



OPEN Alcohol consumption and its association with biochemical indicators and quality of life among rural adults in Northern Thailand

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The prevalence of Alcohol Use Disorder (AUD) is rising in Thailand, but there is still a lack of adequate diagnosis, reporting, and management. This study aimed to assess alcohol consumption and its association with demographic variables, biochemical markers, and quality of life (QoL) among adults living in rural Northern Thailand. A cross-sectional design was adopted, and 405 adults aged ≥ 20 years from ethnic groups in Phayao Province, Northern Thailand were included in the study. Participants were selected using a random sampling technique. Two standardized questionnaires translated into Thai were employed: the Alcohol Use Disorders Identification Test (AUDIT) and the World Health Organization Quality of Life Assessment (WHOQOL-BREF-THAI). The biochemical indicators were Glycated Hemoglobin (HbA1c) and Alanine Aminotransferase (ALT), which were measured objectively through blood sample tests. The mean age of participants was 50.9 years. A total of 43 individuals (10.6%) had a high level of alcohol consumption risk, whereas 37.3% had a low level of risk. The Spearman's rank correlation coefficient analysis revealed a strong positive correlation between ALT enzyme levels and AUDIT scores among female participants ($r_s = 0.802, p < 0.01$). Among male participants, AUDIT scores were positively correlated with ALT levels ($r_s = 0.718, p < 0.01$) and HbA1c levels ($r_s = 0.303, p < 0.01$) but negatively correlated with QoL scores ($r_s = -0.306, p < 0.01$). Linear regression analysis showed statistically significant associations between alcohol consumption risk and ALT levels in both females and males. Alcohol consumption was not significantly associated with HbA1c levels in the adjusted model. Additionally, abnormal ALT ($B = -2.62$) and abnormal HbA1c ($B = -4.29$) were significantly associated with lower QoL scores in the adjusted model. Patterns of alcohol consumption were associated with biochemical indicators and QoL among residents, with sex-specific differences observed. Community empowerment and the development of practical approaches by public health agencies and local policy makers are essential for reducing alcohol-related health problems.

Keywords Alcohol consumption risks, Biochemical indicators, Quality of life, Rural adults, Northern Thailand

Excessive alcohol consumption is a major global public health concern. As an addictive psychoactive substance, alcohol contributes to severe health outcomes, including cirrhosis, multiple cancers, and pancreatitis¹. Beyond physical harm, it adversely affects mental well-being and quality of life, while also increasing the risk of accidents and injuries². Alcohol-related deaths and disabilities impose a substantial economic burden on healthcare systems worldwide. In 2019, 38% of individuals aged ≥ 15 years were current drinkers, with an estimated 400 million (7%) experiencing alcohol-related problems, of whom 209 million (3.7% of adults globally) suffered from alcohol dependence³.

In Thailand, alcohol consumption among individuals aged ≥ 15 years has fluctuated between 2007 and 2024. Prevalence increased steadily until 2015, declined to 28.4% in 2017, and rose again to 35.2% in 2024. Regionally,

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the North reported the highest prevalence (42.0%), with Lampang (59.5%), Chiang Rai (53.7%), and Phayao (53.6%) ranking among the top three provinces⁴. Phayao Province, comprising nine districts, is located in the upper northern part of Thailand. The region is characterized by mountainous terrain and dense forests⁵. This hilly area is home to numerous ethnic groups, most of whom trace their ancestry to migrations from Yunnan Province in northwest China^{5,6}. These communities represent a rich tapestry of diverse socioeconomic backgrounds, cultures, and traditional practices⁵. Previous studies on ethnic groups have shown that cultural patterns of alcohol consumption are closely linked to traditional and religious ceremonies⁶. Some studies have estimated that alcohol-related deaths in Thailand account for approximately 17,726 men (6.50%) and 2,312 women (1.11%) of all annual deaths⁷. Similarly, a study in Brazil reported an average of 6,633 alcohol-related deaths per year, with alcohol consumption exceeding the global average of 6.4 liters⁸. These findings highlight that the causes of chronic alcoholism are multifactorial and may occur simultaneously, influenced by genetic, social, cultural, psychological, and personality-related factors⁹. Several studies have highlighted the physiological harms of alcohol and its association with impaired intentional control and behavior⁸. Previous research has shown that alcohol exerts a progressive linear effect on various liver enzymes, even at low to moderate levels of consumption, suggesting that alcohol-related risks may be linked to liver function^{10,11}. Excessive alcohol intake increases morbidity and mortality rates by contributing to disease development and reduces overall quality of life¹².

Quality of life (QoL), as defined by the World Health Organization, is “an individual’s perception of their position in life in the context of the culture and value systems in which they live, and in relation to their goals, expectations, standards, and concerns.” This concept provides a framework for understanding how individuals perceive their own health¹³. A review has indicated that health-related quality of life (HRQoL) refers to a multidimensional subjective assessment of both positive and negative aspects of life that influence health^{14,15}. Thus, the concept of quality of life and health extends health evaluation beyond morbidity and mortality to encompass physical, psychological, and social well-being¹⁴. Studies conducted in hospitals and primary care settings have reported that individuals who consume alcohol exhibit significantly reduced quality of life, particularly in mental health and social functioning^{8,14}. These studies evaluated factors such as severity of alcohol dependence, drinking intensity, employment status, age, gender, and psychiatric history as predictors of quality of life⁸. Some studies have indicated that alcohol misuse and dependence severely impair quality of life¹⁶. A previous review highlighted that barriers to accessing alcohol treatment in rural areas—such as inconvenient geographic distance and long waiting times—further contribute to reduced quality of life¹⁷.

Therefore, investigating alcohol consumption and its association with personal or demographic variables, biochemical variables, and quality of life is essential for improving interventions and advancing the debate to date. No previous study has focused on this relationship in Northern Thailand, which is a major gap in the literature, since the highest prevalence of alcohol dependence is in this region of Thailand. Moreover, there is a paucity of research assessing the relationship between men and women. Since alcohol consumption patterns differ between men and women, a comparative analysis of the relationship between men and women would yield policy implications. A consideration of biochemical markers in this study is novel, since these measures are objective. Our statistical analysis aims to inform efforts to improve the quality of life in Northern Thailand. Such efforts can help reduce the risks and illnesses associated with excessive alcohol consumption in a more effective and context-appropriate manner.

Methodology

Study design and setting

This study employed a cross-sectional design under the Unit of Excellence Division 2 project: “Survey of Biomarkers, Herbal Use Behaviors, and Self-care Practices for Reducing Pesticide Exposure among Farmers in Rural Areas of Phayao Province”. The research was conducted between June 2024 and April 2025 in the highland border areas of Phayao Province, adjacent to Lampang Province in Northern Thailand. The nearest hospital is located 39.2 km from the community, requiring approximately 1 h and 30 min of travel due to limited accessibility. Random selection at the area level was used to reduce potential selection bias in choosing the study location. One district (Mueang District) was selected from the nine administrative districts of Phayao Province using a lottery method. Within Mueang District, Mae Ka Sub-district was randomly selected from 15 administrative units. Mae Ka comprises 18 villages, from which one village was selected in the same manner. Participants residing in the selected village were subsequently recruited using convenience sampling based on predefined inclusion criteria (Fig. 1).

