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Depressive and anxiety symptoms mediate the relationship between family support and alcohol relapse in transplant recipients with alcohol-associated liver disease

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Alcohol-associated liver disease (ALD) is a leading indication for liver transplantation (LT) worldwide, including Korea, where living donor LT from family members are common. Perceived family support may influence resilience in alcohol consumption, with depressive and anxiety symptoms potentially shaping this relationship. This cross-sectional multicenter study examined whether these psychological symptoms mediate the relationship between perceived family support and risk of alcohol relapse. We recruited 154 LT recipients from two tertiary hospitals in Seoul, Korea, using self-report questionnaires and electronic medical records. Mediation analysis was performed using the PROCESS macro with 5,000 bootstrapped samples. Participants reported moderate to high perceived family support, with depressive and anxiety symptoms varying by sex and socioeconomic status. Higher levels of perceived family support were associated with lower risk of alcohol relapse (direct effect β = −0.115, $p < .05$). Depressive and anxiety symptoms were significant mediators in the relationship between family support and alcohol relapse (total effect β = −0.374, $p < .001$). Perceived family support plays a role in mitigating post-transplant alcohol relapse, both directly and indirectly through psychological symptoms. Future interventions should integrate family support and psychological care to prevent and manage alcohol consumption in LT recipients with ALD.

Keywords Liver transplantation, Alcohol-associated Liver Disease, Alcohol drinking, Alcohol relapse, Family support, Psychosocial factors

Alcohol-associated liver disease (ALD) is the leading indication for liver transplantation (LT) worldwide, accounting for 32.1% of all LT cases in the United States and more than 20% in Europe and Korea[1–3]. With an improved 5-year survival rate of 73%, recipients of LT need self-management in refraining from alcohol consumption and adhering to immunosuppressant prescriptions[4]. Abusive alcohol consumption following LT is associated with higher morbidity and mortality, as it may cause graft injury, and reduced adherence with immunosuppressant medication[5,6]. Unfortunately, the incidence of harmful alcohol relapse among recipients of LT with a history of ALD is as high as 30%[7].

In Korea, 79.7% of LT are living donor liver transplants (LDLT), predominantly from family members[3]. This contrasts with the United States and Europe, where LDLT accounts for only 4.5% and 14% of all LT cases, respectively[2,8]. Organ donations involving family members introduce new interpersonal dynamics related to perceived family support and obligations[9]. These may influence motivation and psychological resilience, both of which are important in preventing alcohol relapse[10]. Therefore, perceived family support could be a distinctive factor influencing post-LT alcohol relapse in Korea. To our understanding, no prior research has examined this potential mechanism, particularly among LT recipients in Korea.

Social cognitive and social support theories suggest that psychological symptoms, such as depression and anxiety, mediate the relationship between social support and health-related behaviors[11,12]. Individuals who

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perceive lower levels of social support are more likely to experience depressive and anxiety symptoms, which can trigger addictive behaviors, such as alcohol use, as a coping mechanism. This is evident in the increased alcohol use during the COVID-19 social isolation period[13] and in individuals with alcohol use disorder, with depression severity mediating the beneficial effects of social support from Alcoholics Anonymous in reducing alcohol consumption[14]. These insights from existing literature led to our hypothesis that depressive and anxiety symptoms would mediate the relationship between perceived family support and post-transplant alcohol relapse. However, the interrelationships between these factors remain unexplored in recipients of LT with ALD, despite the high prevalence of depression and anxiety among this population[15].

Identifying pathways that stimulate alcohol consumption in recipients of LT with alcohol-related etiologies can guide future interventions to prevent and manage post-LT alcohol relapse. Therefore, this study aimed to (1) assess the levels of depressive and anxiety symptoms, perceived family support, and risk of alcohol relapse and (2) examine the mediating effects of these psychological symptoms in the relationship between family support and risk of post-transplant alcohol relapse in recipients of LT with ALD in Korea.

Materials and methods

Design

This multicenter study used a cross-sectional, descriptive design. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist was used to report this study[16] (Supplementary data 1).

