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Mental Vulnerabilities and Physio-Biochemical Alterations Associated with Alcohol Abuse among Adolescents in Sheema Municipality Southwestern Uganda

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Abstract

Introduction: Alcohol abuse among adolescents is a growing public health concern, leading to mental vulnerabilities and physiological disruptions. This study investigated the relationship between alcohol abuse and mental health, cortisol levels, and physiological parameters among adolescents in Sheema Municipality, Southwestern Uganda. The study aimed to determine mental vulnerabilities, measure cortisol levels, assess physiological parameters, and examine the correlation between mental and biochemical alterations.

Methods: A cross-sectional study design was employed, involving 138 adolescents aged 18–19 years. Participants were selected through simple random sampling. Data on anxiety and depression were collected using the Generalized Anxiety Disorder-7 (GAD-7) and Patient Health Questionnaire-9 (PHQ-9). Blood samples were analyzed for cortisol levels using an immunoassay analyzer. Blood pressure and pulse measurements were taken using an electronic monitor. Data were analyzed using descriptive statistics, chi-square tests, independent t-tests, and correlation analysis in STATA 17.0. Ethical considerations, including informed consent and confidentiality, were strictly upheld.

Results: Findings revealed that 81.88% of participants engaged in alcohol abuse. Adolescents who consumed alcohol had significantly higher anxiety (mean score = 16.98, $p < 0.001$) and depression levels (mean score = 22.34, $p < 0.001$) than non-users. Cortisol levels were significantly elevated among alcohol users (M = 299.39, SD = 73.25) compared to non-users (M = 257.08, SD = 45.52, $p = 0.0032$). Alcohol abuse was associated with significantly higher diastolic blood pressure ($p = 0.017$), though systolic blood pressure showed no significant variation. Correlation analysis indicated a strong positive relationship between anxiety and depression ($r = 0.5664$, $p < 0.001$) and moderate correlations between cortisol levels, systolic blood pressure, and mental vulnerabilities.

Conclusions: The study concludes that alcohol abuse significantly contributes to mental health issues and physiological alterations among adolescents. It recommends community-based awareness programs, school interventions, and mental health support services to reduce alcohol consumption and associated risks. Health policies should incorporate early screening for anxiety, depression, and physiological stress markers in adolescents. The study was approved by the Mbarara University of Science and Technology Research Ethics Committee (BSU-REC-2023-313) and the Uganda National Council for Science and Technology [HS4976ES].

Keywords: Mental Vulnerabilities, Physio-Biochemical Alterations, Alcohol Abuse, and Adolescents

INTRODUCTION

Alcohol abuse among adolescents have significant mental, physiological, and biochemical effects (Swahn et al., 2020). It is important to note that alcohol abuse during this critical developmental stage can have long-lasting impacts on both physical and mental health (Berhane et al., 2020,).

It's crucial to address alcohol abuse among adolescents through education, prevention programs, and early intervention (OMS, 2020). Providing support and resources for mental health issues and substance abuse

is essential for promoting healthy development and well-being during this critical stage of life. If you or someone you know is struggling with alcohol abuse or mental health issues, it's important to seek professional help from healthcare providers.

World Health Organisation's global status report on alcohol, 2022, states that Uganda was second highest alcohol consumer per capita in the world and documented to have one of the highest levels of alcohol consumption in Africa (Ashaba et al., 2022). With 49.5 million Uganda's population, adolescents are part of these statistics (NPHC, 2024). The younger an individual is at the onset of alcohol abuse, the greater the likelihood that alcohol use disorders will develop and continue to adulthood (Nalugya-Sserunjogi et al., 2016).

Adolescence is the phase of life between childhood and adulthood 10-19 years of age. It is a unique stage of human development and important time for laying the foundations of good health. Adolescence experience rapid physical, cognitive and psychosocial growth (Chung et al., 2019). Adolescents meet curiosity and can be most stubborn that they can often do things according to their own will that results into mental vulnerabilities. There are approximately 1.2 billion adolescents 10-19 years of age globally, with 90% in low-income countries (UNICEF, 2023).