Community leaders announced and facilitated recruitment through loudspeaker broadcasts in the morning and evening. The minimum sample size of 405 participants was determined using Daniel’s formula¹⁸, consistent with our previous study. Eligible participants were men and women aged ≥ 20 years who had resided in the study area for at least one year, were able to communicate in the local language, and provided written informed consent. Screening was conducted using the Alcohol Use Disorders Identification Test (AUDIT). To facilitate recruitment, five trained village health volunteers, fluent in both local and ethnic languages and familiar with community culture, served as research assistants.

Due to the cultural diversity of the ethnic communities, permission to conduct the study was first obtained from local authorities, with research objectives clearly explained. Community access was then facilitated through coordination with village leaders, community representatives, and village health volunteers, who helped communicate the study purpose at the local level. Before data collection, a two-hour training session was conducted for local research assistants to standardize questionnaire administration, interview scheduling, and protection of participants’ rights. Study information was disseminated in the local language via morning loudspeaker announcements by village leaders, supported by village health volunteers. Participants were instructed to fast for at least 12 h before blood collection and questionnaire administration. After providing

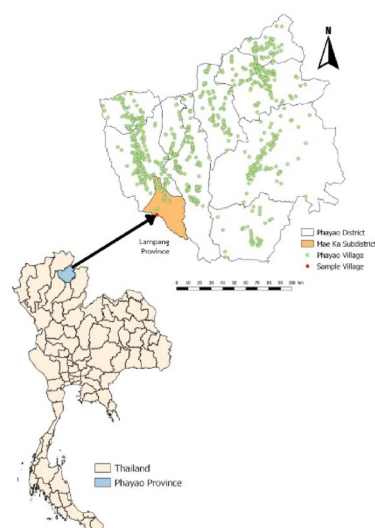


Fig. 1. Geographic location of the sample.

written informed consent, blood samples were drawn, followed by interviews conducted between 9:00 and 12:00 at the community multipurpose hall. Trained research assistants administered the questionnaire, with each session lasting approximately 10–15 min. A small token of appreciation was given to the participants upon completion.

Data were collected using interviewer-administered questionnaires, which were reviewed for content validity by three public health experts. Part 1 presented socio-demographic questions such as gender, age, ethnicity, marital status, education level, occupation, and income. Primary measures included physical examination history, underlying diseases, smoking status, and alcohol use assessed with the Alcohol Use Disorders Identification Test (AUDIT)^{19,20}. The 10-item AUDIT (score range 0–40) classifies drinking behavior into four risk levels: low-risk drinker (0–7), hazardous drinker (8–15), harmful use (16–19), and alcohol dependence (≥ 20). An AUDIT cut-off score of 8 indicates problematic drinking, with a sensitivity of approximately 0.95 and an average specificity of approximately 0.80, based on evidence from multiple international validation studies and diverse population settings²⁰.

Part 2 utilized the WHOQOL-BREF, developed by the World Health Organization²¹. Specifically, the abbreviated Thai version (WHOQOL-BREF-THAI) was adopted from previous research^{22,23}. The 26-item instrument is divided into four domains: physical health (7 items, DOM1), psychological health (6 items, DOM2), social relationships (3 items, DOM3), and environmental health (8 items, DOM4). Each WHOQOL-BREF item was rated on a 5-point scale, with total scores categorized as poor (26–60), moderate (61–95), or good quality of life (96–130). The instrument demonstrated acceptable reliability, with a Cronbach's alpha of 0.80.

Biochemical assessments included blood pressure, alanine transaminase (ALT), and hemoglobin A1c (HbA1c). Participants fasted for 12 h prior to blood collection. Venous blood samples were collected by trained medical personnel and analyzed in a certified laboratory using standard procedures. In this study, the cutoff values for ALT and HbA1c were defined as follows: ALT cutoff levels were set at ≥ 35 U/L for females and ≥ 45 U/L for males²⁴. For HbA1c, a threshold of $\geq 6.5\%$ was applied in accordance with the diagnostic criteria for diabetes established by the World Health Organization²⁵.

Statistical analysis

Data were analyzed using IBM SPSS Statistics version 26.0 (IBM, USA). Descriptive statistics, including means, standard deviations, and percentages, were used to summarize socio-demographic characteristics, AUDIT scores, biochemical indicators, and QoL. Group differences were assessed using independent-samples t-tests or one-way ANOVA, with Welch's correction applied when variances were unequal. Associations between AUDIT scores, biochemical markers, blood pressure markers, and quality of life were examined using Spearman's rank correlation, as AUDIT scores were not normally distributed. Potential outliers were assessed through graphical inspection using boxplots and scatterplots prior to the correlation analyses. No extreme outliers were observed, although several high values fell within plausible clinical ranges (Supplementary Figure S1). Linear regression analyses were conducted to evaluate relationships between dependent variables (i.e., ALT, HbA1c, systolic blood pressure [SBP], diastolic blood pressure [DBP], and QoL) and independent variables (i.e., gender, age, ethnic group, education, occupation, annual physical examination, chronic condition, diabetes, hypertension, asthma, chronic obstructive pulmonary disease [COPD], smoking, and AUDIT risk categories). Variables were identified a priori based on prior evidence and contextual relevance to the study population. AUDIT risk categories were treated as categorical variables in all regression models to facilitate clinical interpretation and to avoid assuming a linear relationship between AUDIT scores and the outcome variables; accordingly, regression coefficients represent differences relative to the reference group rather than ordered or dose-response effects. Variables with p-values < 0.05 from initial group comparisons were included in the full multivariable model.

followed by backward elimination to derive the final model. This approach was applied to retain statistically significant predictors while maintaining a parsimonious and interpretable model. Statistical significance was defined as $p < 0.05$. Across all final models, multicollinearity was assessed using variance inflation factors (VIF), with no problematic multicollinearity detected (maximum VIF = 2.3). Residual diagnostics were examined using standardized residuals, and histograms of standardized residuals indicated approximately normal distributions.