Sample and data collection

Data collection took place between May and September 2022 in the outpatient units of two major tertiary hospitals in Seoul, Republic of Korea. Patients who met the following criteria were included in this study: (a) aged 18 years or above at the time of receiving LT, (b) underwent LT due to ALD, (c) survival beyond one year post-transplant, and (d) able to read and answer the questionnaire. Those requiring emergency care due to critical conditions (e.g. significantly elevated liver laboratory values or indications of sepsis necessitating ICU admission) were excluded from the study. The sample size was calculated using G*Power (version 3.1.9.7) with a conservative approach, assuming an effect size of 0.15, significance level of 0.05, power of 0.9, and 10 predictors[17]. A minimum of 147 participants were required for multiple linear regression analysis. Considering a 10% dropout rate, 162 patients were recruited.

This study was approved by the Institutional Review Board of Samsung Medical Center and Severance Hospital (No. 2022-01-126 and No. 4-2022-0212). All aspects of the study were conducted in accordance with the Declaration of Helsinki and relevant guidelines and regulations to ensure the protection of human subjects. The research team members informed eligible patients about the study objectives. All participants provided written informed consent to participate and to publish their data. They were assured of their privacy and given sufficient time to answer the questionnaire. Those who completed the questionnaire were offered a mobile coupon worth approximately 5 US dollars. Clinical data were obtained from the participants' electronic medical records within a week of their enrollment. A total of 154 patients were included in the final analysis, after excluding eight participants with straight line or missing responses, which were considered inconsistent and unreliable data.

Measurements

Risk of alcohol relapse, psychological symptoms, and perceived family support were measured using self-report questionnaires. To ensure accuracy and validity of the measurements, the internal consistency of each scale was evaluated using Cronbach's alpha coefficients.

Risk of alcohol relapse

Risk of alcohol relapse was measured using the Advance Warning of Relapse (AWARE) questionnaire[18]. The tool predicts the possibility of a relapse, which is defined as heavy drinking that would result in a blood alcohol level over 200 mg/dL within few hours of drinking. It comprises 28 items derived from the warning signs of alcohol relapse as described by Gorski and Miller[19]. The Korean version, adapted and translated by Chae[20] and consisting of 23 items from the original questionnaire, was employed in this study. Scores range from 23 to 161, with higher scores indicating an impending alcohol relapse. Cronbach's alpha values were 0.93 in the original English version, 0.90 in the Korean version, and 0.95 in this study.

Depressive symptoms

The Center for Epidemiologic Studies Depression Scale Revised (CESD-R)[21] was used to measure the level of depressive symptoms. This 20-item self-report questionnaire includes nine subscales: dysphoria, anhedonia, appetite, sleep, thinking/concentration, worthlessness, fatigue, agitation, and suicidal ideation. Participants were asked to respond on a 5-point Likert scale, with a score of 16 or more indicating risk for clinical depression. Cronbach's alpha was 0.98 in the Korean version[22] and 0.95 in this study.

Anxiety symptoms

The Generalized Anxiety Disorder-7 (GAD-7)[23] was used to measure anxiety levels. This 7-item instrument contains items related to feelings of nervousness, worry, and restlessness. Participants responded on a 4-point Likert scale, with a score of 10 to 14 indicating moderate anxiety and that of 15 or more, severe anxiety. Cronbach's alpha was 0.93 both in the Korean version[24] and in the present study.

Perceived family support

Perceived family support was measured using the Family and Medical Staff Support Scale developed by Kim and Choi[25]. Twelve items measuring this construct were extracted from the original scale. Permission for use was obtained from the original author. Participants responded on a 5-point Likert scale, with scores ranging from 12 to 60, and higher scores indicating higher levels of perceived family support. Cronbach's alpha was 0.94 in the original scale and 0.96, in this study, demonstrating high internal consistency.