Over 1.2 million adolescents die each year.(Berhane et al., 2020; Kabwama et al., 2021). In Uganda, the 2024 Population and Housing Census reported that the ratio of adolescents between 10 and 19 years to the total population is 1: 4.5; meaning this age group constitutes about 22.4% of the national population (Gutaka et al., 2023),(NPHC,2024). Adolescents have problems such as unwanted pregnancies, sexually transmitted infections, defilement, rape, alcohol and substance abuse, and unique to females was issue of sexual advances by older men and adolescents.

Worldwide, 3.3 million death every year result from harmful use of alcohol representing 5.9% of all deaths (World Health Organisation, 2018). The harmful use of alcohol is a causal factor in more than 200 disease and injury conditions. Overall, 5.1% of global burden of disease and injury is attributable to alcohol (Kabwama et al., 2021). Alcohol consumption causes death and disability relatively early in life. There is causal relationship between harmful use of alcohol and a range of mental and behavioral disorders, other non-communicable conditions as well as injuries.

Alcohol is metabolized by the liver the second largest organ in the body and nearly all physiological systems of the body are affected by alcohol to varying degree and the behavioral effects observed with intoxication are associated with compromised neurotransmitters functions in the brain and these adverse effects of alcohol intake may be evident in other systems like cardiovascular (Jain et al., 2020),(Wittgens et al., 2022). Alcohol intake interfere with various physio-biochemical and metabolic processes of the body such as metabolic or physiological alterations resulting in diseases like hypertension, mental disorders and nutritional deficiencies in general population (Wittgens et al., 2022). High prevalence of symptoms of depression, anxiety and aggression, high blood pressure among adolescents will lead to the study.

Throughout the world, 1 in every 4 adults suffer from hypertension, a disease that contributes to 49% of ischemic heart diseases and 62% of stroke worldwide (Riley et al., 2018). Blood pressure is highest when the heart is pumping out blood (systolic pressure) and lowest when it is filing up with blood (diastolic pressure). Normal systolic pressure is less than 120mmHg and diastolic pressure is 80mmHg, blood pressure 120/80mmHg (AHA,2023),(Riley et al., 2018). Alcohol has been reported to be a common risk factor for hypertension, and individuals with depression and anxiety are at a high risk of developing hypertension (Unger et al., 2020). This common medical condition affect 3.1% adolescents in Uganda (Katamba et al., 2020). It has no symptoms but can lead to heart attack or stroke. Alcohol can cause inflammation of the digestive tract, leading to issues like gastritis, ulcers, and other gastrointestinal problems.

Stressful situations and alcohol intake activate the body's alert systems. The resulting fight or flight response generates physiological effects such as blood pressure, overall oxygen consumption and release of stress hormone. Alcohol-induced stress has physio-biochemical consequences that affect wellbeing (Najjuka et al., 2021). Psychological distress at adolescence has detrimental effects and lead to high-risk

behaviours, academic failures, unemployment, poor sexual health, self-harm, and premature mortality (Swahn et al., 2020). An understanding of mental vulnerabilities and physio-biochemical alterations among adolescents is critical to lessen harmful consequences of alcohol abuse.

Significance of the study

This research determined the correlation between mental vulnerabilities and physio-biochemical interactions associated with alcohol abuse among adolescents in Sheema Municipality Southwestern Uganda which adds on the literature for future studies.

Policy makers were informed regarding the challenges of adolescents in Ugandan context to put in place healthy working policies that would lead to fundamental changes among adolescents who abuse alcohol in Uganda.

To provide a better understanding of the mental vulnerabilities and physio-biochemical alterations among adolescents who abuse in Southwestern Uganda, thereby combining their views and perspectives to provide recommendations for formulating health policies on alcohol use.

To scale up health education programs and prevention efforts for adolescents in regard to alcohol abuse, provide an intervention program that will be developed towards effective holistic alcohol control in adolescents, identify special needs for adolescents who abuse alcohol and what appropriate support could be provided to them.

Accurately estimate mental vulnerabilities among adolescents who abuse alcohol in Sheema Municipality and identification of the most affected adolescents will facilitate the development and implementation of targeted mental health interventions. Our findings may also be generalizable to other populations in Uganda.