Results

AUDIT scores, biochemical markers, blood pressure, and quality of life of the participants

The distribution of AUDIT risk categories differed by sex. The proportions of low-risk drinkers, hazardous drinkers, harmful use, and alcohol dependence were 54.0% ($n = 122$), 27.4% ($n = 62$), 14.2% ($n = 32$), and 4.4% ($n = 10$), respectively, among females, and 16.2% ($n = 29$), 8.9% ($n = 16$), 56.4% ($n = 101$), and 18.4% ($n = 33$), respectively, among males. Higher ALT levels were observed among participants classified in higher AUDIT risk categories. Females reported ALT ≥ 35 U/L, and 50.0% of them were harmful users, whereas 33.3% were alcohol dependence. Males reported ALT ≥ 45 U/L, and 66.1% of them were harmful users, whereas 32.3% of them were alcohol dependence. Participants with HbA1c $\geq 6.5\%$ also showed higher rates of harmful use (45.8%) and alcohol dependence (13.9%) compared with those with normal HbA1c. Similarly, individuals with elevated blood pressure (SBP ≥ 130 mmHg, DBP ≥ 85 mmHg) were more likely to be alcohol dependence than those with normal blood pressure. Notably, participants with high QoL scores (96–130) were predominantly low-risk drinkers (65.0%) with no alcohol dependence, whereas those with low QoL scores (26–60) reported higher proportions of harmful use (41.9%) and alcohol dependence (16.1%) (Table 1).

Associations of AUDIT scores with demographic factors, biochemical markers, blood pressure, and quality of life

Males had significantly lower mean AUDIT, HbA1c, DBP, and QoL scores compared with females. Using Welch's ANOVA, age was associated with AUDIT, ALT (in females), SBP, DBP, and QoL, with the 20–40 age group reporting the highest QoL. Ethnicity was significantly related to SBP, with indigenous participants showing the highest mean values. No significant associations were found between alcohol dependence and marital status, income, and hyperlipidemia.

Education level was significantly associated with AUDIT, ALT (female), HbA1c, and SBP, while occupation was related to SBP. Annual physical examination was associated with both AUDIT and QoL. Underlying diseases (diabetes, hypertension, depression, asthma, COPD) were associated with multiple variables, including QoL. Smoking was strongly associated with AUDIT, ALT (male and female), HbA1c, SBP, DBP, and QoL; smokers had higher AUDIT and ALT scores but lower QoL than non-smokers (Table 2).

AUDIT scores were strongly correlated with ALT in both females ($r_s = 0.802$, $p < 0.01$) and males ($r_s = 0.718$, $p < 0.01$). Among females, AUDIT was significantly associated with SBP and DBP, while its negative correlation with QoL was not significant. In males, AUDIT was also positively correlated with HbA1c ($r_s = 0.303$, $p < 0.01$) and negatively correlated with QoL ($r_s = -0.306$, $p < 0.01$). These findings indicate that higher levels of alcohol

Outcome	Mean $\pm$ SD	Audit, <i>n</i> (%)			
		Low-risk drinker	Hazardous drinker	Harmful use	Alcohol dependence
Total	10.8 $\pm$ 8.8	151 (37.3%)	78 (19.3%)	133 (32.8%)	43 (10.6%)
Alanine aminotransferase (ALT-female) (n = 226)					
<35 U/L	24.2 $\pm$ 14.1	120 (61.2%)	59 (30.1%)	17 (8.7%)	0 (0.0%)
$\geq$ 35 U/L		2 (6.7%)	3 (10.0%)	15 (50.0%)	10 (33.3%)
Alanine aminotransferase (ALT-male) (n = 179)					
<45 U/L	41.5 $\pm$ 16.6	29 (24.8%)	15 (12.8%)	60 (51.3%)	13 (11.1%)
$\geq$ 45 U/L		0 (0.0%)	1 (1.6%)	41 (66.1%)	20 (32.3%)
Glycated hemoglobin (HbA1c)					
<6.5%	6.0 $\pm$ 0.8	131 (39.3%)	69 (20.7%)	100 (30.0%)	33 (9.9%)
$\geq$ 6.5%		20 (27.8%)	9 (12.5%)	33 (45.8%)	10 (13.9%)
Systolic blood pressure (SBP)					
<130 mmHg	133.9 $\pm$ 11.4	78 (42.4%)	43 (23.4%)	44 (23.9%)	19 (10.3%)
$\geq$ 130 mmHg		73 (33.0%)	35 (15.8%)	89 (40.3%)	24 (10.9%)
Diastolic blood pressure (DBP)					
<85 mmHg	85.1 $\pm$ 5.8	102 (39.8%)	54 (21.1%)	76 (29.7%)	24 (9.4%)
$\geq$ 85 mmHg		49 (32.9%)	24 (16.1%)	57 (38.3%)	19 (12.8%)
Quality of life (QoL)					
Poor (score 26–60)	69.5 $\pm$ 8.9	19 (30.6%)	7 (11.3%)	26 (41.9%)	10 (16.1%)
Moderate (score 61–95)		119 (36.8%)	67 (20.7%)	104 (32.2%)	33 (10.2%)
Good (score 96–130)		13 (65.0%)	4 (20.0%)	3 (15.0%)	0 (0.0%)

Table 1. Descriptive analysis of AUDIT scores, biochemical markers, blood pressure, and quality of life of the participants ($n = 405$).

