adults found that 24% were at higher risk of liver fibrosis based on gamma glutamyl transferase (GGT)-to-platelet ratio, with strong associations to human immunodeficiency virus (HIV), hepatitis B virus (HBV), and alcohol consumption reported.[5] These findings underscore the need for context-specific data to inform public health strategies in the region, especially as non-alcoholic fatty liver disease (NAFLD) remains underdiagnosed despite rising obesity and DM rates.[6]

Rwanda is undergoing a rapid epidemiological transition, with non-communicable diseases (NCDs), accounting for 47.7% of health facility-based deaths and 59.3% of community deaths in the years 2024.[7] The country's aging population and increasing prevalence of DM, hypertension, and obesity have raised concerns about the potential silent burden of liver dysfunction, particularly among older adults. However, national data on liver enzyme abnormalities remain scarce, and liver health is often overlooked in NCD management programs.[8] This gap is particularly concerning given the potential for liver enzyme abnormalities to serve as early markers of hepatic injury and systemic metabolic dysfunction.[9,10]

Emerging evidence suggests that gender differences play a critical role in liver disease presentation and progression.[3,11,12] Men tend to have higher baseline levels of alanine amino transferase (ALT), aspartate aminotransferase (AST), and GGT, while women are more susceptible to autoimmune liver diseases and benign liver tumors, often influenced by hormonal and immunological factors.[13–15] Despite these differences, gender-stratified analyses of liver enzyme abnormalities are rarely conducted in African settings. The study aimed to fill this gap by examining the prevalence and gender-specific patterns of liver enzyme abnormalities among adult patients with NCDs in Rwanda, thereby contributing to more equitable and targeted liver health interventions.

Methods

Study Design and Setting

This descriptive cross-sectional study was conducted at the NCD outpatient clinic of the University Teaching Hospital of Butare (CHUB), located in Huye District, Southern Province, Rwanda. CHUB is a major tertiary referral hospital serving both urban and rural populations across Southern Rwanda and neighboring regions. The NCD clinic provides multidisciplinary ambulatory care for patients with chronic conditions including hypertension, T2DM, dyslipidemia, cardiovascular diseases (CVDs), and chronic respiratory illnesses. The site was selected for its representativeness of Rwanda's NCD care infrastructure and its capacity for clinical diagnostics and biochemical testing.

Sample Size Determination

Due to the absence of similar studies from Rwanda on the prevalence of liver enzyme abnormalities among patients with NCDs, a benchmark was adopted from a study conducted in neighboring Uganda, which reported a prevalence of approximately 13% for abnormal liver enzymes in adults. Using the standard single proportion formula for estimating a population proportion, with a 95% confidence level ($Z = 1.96$) and a precision of ± 5%, the calculated sample size was approximately 174. However, a final sample size of 185 was selected to account for potential non-response, missing data, and to ensure sufficient statistical power for subgroup analyses, particularly gender-stratified comparisons. This conservative adjustment was made to enhance the robustness and generalizability of the study findings.

Study Participants and Sampling

A total of 185 adult patients were enrolled between February and April 2025 using a consecutive sampling technique. For this study, adult patients were defined as individuals aged 18 years and above, in accordance with the World Health Organization (WHO) classification. Eligible participants had a documented diagnosis of at least one NCD, verified

through medical records and aligned with the World Health Organization (WHO) 2023 Fact Sheet on Noncommunicable Diseases.[16] The most prevalent NCDs among study participants were hypertension, T2DM, dyslipidemia, obesity, and CVDs. Participants were required to be clinically stable, with no acute illness or medication changes in the preceding four weeks. Exclusion criteria included a history of hepatitis B or C infections, liver cirrhosis, or acute hepatitis. These conditions were identified through review of medical records, including serological testing (eg, HBsAg, anti-HCV), clinical diagnoses, and where available, imaging reports such as abdominal ultrasound scan or FibroScan.