METHODS

Research design

This study employed a cross-sectional study design and laboratory study involving adolescents age 18-19 years living in Sheema Municipality. It also employed descriptive research design to examine relationship between variables and inferential analysis to compare cortisol levels, blood pressure and pulse between adolescents who abuse alcohol and adolescents who do not abuse alcohol. Mental vulnerabilities were determined using measures of anxiety and depression through quantitative research methods focusing on objective measurements, with statistical analysis. Data was gathered through different methods such as questionnaires. This approach was centred on gathering statistical data to generalize it across groups of people to give details on a particular phenomenon (Boucaud, 2017). Quantitative research is generally good for larger sample groups. Results that are generated objectively are essential because when the results are presented in this fashion they allow future research to be reproduced with similar outcomes in other situations (Tan, 2022).

Blood pressure and pulse were determined using simple blood pressure monitor SANITY AP 1116. Blood cortisol levels was determined using blood sample analyser.

Study Setting

The study was conducted in Sheema Municipality, Sheema District, Southwestern Uganda. Sheema district is bordered by Buhweju in north, Mbarara District to the south, Mitooma District to the southwest and Bushenyi District to the west (Population & Profiles, 2017) on latitude 0.5782° S and longitude 30.3810° E. The Municipality has a population of 109,872 with four divisions and a total of 39,993 adolescents (Uganda Bureau of Statistics 2021 Statistical Abstract, 2021).

Study Population

The study population included adolescents aged 18-19 years old, consisting of both male and female participants. The participants were categorized into two groups: those who abused alcohol and those who did not (control group). The study was conducted in Sheema Municipality, Southwestern Uganda, which has a population of 150,872 and a total of 50,993 adolescents (NPHC, 2024).

Criteria for selection

Inclusion criteria

The adolescents aged 18–19 years, the consenting adolescents, and emancipated who lived or stayed in Sheema Municipality, Southwestern Uganda, and were willing to participate in the proposed study. The participants were both female and male adolescents who abused alcohol and non-alcohol abusers. Participants were also included as per the guidelines of the Uganda National Council for Science and Technology (UNCST).

Exclusion criteria

Adolescents who abused alcohol who refused to participate in the study, those who were critically ill, mentally unstable, and not living/staying in Sheema municipality were excluded from the study.

Sample size

The sample size was determined using the standard statistical formula by Kish and Leslie (1965) at a 95% confidence interval and a 5% error term because proportions were obtained. The Kish and Leslie formula was used because the study was obtaining the proportion. The estimated proportion of adolescents abusing alcohol in Uganda was 10%. As such, the study used an estimated proportion of 10% in the sample size calculation.

The sample size was calculated using the formula below.

$$n=\frac{Z^2p(1-p)}{d^2}$$

n= sample size

Z = Confidence level at 95% corresponding to 1.96

p = Proportion of adolescents 18-19 years (10%) according to a study done in Bushenyi District.

d = Degree of accuracy desired 0.05

$$n = \frac{1.96^2 \times 0.1(1-0.1)}{(0.05)^2}$$

$$n = 138 \text{ respondents}$$

A population of 138 consisting of females and males 18-19 years of age were enrolled into study from Sheema Municipality.

Data Collection Procedure

Upon identifying eligible respondents for the study, various steps were followed. Firstly, a written consent was required from the adolescents to participate in the study. The respondents, upon acceptance by signing the forms, were introduced to the data collection tool. For the adolescents who were willing to voluntarily participate in the study, at the time of data collection, the Principal Investigator explained to them the importance/purpose of the study. Adolescents were given clarification prior to the study about the absence of any incentives or tangible benefits for their participation. Data was collected from adolescents in Sheema Municipality for a period of one month. The research assistants helped in data collection after a one-day training. The training sessions involved briefing on the purpose of the study, the meaning of terms used in the study, and the importance of maintaining ethical standards when collecting data from the respondents. The questionnaire was administered to adolescents using snowball sampling.

Study Tools

Structured questionnaires were administered to collect information on socio-demographic characteristics and mental vulnerabilities.

Generalized Anxiety Disorder-7 (GAD-7)

The GAD-7 is a self-report questionnaire that assesses the presence and severity of generalized anxiety disorder symptoms. It consists of seven items that cover various aspects of anxiety, including excessive worry, restlessness, irritability, and sleep disturbances. Individuals rate the frequency of each symptom

over the past two weeks using a scale ranging from 0 (not at all) to 3 (nearly every day). The total score ranges from 0 to 21, with higher scores indicating more severe anxiety symptoms. It is an easy-to-perform initial screening tool for generalized anxiety disorders.