Variable	Audit		ALT-female (n = 226)		ALT-male (n = 179)		HbA1c		SBP		DBP		QoL	
	Mean ± SD	P-value	Mean ± SD	P-value	Mean ± SD	P-value	Mean ± SD	P-value	Mean ± SD	P-value	Mean ± SD	P-value	Mean ± SD	P-value
Gender														
Male	15.8 ± 7.4	< 0.001 [†]	–	–	41.4 ± 16.6	–	6.1 ± 0.8	0.005 [†]	135.0 ± 10.7	0.063 [†]	85.9 ± 5.7	0.014 [†]	67.3 ± 6.6	< 0.001 [‡]
Female	6.9 ± 7.8		24.2 ± 14.1	–	–	–	5.9 ± 0.8	–	132.9 ± 11.8	–	84.5 ± 5.8	–	71.2 ± 10.1	
Age														
20–40 years	12.5 ± 8.8	0.003 ^{‡‡}	28.4 ± 16.6	< 0.001 ^{‡‡}	38.5 ± 17.0	0.166 ^{††}	5.8 ± 0.8	0.002 ^{††}	129.2 ± 10.1	< 0.001 ^{††}	84.5 ± 5.4	0.038 ^{‡‡}	71.6 ± 9.5	< 0.001 ^{‡‡}
41–60 years	11.4 ± 8.5		26.7 ± 15.0		41.7 ± 16.9		6.0 ± 0.7		139.9 ± 10.2		86.1 ± 6.5		70.0 ± 9.9	
> 60 years	8.7 ± 8.9		19.1 ± 9.1		44.6 ± 16.6		6.1 ± 0.9		130.9 ± 10.7		84.5 ± 5.2		67.2 ± 6.2	
Ethnic group														
Lee So	9.9 ± 9.2	0.559 ^{††}	20.9 ± 13.5	0.167 ^{††}	44.4 ± 19.1	0.628 ^{††}	6.0 ± 0.9	0.194 ^{††}	131.2 ± 11.5	0.001 ^{††}	84.8 ± 5.8	0.591 ^{††}	68.7 ± 8.0	0.104 ^{‡‡}
Mien	10.8 ± 8.6		24.4 ± 13.5		41.6 ± 14.5		6.1 ± 0.8		133.1 ± 11.1		84.6 ± 5.8		68.2 ± 7.4	
Hmong	10.6 ± 8.8		24.1 ± 11.5		39.8 ± 18.4		5.9 ± 0.9		133.3 ± 11.7		85.5 ± 5.9		70.3 ± 8.9	
Indigenous	11.8 ± 8.8		27.1 ± 17.2		40.5 ± 14.9		5.9 ± 0.7		137.5 ± 10.5		85.5 ± 5.8		70.8 ± 10.8	
Marital status														
Single/widowed/divorced/separated	11.1 ± 8.7	0.675 [†]	24.7 ± 15.0	0.680 [†]	39.8 ± 13.4	0.375 [†]	6.0 ± 0.8	0.859 [†]	133.3 ± 12.1	0.525 [†]	85.4 ± 6.6	0.488 [†]	70.6 ± 9.6	0.091 [†]
Married	10.7 ± 8.9		24.0 ± 13.6		42.1 ± 18.0		6.0 ± 0.8		134.1 ± 11.0		85.0 ± 5.4		69.0 ± 8.5	
Education														
No educated	10.3 ± 8.7	0.040 ^{††}	22.2 ± 13.8	0.049 ^{‡‡}	45.7 ± 15.6	0.400 ^{‡‡}	6.0 ± 0.8	0.043 ^{‡‡}	132.0 ± 11.7	0.002 ^{††}	84.7 ± 6.5	0.085 ^{††}	68.4 ± 8.9	0.107 ^{††}
Primary	9.1 ± 8.9		21.5 ± 11.4		41.1 ± 12.3		6.1 ± 1.0		137.2 ± 10.9		86.2 ± 5.9		68.4 ± 8.3	
Secondary/higher	11.7 ± 8.8		26.2 ± 15.2		40.6 ± 18.0		5.9 ± 0.7		132.9 ± 11.3		84.7 ± 5.6		70.3 ± 9.2	
Occupation														
Unemployed	10.2 ± 9.2	0.752 ^{††}	22.2 ± 13.5	0.063 ^{‡‡}	38.4 ± 24.1	0.749 ^{‡‡}	5.8 ± 0.7	0.383 ^{††}	130.2 ± 11.6	0.046 ^{††}	84.7 ± 5.4	0.810 ^{††}	69.6 ± 8.9	0.912 ^{††}
General laborer	11.1 ± 8.8		26.2 ± 15.7		42.2 ± 14.5		6.0 ± 0.8		134.3 ± 11.7		85.0 ± 5.9		69.3 ± 8.7	
Farmer	10.6 ± 8.8		21.8 ± 10.9		41.5 ± 15.6		6.0 ± 0.8		134.5 ± 10.8		85.3 ± 5.9		69.7 ± 9.2	
Income														
Insufficient	10.9 ± 8.7	0.746 [†]	22.8 ± 13.6	0.095 [†]	42.0 ± 17.1	0.543 [†]	6.0 ± 0.7	0.792 [†]	134.1 ± 11.4	0.674 [†]	85.2 ± 5.9	0.729 [†]	69.1 ± 8.7	0.327 [†]
Sufficient	10.6 ± 9.0		25.9 ± 14.5		40.5 ± 16.1		6.0 ± 0.9		133.6 ± 11.5		85.0 ± 5.7		70.0 ± 9.2	
Annual physical examination														
No	11.3 ± 8.8	< 0.001 [†]	24.4 ± 14.0	0.590 [†]	41.4 ± 16.5	0.915 [†]	6.0 ± 0.8	0.744 [†]	133.8 ± 11.3	0.649 [†]	85.1 ± 5.8	0.827 [†]	68.9 ± 8.1	0.008 [‡]
Yes	5.7 ± 7.9		22.9 ± 14.7		40.3 ± 27.7		5.9 ± 0.8		134.7 ± 12.7		84.9 ± 6.2		75.5 ± 13.6	
Chronic condition														
No	10.8 ± 8.8	0.970 [†]	24.8 ± 13.9	0.395 [†]	38.5 ± 16.8	< 0.001 [‡]	5.9 ± 0.8	0.002 [†]	132.4 ± 10.5	0.001 [‡]	84.8 ± 5.3	0.220 [‡]	71.8 ± 9.2	< 0.001 [‡]
Yes	10.8 ± 8.9		23.2 ± 14.3		47.8 ± 14.4		6.1 ± 0.8		136.5 ± 12.4		85.6 ± 6.7		65.3 ± 6.5	
Diabetes														
No	10.9 ± 8.9	0.247 [†]	24.4 ± 14.5	0.409 [†]	41.2 ± 17.0	0.089 [‡]	5.9 ± 0.8	0.002 [†]	133.7 ± 11.4	0.233 [†]	85.1 ± 5.9	0.643 [†]	69.8 ± 8.9	0.008 [†]
Yes	9.0 ± 8.5		21.8 ± 9.0		44.8 ± 4.7		6.4 ± 1.0		136.2 ± 10.8		85.6 ± 5.1		65.3 ± 7.5	
Hypertension														
No	11.0 ± 8.8	0.383 [†]	24.4 ± 14.0	0.605 [†]	39.7 ± 15.8	< 0.001 [†]	5.9 ± 0.8	0.003 [†]	132.8 ± 10.8	< 0.001 [†]	84.8 ± 5.5	0.028 [‡]	70.5 ± 9.1	< 0.001 [‡]
Yes	9.9 ± 9.2		23.2 ± 14.6		53.9 ± 17.7		6.2 ± 0.8		139.4 ± 12.9		86.6 ± 7.3		64.2 ± 5.7	
Hyperlipidemia														
Continued														