Demographic and clinical characteristics

Demographic and clinical data of the participants were collected using self-report questionnaires and electronic medical records. This included age, sex, marital status, family cohabitation status, primary caregiver, occupation, education, income, presence of a family member with alcohol use problem, current smoking status, relationship with the donor, post-transplantation follow-up period, post-LT complications, and diagnosis for receiving LT. Although the participating institutions did not impose the 6-month abstinence rule, they advised LT candidates to refrain from alcohol consumption starting at the first pre-transplantation workup visit. The duration of each participant's pre-transplantation abstinence was obtained from electronic medical records.

Statistical analysis

We used IBM SPSS Version 29 for data analyses (IBM Corp., Armonk, N.Y., USA). Demographic and health-related characteristics were analyzed using frequencies and percentages. Levels of psychological symptoms, perceived family support, and risk of alcohol relapse were described using descriptive statistics. Normality and homoscedasticity of the data were evaluated with QQ plots and residual scatter plots. Independent t-tests and one-way analysis of variance (ANOVA) with Bonferroni post hoc analysis were used to assess differences in the main psychosocial variables based on demographic and clinical characteristics. Pearson's correlation coefficient was employed to examine the linear relationship between the three main psychosocial variables and risk of alcohol relapse. Autocorrelation and multicollinearity were assessed using the Durbin-Watson index and variance inflation factor before conducting the mediation analysis. We performed bootstrapping with 5,000 samples using PROCESS macro to test the mediating effects of psychological symptoms on the relationship between perceived family support and risk of alcohol relapse. Statistical significance for the mediation effect was determined if the 95% confidence interval did not include zero[26].

Results

Sample characteristics

Participants had a mean age of 55.08 years (SD = 9.42) and were predominantly male (67.5%) (Table 1). The majority resided with a family member (88.3%), most commonly with a spouse who served as their primary caregiver (72.1%). More than two-thirds of the participants had a family member with alcohol use problem (64.9%). Among the 153 participants with available data on recipient-donor relationships, 75.8% had received LDLT, with 62.1% receiving allografts from their children. Other living donors included family members such as spouse, parents, and siblings. The mean follow-up period after transplantation was 4.50 years (SD = 3.80), and 36.4% had LT-related complications such as graft rejection, biliary obstruction, or portal vein stenosis. Pre-transplantation abstinence data were available for 148 participants. More than half of them reported less than six months of abstinence prior to receiving LT. The mean scores of depressive symptoms, anxiety symptoms, family support, and risk of alcohol relapse are presented in Table 1.

Variation in psychological symptoms and family support by participant characteristics

Levels of depressive and anxiety symptoms were higher in women and in those without employment or with lower income (Table 2). Participants residing with family members exhibited lower levels of depressive symptoms, While those with a family member experiencing alcohol use issues reported higher anxiety levels. Level of perceived family support showed no statistically significant difference based on demographic or clinical characteristics.

Psychological symptoms, perceived family support, and risk of alcohol relapse

Pearson correlation values for psychological symptoms, perceived family support, and risk of alcohol relapse are shown in Table 3. All variables were correlated, with perceived family support having negative association with depressive symptoms ($r = -.314$, $p < .001$), anxiety symptoms ($r = -.337$, $p < .001$), and risk of alcohol relapse ($r = -.373$, $p < .001$). These psychological symptoms were positively associated with risk of alcohol relapse (depressive $r = .751$, $p < .001$; anxiety $r = .742$, $p < .001$).

Mediation effects of psychological factors on the relationship between perceived family support and risk of alcohol relapse

Increase in perceived family support was associated with reduced levels of depressive and anxiety symptoms (Table 4; Fig. 1). Both psychological symptoms were individually associated with increased risk of alcohol relapse. Perceived family support had significant direct and total effects on risk of alcohol relapse, with a stronger total effect ($\beta = -0.374$, $p < .001$) than direct effect ($\beta = -0.115$, $p < .05$), suggesting presence of indirect effects. The indirect effects of depressive and anxiety symptoms were statistically significant, as indicated by bootstrap confidence intervals that did not include zero, supporting our hypothesis about the mediating role of these variables in the relationship between perceived family support and risk of alcohol relapse (Table 5). Thus, increased perception of family support led to reduced levels of depressive and anxiety symptoms, which, in turn, decreased the risk of alcohol relapse.