Assessment for Depression

Depression was assessed by a Patient Health Questionnaire-9 (PHQ-9) which is a multipurpose instrument for screening, diagnosing, monitoring, and measuring the severity of depression (Cournos & McKinnon, 2022). It involved use of nine questions and scoring the answers on a scale of 27. The interpretation was based on the correlation of the total score with the cut-off points as follows; Score 0-5: Mild depression, Score 6-10: Moderate depression, Score 11-15: Moderately severe depression, and score of 16-20 represents severe depression.

Cortisol levels, Pulse and Blood pressure

Primary quantitative data was obtained by a trained research assistant through use of Interviewer-administered questionnaires that were translated into Runyankole. Both English and Runyankole versions of questionnaires were available depending on the participant's language of choice. Blood cortisol levels were determine using a venous blood sample of 3 mL drawn into an ethylenediamine tetraacetic acid blood collection tube from the study participant in the morning 7am-9am and 4pm-6pm by a qualified laboratory personnel.

Cortisol analysis at the laboratory, free cortisol concentrations were analyzed using an immunoassay analyzer validated for quantitative measurement of blood cortisol. Standards, controls, and blood samples were assayed in duplicate using a 96-well plate. Diluted enzyme conjugate (1:1,600) was added to each well and plates were mixed on a rotator at 500 rpm for 5 minutes. A total of 200 nmol of TMB substrate solution was added to each well; plates were mixed on a plate rotator at 500 rpm for five minutes. A total of 50 nmol of stop solution was added before placing in a plate reader at 450 nm optical density with secondary filter correction at 490 nm using Gen5 software for Windows. Average optical density (OD) for each duplicate well was computed using Excel software.

Average OD for nonspecific binding wells was determined to be zero. Percent bound (B/B0) was calculated for each standard, control, and sample by dividing the OD of each well (B) by the average OD for the zero (B0). Intra-assay percent coefficient of variation (% CV) and inter-assay % CV were calculated. Intra-assay % CV was calculated by dividing the means of high and low standards run in duplicate from each plate by the mean standard deviation and multiplying by 100. Inter-assay % CV was calculated by determining the mean standard deviation of each duplicate on each plate and dividing by the mean of the duplicates, then multiplying by 100. The lower limit of sensitivity was determined in lg/dL.

Blood pressure and pulse were measured after 5 minutes of rest using a blood pressure electronic monitor (SANITY AP 1116). Three measurements were taken at an interval of one minute, and the average was considered as blood pressure and pulse. The researcher wrapped the cuff around the participant's arm with the air hose placed on the inside of the participant's arm following the direction of the ring finger.

The questionnaire was translated from English to Runyankole language to cater for adolescents who did not understand English.

Statistical Analysis

Primary data collected was checked for accuracy and completeness, entered into Microsoft Excel, saved, and exported to STATA version 17.0 for analysis. Mental vulnerabilities like anxiety and depression associated with alcohol abuse among adolescents in Sheema Municipality, was analyzed using descriptive statistics to determine prevalence rates and chi-square tests to assess associations. Cortisol levels among adolescents who abused alcohol, involved descriptive analysis to determine the mean, standard deviation, and range, while ANOVA was used to compare cortisol levels between alcohol-abusing adolescents and a control group. Physiological parameters such as blood pressure and pulse, using descriptive statistics and ANOVA to compare values between adolescents who abused alcohol and those who did not. Correlations between mental vulnerabilities and physio-biochemical alterations using Pearson's

correlation coefficient and multiple regression analysis to determine the strength, direction, and influence of these relationships. This comprehensive analysis provided insights into the mental and physiological effects of alcohol abuse among adolescents in the study area.

RESULTS
Participant characteristics
The study included 138 participants, with 71 females (51.45%) and 67 males (48.55%). Most were 19 years old (79.71%), while 20.29% were 18. Kabwohe Division had the highest representation (31.16%). Most had completed lower secondary education (42.03%), followed by primary (30.43%) and upper secondary (18.12%) (Table 1).