Additional exclusion criteria included excessive alcohol consumption, defined as > 20g/day for women and > 30g/day for men. Alcohol consumption was assessed using a structured questionnaire that captured frequency, quantity, and duration of alcohol intake, with cross-verification from clinical records where available. Participants were also excluded if they were on medications known to affect liver enzymes, such as statins, antiretroviral drugs, antitubercular agents (isoniazid, rifampicin, pyrazinamide), antifungals (ketoconazole, itraconazole), anticonvulsants (valproic acid, phenytoin, carbamazepine), chemotherapeutic agents (methotrexate), certain antibiotics (amoxicillin-clavulanate), or had unstable cardiovascular disease or diabetes mellitus. Although this list is not exhaustive, it reflects the most commonly encountered agents in our setting that could confound liver enzyme interpretation.

Data Collection and Sample Processing

Sociodemographic, behavioral, and clinical data were collected by the researchers using a structured, pretested questionnaire. Variables included age, sex, marital status, education, occupation, smoking status, alcohol use, physical activity, sleep duration, and dietary patterns. Clinical data were extracted from medical records using a standardized data collection sheet. Venous blood samples (5 mL) were collected between 7:00–10:00 a.m., processed under standard laboratory conditions, and stored at –80 °C until analysis.

Serum levels of ALT, AST, and GGT were measured using the HumaLyzer 3500 semi-automated analyzer (Human Diagnostics Worldwide, Germany) with reagent kits supplied by Fortress Diagnostics Ltd. (Antrim, United Kingdom). ALT and AST were quantified via NADH-coupled kinetic methods, while GGT activity was assessed through the enzymatic release of p-nitroaniline. Internal quality control included enzyme-specific control sera at multiple concentrations, with assay validity confirmed as per manufacturer guidelines. Abnormal liver enzyme activities were defined using the following cut-off points based on manufacturer guidelines and clinical standards: ALT: > 40 U/L, AST: > 40 U/L, GGT: > 51 U/L for males, > 33 U/L for females. The De Ritis ratio was calculated as the ratio of AST to ALT. Classification was based on established clinical thresholds: < 1.0: Suggestive of mild hepatic injury or non-alcoholic fatty liver disease, 1.0–2.0: Suggestive of hepatitis or cirrhosis, > 2.0: Suggestive of advanced alcoholic liver disease or cirrhosis.[17]

All laboratory procedures were conducted in accordance with Good Clinical Laboratory Practice guidelines, ensuring the quality, integrity, and reliability of the test results.

Statistical Analysis

Data were analyzed using Stata version 13 (StataCorp, College Station, Texas, USA). Categorical variables were summarized as frequencies and percentages; continuous variables as mean ± standard deviation (SD) or median and interquartile range (IQR). Group comparisons were done using *t*-tests and ANOVA for continuous variables and Chi-square or Fisher's exact tests for categorical variables. Statistical significance was set at $p < 0.05$.

Results

Sociodemographic and Behavioural Characteristics of Participants

The sociodemographic and behavioural characteristics of the study participants are summarised in Table 1. The study enrolled 185 adult patients with NCDs, comprising 54 males (29.2%) and 131 females (70.8%), with a median age of 62 years (interquartile range [IQR]: 51–67). No statistically significant gender difference in age distribution was observed ($p = 0.546$). Males had a significantly longer median history of alcohol consumption (17.5 vs 0 years, $p = 0.023$) and were more likely to drink daily (18.5% (n = 10) vs 6.9% (n = 9), $p = 0.024$) compared to females. Smoking status did not differ significantly

Table 1 Sociodemographic and Behavioural Characteristics of Adult Patients with Non-Communicable Diseases Attending the NCD Outpatient Clinic at CHUB, Stratified by Gender (n = 185)