Characteristics	Category	Mean ± SD or *n* (%)
Clinical		
Donor (*n* = 153)	Children	72 (47.0)
	Deceased	37 (24.2)
	Sibling	19 (12.4)
	Spouse	17 (11.1)
	Parents	3 (2.0)
	Cousins and in-laws	5 (3.3)
Follow-up since LT (years) (*n* = 153)		4.50 ± 3.80
	1–3	71 (46.4)
	3–5	37 (24.2)
	5–7	17 (11.1)
	≥ 7	28 (18.3)
Abstinence before LT (months) (*n* = 148)	≤ 6 > 6	15.73 ± 33.64 85 (57.4) 63 (42.6)
Complication	Yes[a]	56 (36.4)
	Graft rejection	19 (33.9)
	Biliary	35 (62.5)
	Portal Vein	2 (3.6)
	Others	3 (5.4)
	No	98 (63.6)
Reason for LT	LC-A	119 (77.3)
	HCC-A	29 (18.8)
	ALF-A	6 (3.9)
Depressive symptoms		13.63 ± 14.77
	≥ 16 (risk for clinical depression)	48 (31.2)
Anxiety symptoms		3.67 ± 4.72
	10–14 (moderate)	9 (5.8)
	≥ 15 (severe)	8 (5.2)
Perceived family support		49.68 ± 11.17
Risk of alcohol relapse		57.47 ± 28.11

Table 1. Demographic and clinical characteristics with key variables (*continued*). *LT* liver transplantation, *LC-A* alcohol-associated liver cirrhosis, *HCC-A* alcohol-associated hepatocellular carcinoma, *ALF-A* alcohol-associated acute liver failure; Note. [a]Percentages exceed 100% due to overlapping categories where respondents fit into more than one category.

Discussion

This study examined the psychosocial factors that mediate post-transplant alcohol relapse in patients with ALD, considering the cultural context of Korean organ donation and LT. We found that higher levels of perceived family support were associated with a reduced risk of alcohol relapse, both directly and indirectly through depressive and anxiety symptoms.

The participants reported moderate-to-high levels of perceived family support, with nearly 90% living with family members and fewer than 10% reporting divorce or separation. These findings were unexpected given the commonly expressed family conflicts among individuals with alcohol-related problems[27]. This discrepancy may be attributed to Korea's unique family-centered culture, which stems from Confucian family values and emphasizes family cohabitation and blood relations[28]. However, perceived family support was not associated with the anticipated factors, such as marital status, family cohabitation, relationship with the primary caregiver, and donor-recipient relationships. Family support and its perception may depend not only on the physical presence of a family member but also on their supportive gestures, such as words of affirmation and reassurance[29]. Additionally, perceived family support is likely influenced by broader contextual factors. For example, a recent study found that feeling supported was closely tied to reciprocal relationships, particularly with one's own children, among women with alcohol use disorder[30]. Therefore, the contradictory findings warrant in-depth qualitative research to explore additional circumstantial factors affecting perceived family support in Korean recipients of LT with ALD. This exploration will help enhance post-LT care by addressing and leveraging these nuanced experiences.

A promising finding of our study is that increasing perceived family support may help minimize the risk of post-transplant alcohol relapse. A family-based approach is beneficial for individuals with addiction-related issues due to the influence that one family member can have on others' choices[31]. This is further supported by recent evidence indicating that interventions that include family members are effective in preventing alcohol relapse