Variable	Audit		ALT-female (n = 226)		ALT-male (n = 179)		HbA1c		SBP		DBP		QoL	
	Mean ± SD	P-value	Mean ± SD	P-value	Mean ± SD	P-value	Mean ± SD	P-value	Mean ± SD	P-value	Mean ± SD	P-value	Mean ± SD	P-value
No	11.0 ± 8.8	0.212†	24.6 ± 14.3	0.240†	40.9 ± 16.9	0.249†	6.0 ± 0.8	0.429†	133.5 ± 11.2	0.114†	85.0 ± 5.7	0.412†	69.8 ± 9.0	0.073†
Yes	9.2 ± 8.8		21.4 ± 12.5		46.3 ± 12.8		6.1 ± 0.8		136.4 ± 12.6		85.8 ± 6.6		67.2 ± 7.6	
Depression														
No	10.6 ± 8.8	0.020‡	24.2 ± 14.1	0.985†	41.1 ± 16.9	0.262†	6.0 ± 0.8	0.956†	133.9 ± 11.4	0.985†	85.1 ± 5.7	0.693†	69.6 ± 9.0	0.265†
Yes	18.1 ± 7.7		24.0 ± 5.7		48.3 ± 7.6		6.0 ± 0.4		133.8 ± 12.2		84.3 ± 10.5		66.2 ± 5.5	
Asthma														
No	10.7 ± 8.8	0.022‡	24.0 ± 13.8	0.403†	41.2 ± 16.7	0.370†	6.0 ± 0.8	0.163‡	134.0 ± 11.4	0.043†	85.2 ± 5.9	0.208†	69.5 ± 8.9	0.572†
Yes	16.3 ± 6.9		28.6 ± 21.7		48.8 ± 10.7		5.8 ± 0.3		127.0 ± 8.2		82.9 ± 3.5		68.0 ± 8.5	
COPD														
No	10.8 ± 8.9	0.641†	24.1 ± 13.7	0.708†	41.3 ± 16.9	0.826†	6.0 ± 0.8	0.600†	133.9 ± 11.3	0.842†	85.1 ± 5.8	0.670†	69.7 ± 9.0	0.037†
Yes	11.7 ± 8.2		25.7 ± 20.2		42.6 ± 11.7		5.9 ± 0.7		133.3 ± 13.2		84.6 ± 6.4		65.5 ± 4.7	
Smoking														
No	8.6 ± 8.6	<0.001‡	23.6 ± 13.5	<0.001†	34.4 ± 17.1	<0.001‡	5.8 ± 0.8	<0.001†	133.1 ± 11.6	0.011†	84.7 ± 5.8	0.014†	70.6 ± 9.4	<0.001‡
Yes	19.2 ± 2.5		54.0 ± 12.7		49.8 ± 11.3		6.4 ± 0.8		136.7 ± 10.2		86.5 ± 5.7		65.4 ± 4.9	

Table 2. The demographic variables associated with AUDIT scores, biochemical markers, blood pressure, and quality of life of the participants (n = 405).
†Independent-samples t-test; ‡One-way ANOVA; ‡ Welch's t-test; ‡ Welch's ANOVA.

consumption were associated with elevated liver enzyme levels, higher HbA1c, and lower quality of life scores among male participants. (Table 3).

In the final multivariable linear regression model selected using backward elimination, ALT levels differed significantly across AUDIT risk categories, with harmful use and alcohol dependence categories showing stronger associations compared with the low-risk reference group. ALT was analyzed in its original scale without transformation. Although ALT values among females showed moderate right-skewness (skewness=1.617), model diagnostics indicated no influential observations (maximum Cook's distance=0.182; maximum leverage=0.096). HbA1c was positively associated with smoking and diabetes, while females had lower HbA1c than males. Elevated SBP and DBP were observed among participants aged 41–60 years and those with hypertension. QoL was negatively associated with non-communicable diseases (diabetes, hypertension, abnormal ALT/HbA1c), whereas females and those who had undergone a physical examination reported higher QoL (Table 4).

Discussion

This study assessed alcohol consumption and its association with demographic variables, biochemical markers, and quality of life among adults in the selected rural community in Northern Thailand. This study found that 32.8% of participants engaged in harmful use, most commonly among males, individuals with no formal education, and the Lee So ethnic group. This may be explained by the ethnic context of rural Northern Thailand, where cultural beliefs and practices related to alcohol consumption persist, such as its use in traditional rituals and community gatherings⁵. These findings are consistent with the lifestyle of rural labor groups, where alcohol is used as a means of relaxation and social bonding²⁶. Beliefs about alcohol use were also observed among men, who perceived drinking after work to relieve fatigue. This finding aligns with the concept that modifying factors serve as underlying determinants influencing perceptions and behaviors, whereby demographic, social, psychological, personality, and cultural values play critical roles in shaping individual practices²⁷. These findings are consistent with a previous study in Brazil, which reported a prevalence of alcohol consumption of 32.0%. Most drinkers were male, over 40 years of age, married, with low education and income, limited access to basic sanitation, and a high prevalence of common mental disorders⁸. Several studies have reported that individuals classified in harmful use and alcohol dependence categories tend to exhibit a higher prevalence of abnormal ALT levels compared with low-risk drinkers, indicating a consistent association between patterns of alcohol consumption and liver enzyme abnormalities^{10,11}.

Analysis of biochemical indicators revealed that participants with HbA1c≥6.5% had higher proportions of harmful use and alcohol dependence compared with those with normal HbA1c levels. This finding is consistent with scientific evidence showing that heavy alcohol consumption is associated with impaired glycemic control and an increased risk of type 2 diabetes, particularly among individuals with non-alcoholic fatty liver disease (NAFLD)²⁸. Furthermore, analysis of the liver biochemical marker alanine aminotransferase (ALT) showed that females with ALT≥35 U/L and males with ALT≥45 U/L had higher proportions of harmful use and alcohol dependence compared with those with normal ALT levels. This aligns with scientific evidence demonstrating that heavy drinkers have elevated levels of ALT, AST, GGT, ferritin, and albumin compared with moderate drinkers or abstainers²⁹. It was also found that binge drinking significantly increased ALT and GGT levels, even among light drinkers³⁰. Most abnormalities were observed in male farmers. In addition, abnormal blood pressure (SBP≥130 mmHg and DBP≥85 mmHg) and moderate-to-low QoL levels were noted. This can be explained by the impact of non-communicable diseases (NCDs), particularly hypertension, on work capacity

Variables	1	2	3	4	5	6
Female (n = 226)						
1. Audit scores	1					
2. ALT	0.802**	1				
3. HbA1c	0.019	0.088	1			
4. SBP	0.094	0.116	0.161*	1		
5. DBP	0.012	0.046	0.172**	0.575**	1	
6. QoL	− 0.099	− 0.105	− 0.345**	− 0.186**	− 0.048	1
Male (n = 179)						
1. Audit scores	1					
2. ALT	0.718**	1				
3. HbA1c	0.303**	0.430**	1			
4. SBP	0.085	0.234**	0.237**	1		
5. DBP	0.163*	0.234**	0.159*	0.632**	1	
6. QoL	− 0.306**	− 0.384**	− 0.408**	− 0.194**	− 0.071	1

Table 3. Spearman's correlations among AUDIT scores, biochemical, blood pressure markers, and quality of life of the participants. All variables were treated as continuous data. 1 = AUDIT scores; 2 = Alanine aminotransferase (ALT); 3 = Glycated hemoglobin (HbA1c); 4 = Systolic blood pressure (SBP); 5 = Diastolic blood pressure (DBP); 6 = Quality of life (QoL). **Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