Variable*	Total, n = 185	Gender		*p*-Value
		Males, n = 54	Females, n =131	
Age (years), median (IQR)	62 (51–67)	61 (50–67)	62 (51–67)	0.546
Duration Drinking (Years) Median (IQR)	10 (0–25)	17.5 (0–28)	0 (0–24)	0.023*
	n (%)	**n (%)**	**n (%)**	
Smoking Status				
Never	142 (76.8)	38 (70.4)	104 (79.4)	0.213
Former	40 (21.6)	14 (25.9)	26 (19.9)	
Current	3 (1.6)	2 (1.6)	1 (0.8)	
Drinking status				
Never	85 (46.0)	17 (31.5)	68 (51.9)	0.024*
1–3 times/month	48 (26.0)	15 (27.8)	33 (25.2)	
1–3 times/week	33 (17.8)	12 (22.2)	21 (16.0)	
Daily	19 (10.2)	10 (18.5)	9 (6.9)	
Marital Status				
Single	15 (8.1)	6 (11.1)	9 (6.9)	<0.001*
Divorced	8 (4.3)	2 (3.7)	6 (4.6)	
Widowed	55 (29.8)	2 (3.7)	53 (40.5)	
Married	107 (57.8)	44 (81.5)	63 (48.0)	
Educational attainment				
No formal education	40 (21.6)	5 (9.3)	35 (26.7)	0.066
Primary	116 (62.7)	38 (70.4)	78 (59.5)	
Secondary	24 (13.0)	9 (16.7)	15 (11.5)	
Tertiary	5 (2.7)	2 (3.7)	3 (2.3)	
Occupation Status				
Unemployed	38 (20.5)	14 (25.9)	24 (18.3)	0.001*
Informal employment	14 (7.6)	7 (13.0)	7 (5.3)	
Formal employment	8 (4.3)	6 (11.1)	2 (1.5)	
Farmer	125 (67.6)	27 (50.0)	98 (74.8)	
NCD Family History				
No	113 (61.1)	31 (57.4)	82 (62.6)	0.511
Yes	72 (38.9)	23 (42.6)	49 (37.4)	

Notes: *Statistically significant at $p < 0.05$.
Abbreviations: IQR, Interquartile range; NCD, Non-communicable diseases.

according to gender ($p = 0.213$). Marital status differed significantly by gender ($p < 0.001$), with 81.5% (n = 44) of male participants being married compared to 48.0% (n = 63) of females. Conversely, 40.5% (n = 53) of female participants were widowed, compared to only 3.7% (n = 2) of males. Occupational roles differed significantly by gender ($p = 0.001$), with 74.8% (n = 98) of female participants engaged in farming activities compared to 50.0% (n = 27) of males. Educational attainment ($p = 0.066$) and family history of NCDs ($p = 0.511$) showed no statistically significant gender differences.

Distribution of Non-Communicable Diseases Among the Study Participants

Table 2 summarises the distribution of NCDs among the study participants by sex. Hypertension was the most common NCD, affecting 41% of participants, and occurred slightly more often in females than males. Multimorbidity was also frequent, with 13% having both diabetes and hypertension, and smaller proportions presenting with other combinations involving diabetes, hyperlipidaemia, heart disease, or lung disease. Diabetes alone accounted for 9% of cases. Most other individual or combined NCDs occurred in less than 5% of participants. Overall, females generally had a higher burden of single NCDs, whereas males showed slightly higher proportions in some multimorbidity patterns.