Table 1: Demographic characteristics of study participants (n=138)

Variable	Freq.	Percent	Cum.
Gender			
Female	71	51.45	51.45
Male	67	48.55	100.00
Age			
18 years	28	20.29	20.29
19 years	110	79.71	100.00
Division (Residence)			
Central Division	34	24.64	24.64
Kagango Division	33	23.91	48.55
Kashozi Division	28	20.29	68.84
Kabwohe Division	43	31.16	100.00
Education_Level			
P.1- P.3	2	1.45	1.45
P.4- P.5	9	6.52	7.97
P.6- P.7	42	30.43	38.41
S.1- S.2	58	42.03	80.43
S.3- S.4	25	18.12	98.55
S.5- S.6	2	1.45	100.00

Mental vulnerabilities such as anxiety and depression associated with alcohol abuse among adolescents in Sheema Municipality

Alcohol abuse among adolescents
Of the 138 adolescents surveyed, 113 (81.88%) reported engaging in alcohol abuse, while 25 (18.12%) did not. These findings suggest that alcohol abuse is prevalent among the adolescent population in the study area (Table 2: alcohol abuse among adolescents (n=138)).

Table 2: alcohol abuse among adolescents (n=138)

Alcohol	Freq.	Percent
Yes	113	81.88
No	25	18.12
Total	138	100.00

Chi-square tests for the association between alcohol use and mental vulnerabilities.
A chi-square test was conducted to assess the association between alcohol use and anxiety levels among participants. The results indicated a statistically significant association, x^2 (137) = 91.56, p < .001. Table 4 shows that all participants who reported alcohol use had either moderate or severe anxiety. Specifically, 86.7% of alcohol users experienced severe anxiety compared to 16% of non-users, while 12.3% of alcohol users experienced moderate anxiety compared to 16% of non-users. Notably, none of the alcohol users fell into the minimal or mild anxiety categories, as opposed to 68% and 16% of non-users, respectively. These findings suggest that alcohol use is strongly associated with higher anxiety levels, with alcohol users predominantly experiencing severe anxiety symptoms.

Similarly, a chi-square test revealed a statistically significant association between alcohol use and depression levels, x^2(137) = 57.98, p < .001. As shown in Table 4, 80.5% of alcohol users reported severe depression, compared to 32% of non-users. Furthermore, 18.6% of alcohol users experienced moderately severe depression, whereas 32% of non-users fell within this category. None of the alcohol users reported minimal to mild levels of depression, as opposed to 4% and 16% of non-users, respectively. These results indicated a significant relationship between alcohol use and depression, with alcohol users more likely to experience severe depressive symptoms than their non-using counterparts.

Table 3: Chi-square tests for the association between alcohol use and mental vulnerabilities.

Mental vulnerabilities	alcohol		X^2, df	p-value
	Yes (113)	No (25)		
Anxiety			91.5604, 137	**0.000**
Score 0-4: Minimal Anxiety	0(0%)	17(68.0%)		
Score 5-9: Mild Anxiety	0(0%)	4(0%)		
Score 10-14: Moderate Anxiety	14(12.3%)	4(16%)		
Score greater than 15: Severe Anxiety	98(86.7%)	4(16%)		
Depression			57.9817, 137	**0.000**
0 – 4: None-minimal	0(0.0%)	1(4.0%)		
5 – 9: Mild	0(0.0%)	4(16.0%)		
10 – 14: Moderate	1(0.9%)	4(16.0%)		
15 – 19: Moderately Severe	21(18.6%)	8(32.0%)		
20 – 27: Severe	91(80.5%)	8(32.0%)		

Multivariable logistic regression analysis examining the association between mental vulnerabilities and alcohol use among adolescents
The results of a multivariable logistic regression analysis examining the association between mental vulnerabilities and alcohol use among adolescents indicate that gender was significantly associated with alcohol use (AOR = 0.37, 95% CI [0.15, 0.94], *p* = .036), suggesting that one vgender (likely females) had lower odds of alcohol consumption. However, age (AOR = 0.95, 95% CI [0.31, 2.93], *p* = .927) and education (AOR = 1.024, 95% CI [0.62, 1.699], *p* = .927) were not significant predictors of alcohol use. Mental health factors, including anxiety (AOR = 0.7162, 95% CI [0.60, 0.85], *p* < .001) and depression (AOR = 0.7587, 95% CI [0.62, 0.93], *p* < .001), were both significantly associated with lower odds of alcohol use, indicating that adolescents experiencing higher levels of anxiety and depression were less

likely to engage in alcohol consumption (Table 4). These findings highlight the complex relationship between mental health and substance use behaviors in adolescents.