Outcome	Variable	Univariable analysis		Multivariable analysis, Full model		Multivariable analysis, Final model	
		B (95%CI)	P-value	B (95%CI)	P-value	B (95%CI)	P-value
ALT (female) (n = 226)	Age						
	20–40 year	9.30 (4.71, 13.89)	<0.001	1.13 (– 2.09, 4.36)	0.489	–	–
	41–60 year	7.63 (3.56, 11.71)	<0.001	1.94 (– 0.61, 4.49)	0.135	–	–
	Education						
	Primary	– 0.76 (– 6.37, 4.85)	0.790	0.07 (– 3.07, 3.22)	0.963	–	–
	Secondary/higher	3.98 (– 1.13, 9.08)	0.126	2.46 (– 0.81, 5.72)	0.139	–	–
	Smoking (yes)	30.36 (16.93, 43.79)	<0.001	1.79 (– 6.33, 9.92)	0.664	–	–
	Audit risk categories						
	Hazardous drinker	10.46 (8.09, 12.83)	<0.001	9.65 (7.22, 12.07)	<0.001	10.46 (8.09, 12.83)	<0.001
	Harmful use	24.57 (21.55, 27.59)	<0.001	23.64 (20.58, 26.71)	<0.001	24.57 (21.55, 27.59)	<0.001
	Alcohol dependence	45.90 (40.90, 50.90)	<0.001	45.19 (39.83, 50.55)	<0.001	45.90 (40.90, 50.90)	<0.001
				Adjusted R ² = 0.707		Adjusted R ² = 0.699	
ALT (male) (n = 179)	Chronic condition (yes)	9.30 (4.15, 14.45)	<0.001	– 0.12 (– 3.96, 3.72)	0.950	–	–
	Hypertension (yes)	14.22 (6.86, 21.57)	<0.001	6.89 (1.48, 12.30)	0.013	6.80 (2.19, 11.40)	0.004
	Smoking (yes)	15.45 (11.07, 19.83)	<0.001	5.39 (2.13, 8.66)	0.001	5.37 (2.16, 8.59)	0.001
	Audit risk categories						
	Hazardous drinker	17.19 (10.84, 23.55)	<0.001	15.43 (9.26, 21.60)	<0.001	15.41 (9.28, 21.55)	<0.001
	Harmful use	30.67 (26.38, 34.97)	<0.001	27.00 (22.53, 31.46)	<0.001	26.99 (22.55, 31.42)	<0.001
	Alcohol dependence	41.13 (35.94, 46.32)	<0.001	37.05 (31.76, 42.33)	<0.001	37.03 (31.78, 42.29)	<0.001
				Adjusted R ² = 0.653		Adjusted R ² = 0.655	
HbA1c	Gender (female)	– 0.23 (– 0.39, – 0.07)	0.005	0.02 (– 0.18, 0.21)	0.848	–	–
	Age						
	20–40 year	– 0.37 (– 0.57, – 0.17)	<0.001	– 0.30 (– 0.54, – 0.07)	0.012	– 0.29 (– 0.46, – 0.13)	0.001
	41–60 year	– 0.16 (– 0.35, 0.03)	0.094	– 0.11 (– 0.30, 0.09)	0.268	–	–
	Education						
	Primary	0.14 (– 0.12, 0.39)	0.300	0.11 (– 0.14, 0.36)	0.396	–	–
	Secondary/higher	– 0.12 (– 0.35, 0.11)	0.289	0.03 (– 0.22, 0.27)	0.842	–	–
	Chronic condition (yes)	0.23 (0.09, 0.42)	0.002	– 0.03 (– 0.24, 0.27)	0.816	–	–
	Diabetes (yes)	0.47 (0.17, 0.77)	0.002	0.37 (0.25, 0.68)	0.023	0.41 (0.13, 0.70)	0.005
	Hypertension (yes)	0.33 (0.11, 0.54)	0.003	0.20 (– 0.06, 0.46)	0.125	–	–
	Smoking (yes)	0.57 (0.38, 0.76)	<0.001	0.48 (0.25, 0.72)	<0.001	0.60 (0.41, 0.78)	<0.001
	Audit risk categories						
	Hazardous drinker	– 0.10 (– 0.32, 0.12)	0.358	– 0.05 (– 0.27, 0.16)	0.644	–	–
	Harmful use	0.34 (0.15, 0.53)	<0.001	0.17 (– 0.05, 0.38)	0.131	–	–
	Alcohol dependence	0.14 (– 0.01, 0.53)	0.056	0.17 (– 0.13, 0.46)	0.263	–	–
				Adjusted R ² = 0.127		Adjusted R ² = 0.124	
Continued							

		Univariable analysis		Multivariable analysis, Full model		Multivariable analysis, Final model	
Outcome	Variable	B (95%CI)	P-value	B (95%CI)	P-value	B (95%CI)	P-value
SBP	Age						
	20–40 year	– 1.61 (– 4.19, 0.97)	0.221	– 0.68 (– 3.92, 2.56)	0.681	–	–
	41–60 year	9.03 (6.63, 11.43)	<0.001	8.31 (5.56, 11.07)	<0.001	9.07 (6.96, 11.18)	<0.001
	Ethnic group						
	Lee So	1.61 (– 5.05, 1.30)	0.246	– 0.29 (– 3.13, 2.55)	0.841	–	–
	Hmong	0.14 (– 2.84, 3.13)	0.926	0.38 (– 2.31, 3.07)	0.781	–	–
	Indigenous	4.37 (1.33, 7.40)	0.005	3.30 (0.41, 6.20)	0.025	2.83 (0.46, 5.19)	0.020
	Education						
	Primary	5.25 (1.67, 8.83)	0.004	2.68 (– 0.58, 5.94)	0.107	–	–
	Secondary/higher	0.92 (– 2.27, 4.11)	0.570	– 0.20 (– 3.45, 3.05)	0.950	–	–
	Occupation						
	General laborer	4.04 (0.56, 7.52)	0.023	1.22 (– 1.95, 4.39)	0.450	–	–
	Farmer	4.33 (0.77, 7.89)	0.017	1.01 (– 2.26, 4.27)	0.544	–	–
	Chronic condition (yes)	4.05 (1.76, 6.35)	0.001	2.13 (– 0.55, 4.82)	0.119	–	–
	Hypertension (yes)	6.55 (3.55, 9.56)	<0.001	3.09 (– 0.30, 6.48)	0.074	–	–
	Asthma (yes)	– 7.04 (– 13.86, – 0.22)	0.043	– 6.10 (– 12.49, 0.29)	0.061	–	–
	Smoking (yes)	3.54 (0.83, 6.26)	0.011	1.98 (– 0.86, 4.82)	0.171	–	–
	Audit risk categories						
	Hazardous drinker	– 0.34 (– 3.43, 2.75)	0.827	– 0.53 (– 3.32, 2.27)	0.712	–	–
	Harmful use	3.90 (1.27, 6.54)	0.004	2.81 (0.15, 5.47)	0.039	3.15 (1.01, 5.28)	0.004
	Alcohol dependence	2.96 (– 0.87, 6.79)	0.129	2.44 (– 1.31, 6.18)	0.202	–	–
				Adjusted R ² = 0.247		Adjusted R ² = 0.195	
DBP	Gender (female)	– 1.43 (– 2.57, – 0.29)	0.014	– 0.52 (– 1.99, 0.95)	0.490	–	–
	Age						
	20–40 year	– 0.01 (– 1.45, 1.43)	0.988	– 0.05 (– 1.55, 1.45)	0.947	–	–
	41–60 year	1.59 (0.25, 2.93)	0.020	1.52 (0.17, 2.88)	0.027	1.53 (0.37, 2.69)	0.010
	Hypertension (yes)	1.75 (0.19, 3.31)	0.028	1.64 (0.05, 3.23)	0.043	1.64 (0.09, 3.19)	0.038
	Smoking (yes)	1.75 (0.36, 3.13)	0.014	0.64 (– 1.09, 2.36)	0.469	–	–
	Audit risk categories						
	Hazardous drinker	0.02 (– 1.56, 1.60)	0.983	– 0.05 (– 1.65, 1.56)	0.955	–	–
	Harmful use	1.63 (0.28, 2.98)	0.018	1.01 (– 0.61, 2.62)	0.222	–	–
	Alcohol dependence	2.59 (0.62, 4.54)	0.010	2.01 (– 0.18, 4.20)	0.072	–	–
				Adjusted R ² = 0.040		Adjusted R ² = 0.023	
Continued							