Table 2 Distribution of Non-Communicable Diseases Among the Study Participants

NCDs	Overall, n (%)	Female, n (%)	Male, n (%)
Hypertension	76 (41.1)	56 (42.7)	20 (37)
DM + Hypertension	24 (13)	14 (10.7)	10 (18.5)
DM	16 (8.6)	12 (9.2)	4 (7.4)
DM + Hypertension + Hyperlipidaemia	16 (8.6)	10 (7.6)	6 (11.1)
Hypertension + Hyperlipidemia	10 (5.4)	8 (6.1)	2 (3.7)
Lung Disease	8 (4.3)	6 (4.6)	2 (3.7)
Hypertension + Heart disease	6 (3.2)	5 (3.8)	1 (1.9)
Hyperlipidemia	5 (2.7)	4 (3.1)	1 (1.9)
Heart Disease	5 (2.7)	3 (2.3)	2 (3.7)
Hypertension + Asthma	3 (1.6)	3 (2.3)	0 (0)
Hypertension + Kidney disease	3 (1.6)	2 (1.5)	1 (1.9)
DM + Hyperlipidemia	2 (1.1)	2 (1.5)	0 (0)
Hypertension + lung disease	2 (1.1)	0 (0)	2 (3.7)
Back Pain (chronic musculoskeletal condition)	1 (0.5)	1 (0.8)	0 (0)
DM + Hypertension + Heart disease	1 (0.5)	1 (0.8)	0 (0)
DM + Hypertension + Hyperlipidaemia + Asthma	1 (0.5)	1 (0.8)	0 (0)
DM + Hypertension + Stroke	1 (0.5)	1 (0.8)	0 (0)
Hypertension + Abdominal Pain	1 (0.5)	1 (0.8)	0 (0)
Neck pain (chronic musculoskeletal condition)	1 (0.5)	1 (0.8)	0 (0)
Heart Disease + DM	1 (0.5)	0 (0)	1 (1.9)
Hypertension + Heart disease + Heart disease	1 (0.5)	0 (0)	1 (1.9)
Hypertension + Stroke	1 (0.5)	0 (0)	1 (1.9)

Abbreviations: NCDs, Non-communicable diseases; DM, Diabetes Mellitus.

Prevalence and Clustering of Liver Enzyme Abnormalities

Table 3 summarises the prevalence and clustering of liver enzyme abnormalities. Liver enzyme abnormalities were observed in 27.6% (n = 51) of participants, with a slightly higher prevalence in males (29.8% n = 39) compared to females (22.2% n = 12), though the difference was not statistically significant ($p = 0.296$). Clustering patterns showed that the most common abnormality was isolated GGT elevation (9.7% n =18), followed by combined abnormalities of

Table 3 Prevalence and Clustering Patterns of Liver Enzyme Abnormalities Among Adult Patients with NCDs by Gender

Variable	Total	Gender		*p*-Value
		Females	Males	
Liver Enzyme abnormality, n (%)				
Abnormal	51 (27.6)	39 (29.8)	12 (22.2)	0.296
Normal	134 (72.4)	92 (70.2)	42 (77.8)	
Liver Enzyme Abnormalities Clustering, n (%)				
Abnormal ALT Only	3 (1.6)	2 (1.5)	1 (1.9)	0.855
Abnormal AST & ALT only	4 (2.2)	3 (2.3)	1 (1.9)	
Abnormal AST Only	2 (1.1)	2 (1.5)	0	
Abnormal GGT & ALT only	6 (3.2)	4 (3.1)	2 (3.7)	
Abnormal GGT & AST & ALT	14 (7.6)	11 (8.4)	3 (5.6)	
Abnormal GGT & AST Only	4 (2.2)	4 (3.1)	0	
Abnormal GGT Only	18 (9.7)	13 (9.9)	5 (9.3)	
Normal	134 (72.4)	92 (70.2)	42 (77.8)	

Notes: Reference values: ALT: > 40 U/L, AST: > 40 U/L, GGT: > 51 U/L for males, > 33 U/L for females.
Abbreviations: ALT, Alanine aminotransferase; AST, Aspartate aminotransferase; GGT, Gamma glutamyl transferase.

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GGT, AST, and ALT (7.6% n = 14). No significant gender differences were observed in the clustering patterns (p = 0.855).

Liver Enzyme Profiles and De Ritis Ratio by Gender

A summary of the liver enzyme profiles according to gender are presented in Table 4. Median values for ALT, AST, and GGT were not significantly different between males and females ($p > 0.05$). However, the De Ritis ratio was significantly higher in females with median (IQR); 1.04 (0.83–1.4) compared to males with median 0.87 (IQR0.68–1.18), with a p-value of 0.019. Classification of De Ritis ratio status showed that 47.6% (n = 88) of participants had values suggestive of probable hepatitis or cirrhosis and 3 (1.6%) had probable advanced hepatitis or cirrhosis, although no statistically significant differences were observed according to gender (p = 0.231).