Characteristics	Category	Mean ± SD or *n* (%)
Demographics		
Age (years)		55.08 ± 9.42
	< 45	22 (14.3)
	45–54	51 (33.1)
	55–64	51 (33.1)
	≥ 65	30 (19.5)
Sex	Male	104 (67.5)
	Female	50 (32.5)
Marital status	Married	118 (76.6)
	Single	17 (11.1)
	Divorced or separated Widowed	15 (9.7) 4 (2.6)
Living with family	Yes No	136 (88.3) 18 (11.7)
Primary caregiver	Spouse Parent Children Sibling Other	111 (72.1) 22 (14.3) 12 (7.8) 5 (3.2) 4 (2.6)
Occupation	Yes	92 (59.7)
	No	62 (40.3)
Education (*n* = 152)	< High school	23 (15.1)
	High school	77 (50.7)
	≥ College	52 (34.2)
Monthly household income (*n* = 153)	≤ $ 2000	29 (19.0)
	$ 2000 – $ 4000	54 (35.3)
	≥ $ 4000	70 (45.7)
Family member with alcohol issues	Yes No	100 (64.9) 54 (35.1)
Smoking (*n* = 153)	Yes No	49 (32.0) 104 (68.0)

Table 1. Demographic and clinical characteristics with key variables (*N* = 154). *LT* liver transplantation, *LC-A* = alcohol-associated liver cirrhosis, *HCC-A* alcohol-associated hepatocellular carcinoma, *ALF-A* alcohol-associated acute liver failure [a]Percentages exceed 100% due to overlapping categories where respondents fit into more than one category.

and readmissions in patients with alcohol use disorder[32]. Furthermore, this study demonstrated a relationship between perceived family support and both psychological symptoms, suggesting that interventions that enhance family support for post-LT patients may effectively address and mitigate all three issues of depressive symptoms, anxiety symptoms, and alcohol relapse. In our sample, most participants resided with their families and were cared for by family members, providing an ideal setting for implementing family-based interventions. Therefore, we recommend that future interventions aimed at preventing and managing post-LT alcohol relapse incorporate family caregivers in both the design and implementation to enhance their efficacy.

In the current study, depressive and anxiety symptoms mediated the association between perceived family support and risk of alcohol relapse. This finding aligns with that of previous studies demonstrating the triggering effect of psychological distress on harmful alcohol use[33,34]. These results underscore the need for increased focus on the adverse psychological conditions experienced by recipients of LT with alcohol-related etiologies. Notably, in our sample, 31.2% of participants were at risk for clinical depression — a rate higher than that of recipients of other solid organ transplant (lung transplant: 14%, kidney transplant: 10%)[35,36]. Conversely, only about 10% of our participants exhibited moderate-to-severe levels of anxiety, while a prior study indicated that up to 23% of recipients of LT experience anxiety symptoms[37]. While psychological factors have been recently incorporated into preoperative screening assessments and treatment plans for candidates of LT with alcohol-related etiologies, the follow-up care for psychiatric symptoms is often overlooked after transplantation[38]. Our findings indicate that psychological adversities must be continuously monitored and managed even post-LT. Additionally, higher levels of depressive and anxiety symptoms were observed in women and in those who were unemployed or had lower economic status, highlighting potential health disparities. Therefore, new strategies to curb post-transplant alcohol relapse by addressing such psychological symptoms should be devised prioritizing those who are marginalized.

This study has few limitations. Participants were recruited from the outpatient units of two tertiary hospitals in Seoul, potentially limiting the representation of recipients of LT with ALD in other settings. Additionally, patients who regularly attend outpatient clinics may adhere better to medical advice and are more likely to abstain from alcohol consumption. Therefore, our findings may not represent the broader population of LT recipients