Table 4: A multivariable logistic regression showing the association between mental vulnerabilities and alcohol use among adolescents

Variable	AOR (Adjusted odds ratio)	95% CI (Confidence Interval)	p-value
Gender	0.37	0.15 - 0.94	0.036
Age	0.95	0.31 - 2.93	0.927
Education	1.024	0.62 - 1.699	0.927
Anxiety	0.7162	0.60-0.85	0.000
Depression	0.7587	0.62 - 0.93	0.000

Cortisol levels among Adolescents who abuse alcohol in Sheema Municipality
t-test analysis of cortisol levels between alcohol abusers and non-abusers.
The results revealed that cortisol levels were higher among adolescents who abuse alcohol (M = 299.39, SD = 73.25) compared to those who did not abuse alcohol (M = 257.08, SD = 45.52). An independent samples t-test indicated that this difference was statistically significant, t(136) = 2.7677, p < .05 =0.0032, suggesting that alcohol abuse may be associated with elevated cortisol levels among adolescents.

Table 5: t-test analysis of cortisol levels between alcohol abusers and non-abusers.

Alcohol	Frequency	Mean	Std. Err.	Std. Dev.	95% Confidence Interval	t	p-value
Yes	113	299.3938	6.891206	73.25452	285.7398-313.0478	2.7677	0.0032
No	25	257.08	9.104014	45.52007	238.2902 - 275.8698		
combined	138	291.7283	6.029826	70.83442	279.8047 - 303.6518		
diff	42.31381	15.28857	12.07972	72.54789			

A multivariable logistic regression showing the association between cortisol levels between alcohol abusers and non-abusers

A multivariable logistic regression analysis was conducted to examine the association between alcohol abuse and various predictors, including gender, age, education level, and morning cortisol levels. The results indicated that gender was significantly associated with alcohol abuse, with an adjusted odds ratio (AOR) of 0.34, 95% confidence interval (CI) [0.13, 0.89], p = .028, suggesting that one gender (likely female) had lower odds of alcohol abuse compared to the reference group. Age was not a significant predictor (AOR = 0.92, 95% CI [0.29, 2.97], p = .895), nor was education level (AOR = 1.00, 95% CI [0.58, 1.71], p = .998). However, cortisol levels were significantly associated with alcohol abuse (AOR = 1.01, 95% CI [1.00, 1.02], p = .009), indicating that higher cortisol levels were related to an increased likelihood of alcohol abuse. These findings suggest that biological stress markers, such as cortisol, may play a role in alcohol abuse, while demographic factors such as age and education level do not appear to have a significant influence.

Table 6: A multivariable logistic regression showing the association between cortisol levels between alcohol abusers and non-abusers

Variable	AOR (Adjusted Odds Ratio)	95%, CI [Confidence Interval]	p-value
Gender	0.34	0.13 - 0.89	**0.028**
Age	0.92	0.29 - 2.97	0.895
Education level	1.00	0.58 - 1.71	0.998
Cortisol level	1.01	1.00 - 1.02	**0.009**

Physiological parameters such as blood pressure and pulse in adolescents who abuse alcohol adolescents in Sheema Municipality

ANOVA to assess differences in Physiological parameters such as blood pressure and pulse in adolescents who abuse alcohol adolescents

A one-way analysis of variance (ANOVA) was conducted to assess the differences in physiological parameters (systolic blood pressure and diastolic blood pressure) among adolescents who abuse alcohol in Sheema Municipality. The results presented in Table 12 show that the overall model was statistically significant, $F_{(83, 54)} = 1.61$, p-value = 0.032, indicating that there were significant differences in physiological parameters among the groups analyzed. The model explained approximately 71.19% of the variance in physiological parameters ($R^2 = 0.7119$), although the adjusted R-squared value (Adj. R^2 = .2690) suggests that the model may have limited predictive power after accounting for the number of predictors.