Outcome	Variable	Univariable analysis		Multivariable analysis, Full model		Multivariable analysis, Final model	
		B (95%CI)	P-value	B (95%CI)	P-value	B (95%CI)	P-value
QoL	Gender (female)	3.94 (2.23, 5.66)	<0.001	3.23 (1.38, 5.08)	0.001	2.83 (1.23, 4.43)	0.001
	Age						
	20–40 year	4.46 (2.28, 6.65)	<0.001	2.31 (0.22, 4.39)	0.030	–	–
	41–60 year	2.81 (0.77, 4.84)	0.007	2.21 (0.35, 4.06)	0.020	–	–
	Annual physical examination (yes)	6.58 (3.55, 9.62)	<0.001	5.41 (2.62, 8.20)	<0.001	6.15 (3.42, 8.88)	<0.001
	Chronic condition (yes)	– 6.54 (– 8.25, – 4.84)	<0.001	– 5.65 (– 8.07, – 3.23)	<0.001	– 6.54 (– 8.13, – 4.96)	<0.001
	Diabetes (yes)	– 4.50 (– 7.80, – 1.20)	0.008	0.43 (– 2.89, 3.75)	0.799	–	–
	Hypertension (yes)	– 6.23 (– 8.56, – 3.91)	<0.001	– 1.31 (– 4.11, 1.48)	0.356	–	–
	COPD (yes)	– 4.26 (– 8.27, – 0.26)	0.037	– 0.01 (– 4.04, 4.03)	0.999	–	–
	Smoking (yes)	– 5.24 (– 7.32, – 3.16)	<0.001	0.16 (– 2.24, 2.56)	0.895	–	–
	ALT (abnormal)	– 4.62 (– 6.65, – 2.58)	<0.001	– 2.96 (– 2.24, 2.56)	0.004	– 2.62 (– 4.50, – 0.75)	0.006
	HbA1c ($\geq 6.5\%$)	– 6.20 (– 8.40, – 4.00)	<0.001	– 3.88 (– 5.99, – 1.77)	<0.001	– 4.29 (– 6.31, – 2.28)	<0.001
				Adjusted $R^2 = 0.269$		Adjusted $R^2 = 0.265$	

Table 4. Factors associated with biochemical markers, blood pressure, and quality of life among the participants by linear regression analysis ($n = 405$). Variables: Gender (0 = male, 1 = female); Age (0 = > 60, 1 = 20–40, 2 = 41–60); Ethnic group (0 = Mien, 1 = Lee So, 2 = Hmong, 3 = Indigenous); Education (0 = no, 1 = yes); Occupation (0 = no, 1 = yes); Annual physical examination (0 = no, 1 = yes); Chronic condition (0 = no, 1 = yes); Diabetes (0 = no, 1 = yes); Hypertension (0 = no, 1 = yes); Asthma (no = 0, yes = 1); COPD (0 = no, 1 = yes); Smoking (no = 0, yes = 1); Audit scores (0 = Low risk drinker, 1 = Hazardous drinker, 2 = Harmful use, 3 = Alcohol dependence); ALT (0 = normal, 1 = abnormal); HbA1c (0 = < 6.5%, 1 = $\geq 6.5\%$).

and daily functioning, which in turn reduces QoL. These findings are consistent with previous studies showing that hypertension and other chronic diseases impair physical performance and daily activities, thereby lowering quality of life^{31,32}.

Analysis revealed that education, occupation, and annual physical examination were associated with AUDIT, ALT (female), HbA1c, SBP, and QoL, reflecting the influence of social, economic, and health behavior factors. Higher education levels are linked to greater health literacy, enabling individuals to modify health behaviors and reduce the risk of NCDs^{27,33}. In contrast, occupation affects lifestyle, diet, and stress, which are related to alcohol consumption behaviors and liver function (ALT)³⁴. Annual health examinations serve as an important mechanism for detecting early abnormalities in the body and have been reported to help reduce metabolic risk factors such as blood pressure and HbA1c levels³⁵. The findings of this study are consistent with previous research indicating that higher education levels and participation in annual health check-ups are associated with better health status and improved quality of life in the general population³⁶.

An important finding was that underlying diseases such as diabetes, hypertension, depression, asthma, and COPD, as well as smoking, were significantly associated with AUDIT, ALT (female and male), HbA1c, SBP, DBP, and QoL. Smokers had higher AUDIT and ALT scores but lower QoL compared with non-smokers. These findings suggest that comorbidities and smoking may co-occur with higher alcohol consumption risk and poorer health indicators, and are associated with lower quality of life³⁷. This is consistent with studies reporting that smoking is associated with harmful use³⁸ as well as with abnormal liver function (ALT), which complicates the management of NCDs³⁹ and adversely affects overall quality of life³⁷. Several studies have shown that NCDs such as diabetes, hypertension, heart disease, and chronic liver disease are associated with harmful use. Heavy and prolonged alcohol consumption was associated with NCDs through mechanisms including liver damage, promotion of insulin resistance, increased blood pressure, and stimulation of chronic inflammatory processes^{40,41}. Some studies have further reported that elevated blood pressure is significantly associated with higher HbA1c levels⁴². Previous studies have found that patients with diabetes and hypertension often exhibit poor glycemic control, which is significantly associated with alcohol consumption^{43,44}. Furthermore, alcohol use has been linked to reduced quality of life, particularly among patients with NCDs, due to its combined physical and psychological impacts^{5,26}.