Variable	Category	Depressive symptoms			Anxiety symptoms			Perceived family support		
		Mean (SD)	F/t	p	Mean (SD)	F/t	*p*	Mean (SD)	F/t	*p*
Age (years)	< 45	16.50 (17.84)	0.67	0.571	4.95 (5.14)	0.73	0.537	49.64 (11.94)	1.67	0.177
	45–54	14.82 (15.66)			3.73 (4.63)			52.35 (8.36)		
	55–64	12.00 (12.09)			3.24 (4.46)			47.59 (12.33)		
	≥ 65	12.30 (15.18)			3.37 (5.04)			48.70 (12.32)		
Sex	Male	11.68 (13.95)	-2.40	**0.017***	2.98 (4.33)	-2.66	**0.009***	50.49 (11.08)	1.30	0.193
	Female	17.70 (15.72)			5.10 (5.20)			47.98 (11.29)		
Marital status	Married	12.70 (13.82)	1.17	0.323	3.65 (4.73)	0.40	0.756	49.64 (11.44)	0.61	0.612
	Single	13.76 (17.28)			4.59 (5.36)			51.82 (10.98)		
	Divorced or separated	20.13 (17.49)			3.13 (4.29)			46.80 (10.71)		
	Widowed	16.25 (19.86)			2.25 (3.86)			52.25 (2.06)		
Living with family	Yes	12.38 (13.82)	2.41	**0.026***	3.41 (4.44)	1.45	0.164	49.76 (10.87)	-0.27	0.786
	No	23.17 (18.35)			5.61 (6.24)			49.00 (13.63)		
Primary caregiver	Spouse	12.64 (13.83)	1.01	0.402	3.42 (4.54)	1.19	0.320	49.93 (11.34)	1.45	0.220
	Parent	13.68 (16.93)			4.64 (5.46)			51.00 (10.51)		
	Children	17.17 (15.73)			3.92 (4.29)			42.67 (10.45)		
	Sibling	24.40 (15.29)			6.60 (7.09)			53.00 (9.27)		
	Other	17.00 (24.32)			0.75 (1.50)			52.25 (11.03)		
Abstinence before LT (n = 148)	≤ 6 months	15.42 (15.48)	1.25	0.212	4.31 (5.04)	1.64	0.104	48.84 (11.51)	-0.70	0.487
	> 6 months	12.33 (13.89)			3.02 (4.29)			50.14 (11.00)		
Complication	Yes	14.69 (15.58)	0.67	0.502	4.21 (5.14)	1.09	0.280	49.86 (12.76)	-0.27	0.879
	No	13.03 (14.33)			3.36 (4.45)			49.57 (10.23)		

Table 2. Variation in psychological symptoms and perceived family support by participant characteristics (N = 154). *LT* liver transplantation; Note. $^{*}p < .05$; $^{**}p < .001$; [a] Sibling, spouse, parent, cousin, and in-laws.

Variables	Depressive symptoms	Anxiety symptoms	Perceived family support
Anxiety symptoms	0.777**		
Perceived family support	− 0.314**	− 0.337**	
Risk of alcohol relapse	0.751**	0.742**	− 0.373**

Table 3. Correlation between psychological symptoms, perceived family support, and risk of alcohol relapse (N = 154). $^{**}p < .001$.

Variables	Depressive symptoms					Anxiety symptoms					Risk of alcohol relapse				
	B	SE	β	t	*P*	B	SE	β	T	*P*	B	SE	β	T	*p*
Constant	34.218	5.182	-	6.603	0.000**	10.735	1.642	-	6.539	0.000**	52.593	7.230	-	7.271	0.000**
FS	− 0.414	0.102	− 0.314	-4.070	0.000**	− 0.142	0.032	− 0.337	-4.411	0.000**	− 0.288	0.132	− 0.115	-2.188	0.030*
Depressive symptoms	-					-					0.811	0.149	0.426	5.453	0.000**
Anxiety symptoms	-					-					2.216	0.470	0.372	4.719	0.000**
	F (1,152) = 16.568**					F (1,152) = 19.460**					F (3,150) = 88.488**				
	R^2 = 0.098					R^2 = 0.114					R^2 = 0.639				

Table 4. Mediation effects of psychological symptoms on the relationship between family support and risk of alcohol relapse (N = 154). *FS* perceived family support; Note. Bootstrap samples = 5,000; $^{*}p < .05$; $^{**}p < .001$.

with ALD, particularly those not engaged in regular outpatient care but experience severe alcohol relapse. We also relied solely on the participants' self-reports regarding their risk of alcohol relapse after transplantation, which are susceptible to social desirability and recall biases. Future studies are recommended to incorporate additional objective measurements, such as phosphatidylethanol or laboratory results for serum and urine, to improve the reliability of self-reported alcohol use.