Correlates of Liver Enzyme Abnormalities

Potential correlates of liver enzyme correlates are presented in Table 5. The study explored potential correlates of liver enzyme abnormalities and the results showed no statistically significant associations between liver enzyme abnormalities and age category, occupation, education level, smoking status, alcohol consumption frequency, alcohol abuse, duration of

Table 4 Liver Enzyme Levels and De Ritis Ratio Among Adult Patients with NCDs, Stratified by Gender

Variable*	Overall	Gender		p-Value
		Male	Female	
ALT U/L	23 (17–31)	25 (18–30)	23 (17–31)	0.366
AST U/L	23 (19–28)	22 (17–28)	24 (19–29)	0.090
GGT U/L	30 (20–48)	33 (21–45)	29 (19–49)	0.965
De Ritis ratio	0.99 (0.78–1.31)	0.87 (0.68–1.18)	1.04 (0.83–1.4)	0.019
De Ritis ratio status, n (%)				
Normal	94 (50.8)	32 (59.2)	62 (47.3)	0.231
Probable Hepatitis/Cirrhosis	88 (47.6)	21 (38.9)	67 (51.2)	
Probable advanced Hepatitis/Cirrhosis	3 (1.6)	1 (1.9)	2 (1.5)	

Notes: * Median (Interquartile range) unless otherwise stated; Medians compared using Wilcoxan rank sum test and proportions compared using the Chi-square test. p set at 0.05.*De Ritis ratio: the median AST/ALT ratio. **Reference values**: ALT: > 40 U/L, AST: > 40 U/L, GGT: > 51 U/L for males, > 33 U/L for females.

Table 5 Sociodemographic and Behavioural Correlates of Liver Enzyme Abnormalities Among Adult Patients with NCDs

Variable n (%)	Total	Liver Function Tests Status		*p*-Value
		Abnormal	Normal	
Age Category (years)				
19–39	3 (1.6)	1 (2)	2 (1.5)	0.908
40–64	106 (57.3)	28 (54.9)	78 (58.2)	
65+	76 (41.1)	22 (43.1)	54 (40.3)	
Occupation				
Farmer	125 (67.6)	32 (62.8)	93 (69.4)	0.431
Formal employment	8 (4.3)	4 (7.8)	4 (3.0)	
Informal employment	14 (7.6)	5 (9.8)	9 (6.8)	
Unemployed	38 (20.5)	10 (19.6)	28 (20.9)	

(*Continued*)

Table 5 (Continued).

Variable n (%)	Total	Liver Function Tests Status		*p*-Value
		Abnormal	Normal	
Educational attainment				
No formal education	40 (21.6)	13 (25.5)	27 (20.2)	0.691
Primary	116 (62.7)	31 (60.8)	85 (63.4)	
Secondary	24 (13.0)	5 (9.8)	19 (14.2)	
Tertiary	5 (2.7)	2 (3.9)	3 (2.2)	
Smoking status				
Current	3 (1.6)	1 (2.0)	2 (1.5)	0.71
Former	40 (21.6)	9 (17.7)	31 (23.1)	
Never	142 (76.8)	41 (80.3)	101 (75.4)	
Alcohol Consumption Status				
1–3 times per month	48 (26.0)	11 (21.6)	37 (27.6)	0.062
1–2 times per week	33 (17.8)	7 (13.7)	26 (19.4)	
Daily	19 (10.2)	2 (3.9)	17 (12.7)	
Never	85 (46.0)	31 (60.8)	54 (40.3)	
NCD Family history				
No	113 (61.1)	33 (64.7)	80 (59.7)	0.533
Yes	72 (38.9)	18 (35.3)	54 (40.3)	
Alcohol abuse Status				
No	139 (75.1)	38 (74.5)	101 (75.4)	0.903
Yes	46 (24.9)	13 (25.5)	33 (24.6)	
Duration of Alcohol consumption				
0 years	84 (45.4)	29 (56.9)	55 (41.0)	0.139
1–10 years	12 (6.5)	3 (5.9)	9 (6.7)	
11–20 years	30 (16.2)	6 (11.8)	24 (17.0)	
>20 years	59 (31.9)	13 (25.5)	46 (34.3)	
Physical Activity Frequency				
1–2 Times a Week	23 (12.4)	7 (13.7)	16 (11.9)	0.250
3–5 Times a Week	19 (10.3)	4 (7.8)	15 (11.2)	
Daily	43 (23.2)	7 (13.7)	36 (26.9)	
Never	43 (23.2)	16 (31.4)	27 (20.2)	
Rarely	57 (30.8)	17 (33.3)	40 (29.9)	