The analysis for systolic blood pressure was not statistically significant, $F_{(47, 54)} = 1.37$, p = .134, indicating that there were no significant differences in systolic blood pressure among the groups of adolescents. The analysis for diastolic blood pressure was statistically significant, $F_{(36, 54)} = 1.89$, p-value = .017, indicating that there were significant differences in diastolic blood pressure among the groups of adolescents who abuse alcohol. The results suggest that alcohol abuse may have a more pronounced effect on diastolic blood pressure compared to systolic blood pressure among adolescents in the participants of the study.

Table 7: ANOVA to assess differences in Physiological parameters such as blood pressure and pulse in adolescents who abuse alcohol

Source	Partial SS	df	MS	F	R-squared	Adj R-squared	Prob > F
Model	25676.7801	83	309.358797	1.61	0.7119	0.2690	0.0317
systolic_bp	12359.2673	47	262.963135	1.37			0.1336
Diastolic_bp	13069.5503	36	363.043063	1.89			**0.0169**
Residual	10391.8648	54	192.441941				
Total	**36068.6449**	**137**	**263.27478**				

A multivariable logistic regression showing the association between Physiological parameters such as blood pressure and pulse rate and adolescents who abuse alcohol.

A multivariable logistic regression analysis was conducted to examine the association between physiological parameters (systolic blood pressure, diastolic blood pressure, and pulse rate) and alcohol abuse among adolescents while controlling for gender, age, and education level. The results indicated that systolic blood pressure was significantly associated with alcohol abuse (AOR = 1.16, 95% CI [1.09, 1.23], $p < .001$), suggesting that higher systolic blood pressure was linked to an increased likelihood of alcohol abuse. However, diastolic blood pressure (AOR = 0.97, 95% CI [0.90, 1.05], $p = .460$) and pulse rate (AOR = 1.01, 95% CI [0.98, 1.05], $p = .474$) were not significantly associated with alcohol abuse. Additionally, demographic factors such as gender (AOR = 0.37, 95% CI [0.11, 1.30], $p = .122$), age (AOR = 0.94, 95% CI [0.20, 4.34], $p = 0.932$), and education level (AOR = 1.11, 95% CI [0.55, 2.25], $p = 0.768$) did not show significant associations with alcohol abuse. These findings suggest that elevated systolic blood pressure may be a physiological indicator of alcohol abuse among adolescents, whereas other cardiovascular parameters and demographic factors do not appear to have a significant influence (Table 8).

Table 8: A multivariable logistic regression showing the association between physiological parameters and alcohol abuse among adolescents

Variable	AOR [Adjusted Odds Ratio]	95%, CI [Confidence Interval]	p-value
Gender	0.37	0.11 - 1.30	0.122
Age	0.94	0.20 - 4.34	0.932
Education level	1.11	0.55 - 2.25	0.768
Systolic_bp	1.16	1.09 - 1.23	**0.000**
Diastolic_bp	0.97	0.90 - 1.05	0.460
Pulse rate	1.01	0.98 - 1.05	0.474

Correlation between mental vulnerabilities and physio-biochemical alterations among adolescents who abuse alcohol in Sheema Municipality

Results showed a strong positive correlation was found between anxiety and depression ($r = 0.5664$, $p < 0.001$), indicating that higher levels of anxiety are associated with higher levels of depression. Anxiety was weakly positively correlated with cortisol levels ($r = 0.2408$, $p < 0.01$), suggesting a slight increase in cortisol levels with elevated anxiety, while depression showed a weak positive correlation with cortisol levels ($r = 0.1710$, $p < 0.05$). Anxiety exhibited a moderate positive correlation with systolic blood pressure ($r = 0.5373$, $p < 0.001$) but no significant correlation with diastolic blood pressure ($r = 0.1595$, $p > 0.05$). Similarly, depression was weakly positively correlated with systolic blood pressure ($r = 0.3540$, $p < 0.001$) but not significantly correlated with diastolic blood pressure ($r = 0.1650$, $p > 0.05$). Lastly, cortisol levels showed a moderate correlation with systolic blood pressure ($r = 0.4932$, $p < 0.001$) and a weak correlation with diastolic blood pressure ($r = 0.2786$, $p < 0.001$). These findings suggest that mental vulnerabilities, particularly anxiety, were significantly associated with both cortisol levels and systolic blood pressure. Depression also demonstrated a weaker but significant association with these parameters.