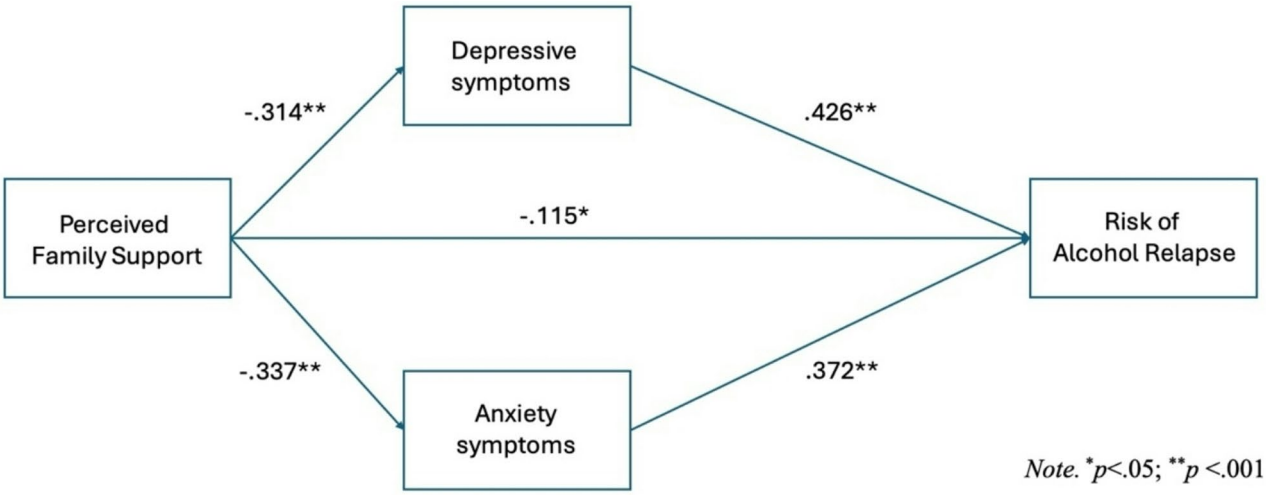

Fig. 1. Mediation effects of psychological symptoms on the relationship between family support and risk of alcohol relapse ($N = 154$).

Variables	Indirect effect	BootSE	95% Confidence interval	
			ULCI	LLCI
Depressive symptoms	− 0.336	0.133	− 0.125	− 0.634
Anxiety symptoms	− 0.315	0.121	− 0.113	− 0.591

Table 5. Mediation effects of psychological symptoms on the relationship between family support and risk of alcohol relapse ($N = 154$). *BootSE* bootstrap standard error, *ULCI* upper limit confidence interval, *LLCI* lower limit confidence interval; Note. Bootstrap samples = 5,000.

Conclusion

This study provides valuable insights into the importance of integrating psychosocial factors in care plans for recipients of LT with ALD to enhance the management of post-transplant alcohol relapse. The findings contribute to the existing literature by providing a comprehensive understanding of the interconnected nature of perceived family support and psychological symptoms, which constitute the psychosocial mechanisms influencing alcohol consumption post-LT. Family support may have significant implications for reducing alcohol relapse in this population and should be integrated into future care plans. Additionally, care plans should address potential psychological distress, such as depressive and anxiety symptoms, and include targeted education on healthy coping strategies to effectively manage them. Overall, these insights underscore the need for a holistic approach in post-transplant care, emphasizing the integration of family support and psychological management to improve outcomes and reduce alcohol relapse among recipients of LT.

Data availability

The data supporting the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy and/or ethical restrictions.

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Author contributions

SHK-Conceptualization, methodology, formal analysis, investigation, data curation, writing – original draft, and visualization.OYK-Validation, formal analysis, data curation, and visualization.HK-Investigation and data curation.KS-Validation and formal analysis.YJ-Conceptualization, methodology, validation, formal analysis, writing – review and editing, and supervision.

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Declarations

Competing interests
The authors declare no competing interests.

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