alcohol use, physical activity, or family history of NCDs (all $p > 0.05$). Although no variable reached statistical significance, some patterns are noteworthy. For example, among participants with abnormal liver enzymes (n = 51), 16 (31.4%) reported never engaging in physical activity compared to 27 (20.2%) among those with normal enzymes (n = 134). Similarly, 17 (33.3%) in the abnormal group reported rare activity versus 40 (29.9%) in the normal group. Regarding alcohol, 31 (60.8%) of those with abnormal enzymes reported never drinking compared to 54 (40.3%) in the normal group, while daily alcohol use was reported by only 2 (3.9%) in the abnormal group versus 17 (12.7%) in the normal group. These trends suggest possible behavioral influences on liver enzyme abnormalities, warranting further investigation in larger studies.

Discussion

The present study investigated the prevalence and clustering of liver enzyme abnormalities among adult patients attending the NCD clinic at CHUB in southern Rwanda. Our findings revealed that 27.6% of participants exhibited abnormal liver enzyme levels, with distinct patterns of elevation across AST, ALT, and GGT. Notably, the De Ritis ratio (AST/ALT) was significantly higher in females compared to males ($p = 0.019$). Gender stratification was important in this context because men and women differ in NCD prevalence, metabolic profiles, and liver disease progression, which

can influence both the pattern and underlying causes of enzyme abnormalities.[15,18] Gender-specific trends suggest alcohol-related liver injury in males and metabolic or environmental factors in females.[19–21] These findings support integrating liver function screening into routine NCD care.

The findings also reveal a notably high prevalence of liver enzyme abnormalities (27.6%) among adult patients with NCDs, with isolated GGT elevation emerging as the most common pattern (9.7%). This aligns with previous studies identifying GGT as a sensitive marker for hepatic dysfunction, particularly in populations with metabolic syndrome or alcohol-related liver injury.[10] Similarly, a Ugandan cohort study found 11% of patients had AST/ALT > 2 and 24% had elevated GGT-platelet ratios, supporting our observation of GGT as a key marker.[5] The prevalence of 27.6% liver enzyme abnormalities is comparable to findings from SSA, where a meta-analysis reported a 29.2% pooled prevalence of MAFLD among adults, with higher rates in diabetics (37.1%) and hypertensive patients (36.8%).[22]

Although males reported a significantly longer history and higher daily alcohol consumption patterns, females exhibited a relatively higher frequency of elevated GGT levels despite lower alcohol intake. Given that women typically have lower baseline GGT activity, these elevations may suggest alternative etiologies. Non-alcoholic fatty liver disease is increasingly prevalent among women in SSA, particularly in individuals with obesity, DM, or metabolic syndrome.[3,23] Environmental exposures, including air pollutants ($PM_{2.5}$, NO_2) and endocrine-disrupting chemicals, have been associated with hepatic steatosis and elevated GGT, with stronger effects observed in females.[24–26] Hormonal influences, such as estrogen-related modulation of hepatic metabolism, may also contribute to sex-specific differences in liver enzyme profiles.[27] These findings underscore the need for a tiered response on elevated GGT rather than universal imaging: confirm persistence, evaluate clinical risk factors (alcohol use, obesity, diabetes), and prioritize imaging or fibrosis assessment only for high-risk individuals. This approach optimizes resource allocation while addressing the growing burden of liver disease among NCD patients. Although females exhibited higher GGT levels and De Ritis ratios, these findings should be interpreted with caution given the limited timeframe of this study and the underrepresentation of male participants. The observed patterns may reflect underlying biological or behavioral differences; however, confirmation will require larger, more balanced cohorts and extended follow-up periods.