Correlation analysis stratified by sex revealed that, among females, AUDIT scores showed a strong positive correlation with ALT enzyme levels ($r_s = 0.802$) and were also associated with blood pressure. This finding reflects a strong association between alcohol consumption behavior, elevated ALT levels, and indicators of poorer overall health^{5,8,26}. In addition, QoL was found to be significantly and negatively correlated with AUDIT scores. This aligns with previous reviews indicating that heavy alcohol consumption is associated with reduced quality of life across physical, psychological, and social domains^{45,46}. Previous studies consistently demonstrate that heavy alcohol consumption is associated with elevated ALT levels and an increased risk of chronic liver disease^{40,41,47}. Evidence further suggests a link between alcohol intake and elevated blood pressure in both sexes, with women appearing more susceptible to its adverse health effects⁴¹. Among males, AUDIT risk scores showed a strong positive correlation with ALT levels ($r_s = 0.718$) and were significantly associated with both blood pressure and HbA1c. These findings highlight significant associations between alcohol consumption patterns and indicators of poorer health and quality of life among men^{5,26}. Men appeared more likely to engage in higher-risk drinking

patterns, which were associated with poorer health indicators compared with women⁴⁸. This aligns with prior evidence demonstrating that heavy alcohol use is associated with elevated ALT, increased blood pressure, and impaired HbA1c regulation^{40,41}.

A noteworthy finding of this study is that ALT levels in both men and women were significantly associated with AUDIT risk categories, particularly at the levels of harmful use and alcohol dependence. Compared with low-risk drinkers, ALT levels among individuals with alcohol dependence were substantially higher by approximately 46 U/L in females and 37 U/L in males. This highlights the utility of ALT as a biochemical marker of alcohol-related liver damage and its strong linkage to patterns of heavy drinking⁸. In the rural Thai context, alcohol consumption has become a socially accepted practice, which may further reinforce risky drinking behaviors^{5,49}. Research in comparable settings has shown that harmful use is highly prevalent, particularly among ethnic minority groups, where the production and consumption of traditional homemade alcohol is widespread⁴⁹. These findings align with evidence that ALT serves as a reliable indicator of alcohol-related liver disease (ALD) and demonstrates a positive association with harmful use behaviors⁵⁰. In the present study, the increase in ALT levels associated with alcohol dependence differed between males and females. Sex-related biological differences may help explain variation in liver enzyme responses to alcohol consumption. Previous research suggests that women are generally more susceptible to alcohol-related liver injury compared with men, even when consuming smaller amounts of alcohol or drinking for a shorter duration. This increased susceptibility has been attributed to several biological mechanisms, including lower gastric alcohol dehydrogenase activity, reduced body water content, and higher blood alcohol concentrations after consuming the same amount of alcohol as men⁵¹. However, the relatively large regression coefficient observed for alcohol dependence among females may partly reflect the smaller sample size in this category (4.4%), which could contribute to greater variability in the estimates. In addition, several studies have confirmed the direct impact of alcohol consumption on liver function, as reflected by elevated ALT levels, thereby increasing the risk of chronic liver disease⁴¹.

This study further revealed a significant positive association between HbA1c, smoking, and diabetes mellitus (DM). Prior reviews have shown that smoking impairs glycemic control by promoting insulin resistance and triggering inflammatory pathways⁵². Supporting this, a study from Korea reported that smokers exhibited significantly higher HbA1c levels than non-smokers, with the relationship demonstrating a clear dose-dependent effect⁵³. Evidence suggests that smoking increases the risk of complications and further diminishes quality of life among individuals with diabetes⁴². This aligns with prior research demonstrating that risky health behaviors, particularly alcohol consumption and smoking, are closely linked to key health indicators and serve as major accelerators in the progression of NCDs^{40,41}.

Our findings indicate that elevated blood pressure, including both SBP and DBP, was most prevalent among individuals aged 41–60 years and those with diagnosed hypertension. This pattern likely reflects physiological changes and the accumulation of risk factors that emerge during midlife^{54,55}. Consistent with previous evidence, the risk of elevated SBP increases progressively from around age 35 and becomes particularly pronounced after age 40 in both men and women⁵⁶. This study also revealed a significant negative association between QoL and NCDs, including diabetes and hypertension, as well as abnormal ALT and HbA1c levels. These findings suggest that individuals with such conditions or elevated biochemical markers tend to experience poorer QoL^{5,26}. Consistent evidence from Ghana showed that adults with diabetes, hypertension, or obesity had significantly lower QoL scores in the physical health domain⁵⁷. Similarly, a study in Sweden reported that diabetic patients with elevated HbA1c levels exhibited significantly lower QoL scores across multiple dimensions⁵⁸. Given the cross-sectional design of this study, all observed relationships should be interpreted as associations rather than causal or directional effects.

Limitations

This study is subject to several limitations. First, its cross-sectional design precludes the establishment of causal relationships. Additionally, limitations related to the sampling approach—the participant-level sampling as non-probability sampling—may introduce selection bias which limit generalizability and representativeness of the findings. Second, alcohol use was assessed using the AUDIT, which is prone to reporting bias, as the accuracy of responses depends on participants' honesty and recall. This may have led to underreporting of alcohol consumption. Furthermore, although AUDIT is an internationally standardized tool, it may not fully capture the linguistic and cultural nuances of ethnic minority groups. Consequently, the interpretation of findings should be approached with caution. Finally, several potential confounders—such as nutritional status, physical activity, stress, and the use of medications that may affect ALT, HbA1c, and blood pressure—were not fully controlled in this study. Future research should incorporate psychosocial factors, including stress assessment, to better account for these influences. Moreover, qualitative investigations are needed to gain deeper insights into the cultural context, beliefs, and alcohol consumption behaviors of ethnic groups. Longitudinal studies are also warranted to establish causal pathways between harmful alcohol use, liver dysfunction, glycemic control, blood pressure regulation, and the long-term effects on quality of life.

Conclusion

This study demonstrates significant associations between harmful alcohol use and elevated ALT, HbA1c, increased blood pressure, and lower quality of life. Individual characteristics such as sex, age, educational attainment, occupation, risky health behaviors, or statuses (e.g., smoking, neglecting annual health check-ups, and chronic conditions) were associated with harmful use and alcohol dependence. These findings underscore the need for integrated strategies to address alcohol-related problems in ethnic and rural communities. Efforts should incorporate systematic screening and monitoring of biochemical indicators, health status, and sociocultural factors to ensure context-specific interventions. Community empowerment is critical for enhancing knowledge

and fostering behavioral change in relation to alcohol consumption and its associations with liver function, blood pressure, glycemic control, and quality of life. Finally, policy actions and practice guidelines involving local administrative organizations, primary healthcare units, and social and cultural agencies are needed to regulate and monitor alcohol accessibility in high-risk areas.

Data availability

The datasets generated during and/or analyzed during the current study will be available upon reasonable request from the corresponding author. Email: manuchet.ma@up.ac.th.

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Author contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Declarations

Ethical approval and information consent

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the University of Phayao Human Ethics Committee, Thailand (HREC-UP-HSST 1.2/074/67, approved May 2024).

The trial was registered participants gave a written informed consent prior to data collection.

Competing interests

The authors declare no competing interests.

Additional information

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