Globally, a meta-analysis of 278,000 participants reported significantly higher ALT (+7.1 IU/L), AST (+2.7 IU/L), and GGT (+11.2 IU/L) in individuals with metabolic syndrome,[9] reinforcing the link between NCDs and liver dysfunction. Gender differences in our study, higher De Ritis ratios and GGT in females, align with evidence of rising NAFLD prevalence among African women (≈13.5%).[6] Furthermore, elevated De Ritis ratios have been associated with increased mortality risk in long-term cohorts, highlighting their prognostic value.[28] These comparisons emphasize the need for gender-sensitive liver health strategies in NCD care across SSA.

Although no statistically significant associations were found between liver enzyme abnormalities and behavioral or sociodemographic variables, the trends observed, such as higher prevalence among daily alcohol users and those with lower physical activity, warrant further investigation. These findings underscore the importance of integrating liver function screening tests into routine NCD care, especially in resource-limited settings where liver disease often remains undiagnosed until advanced stages.[5]

The study has notable strengths. This research fills a critical data gap by examining gender-specific liver enzyme abnormalities among Rwandan adults with NCDs. Its methodological rigor is supported by standardized data collection tools, reliable biochemical assays, and exclusion of confounding hepatic conditions. The inclusion of sociodemographic and behavioral factors enhances interpretability, while the use of De Ritis ratio analysis adds diagnostic value. Conducted in a well-equipped tertiary hospital, the study offers actionable insights for liver health integration into NCD care in sub-Saharan Africa. Nevertheless, several limitations warrant consideration. The cross-sectional design of this study restricts the ability to draw causal inferences. Liver enzyme levels were assessed in the absence of imaging modalities or fibrosis biomarkers, which may have led to an underestimation of liver disease severity. The reliance on self-reported alcohol consumption introduces potential recall and social desirability bias. Furthermore, as the data were drawn from a single tertiary hospital, the findings may not be generalizable to the broader Rwandan population or to other sub-Saharan African cohorts affected by non-communicable diseases.

Conclusion

Liver enzyme abnormalities are prevalent among older Rwandan adults suffering from NCDs, with gender-specific patterns suggesting differing aetiologies such as alcohol-related liver injury in males and metabolic or environmental factors in females. These findings emphasize the importance of routine liver function screening and the integration of liver health into NCD care strategies. Future research should explore longitudinal outcomes and incorporate imaging and fibrosis assessments to better characterize liver disease burden in this population.

Abbreviations

IQR, Interquartile range; NCD, Non-communicable diseases; ALT, Alanine aminotransferase; AST, Aspartate aminotransferase; GGT, Gamma glutamyl transferase.

Data Sharing Statement

All data generated in this study are included in this manuscript. However, the dataset will be made available by the corresponding author (nzitakera@gmail.com) upon reasonable request.

Ethics Approval and Consent to Participate

This study was conducted in accordance with internationally recognized ethical standards, including the principles outlined in the Declaration of Helsinki and applicable national research ethics guidelines. Ethical approval was obtained from the Institutional Review Board (IRB) of the University of Rwanda, College of Medicine and Health Sciences (Approval No. IRB/CMHS/041/2025), as well as from the Research Ethics Committee of the University Teaching Hospital of Butare (Approval No.: REC/CHUB/014/2025), which authorized participant recruitment and data collection. All participants provided written informed consent after receiving comprehensive information regarding the study's objectives, procedures, potential risks, and anticipated benefits. To ensure confidentiality, each participant was assigned a unique study identification code unrelated to personal identifiers. Physical records were securely stored in locked cabinets accessible only to authorized personnel, while electronic data were encrypted, password-protected, and accessible solely to the principal investigators.

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Author Contributions

All authors significantly contributed to the reported work, including its conception, study design, execution, data acquisition, analysis, and interpretation. They participated in drafting, revising, or critically reviewing the article, gave final approval for the version to be published, agreed on the journal to which the article was submitted, and committed to being accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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