Table 9: Correlation analysis between mental vulnerabilities and physio-biochemical parameters (n = 138)

Variables	Anxiety	Depression	Cortisol Level	Systolic BP	Diastolic BP
Anxiety	1.0000				
Depression	0.5664*	1.0000			
	0.0000				
Cortisol Level	0.2408*	0.1710**	1.0000		
	0.0044	0.0449			
Systolic BP	0.5373*	0.3540*	0.4932*	1.0000	
	0.0000	0.0000	0.0000		
Diastolic BP	0.1595	0.1650	0.2786*	0.4883*	1.0000
	0.0617	0.0531	0.0009	.0000	

*Correlation is significant at p < 0.01.

**Correlation is significant at p < 0.05.

A multivariable logistic regression showing the association between mental vulnerabilities and physio-biochemical alterations among adolescents who abuse alcohol in Sheema Municipality

A multivariable logistic regression analysis was conducted to examine the association between mental vulnerabilities and physio-biochemical alterations among adolescents who abuse alcohol. The results indicated that systolic blood pressure (AOR = 1.137, 95% CI [1.026, 1.259], p = .014), anxiety (AOR = 1.511, 95% CI [1.101, 2.073], p = .011), and depression (AOR = 1.580, 95% CI [1.063, 2.347], p = .023) were significantly associated with alcohol abuse, suggesting that higher systolic blood pressure and greater levels of anxiety and depression increase the likelihood of alcohol abuse. Gender approached significance (AOR = 0.038, 95% CI [0.001, 1.149], p = .060), indicating a potential but inconclusive association. Other variables, including age (AOR = 2.044, 95% CI [0.101, 41.491], p = .642), education level (AOR = 1.324, 95% CI [0.257, 6.836], p = .737), pulse rate (AOR = 0.999, 95% CI [0.951, 1.047], p = .927), cortisol level (AOR = 0.989, 95% CI [0.969, 1.009], p = .290), and diastolic blood pressure (AOR = 1.115, 95% CI [0.968, 1.285], p = .131), were not significantly associated with alcohol abuse (Table 15). These findings highlight the importance of mental health factors and systolic blood pressure in understanding alcohol abuse among adolescents.

Table 10: A multivariable logistic regression showing the association between mental vulnerabilities and physio-biochemical alterations among adolescents who abuse alcohol

Variable	AOR (Adjusted Odds Ratio)	p-value	[95% Conf.Interval]
Gender	0.038	0.060	0.001 - 1.149
Age	2.044	0.642	0.101 - 41.491
Education_Level	1.324	0.737	0.257 - 6.836
Pulse_Rate	0.999	0.927	0.951 - 1.047
Cortisol_Level_Am	0.989	0.290	0.969 - 1.009
Systolic_Bp	1.137	0.014	1.026 - 1.259
Diastolic_Bp	1.115	0.131	0.968 - 1.285
Anxiety	1.511	0.011	1.101 - 2.073
Depression	1.580	0.023	1.063 - 2.347

DISCUSSION OF RESULTS

While the present study found that adolescents with higher levels of anxiety and depression were less likely to consume alcohol (AOR = 0.7162 and AOR = 0.7587, respectively, p < .001), studies such as

those by Hussong et al. (2017) and Marmorstein (2020) have suggested the opposite that mental health disorders, particularly anxiety and depression, are positively associated with increased alcohol use among adolescents. These studies argue that adolescents often use alcohol as a coping mechanism to self-medicate distressing emotions, which would suggest a higher, rather than lower, likelihood of alcohol consumption among those experiencing mental health challenges.

The findings of elevated cortisol levels among alcohol-abusing adolescents align with the results of Lovallo et al. (2012), who reported that chronic alcohol consumption dysregulates the hypothalamic-pituitary-adrenal (HPA) axis, leading to heightened cortisol production. This physiological stress response may explain the significantly higher mean cortisol levels (M = 299.39, SD = 73.25) observed in adolescents who abuse alcohol compared to their non-abusing peers (M = 257.08, SD = 45.52). These findings emphasize the role of alcohol in exacerbating stress-related biomarkers, suggesting that adolescents engaging in alcohol abuse are at increased risk for stress-related health issues.

The findings reveal significant differences in physiological parameters among adolescents who abuse alcohol, with diastolic blood pressure significantly affected compared to systolic blood pressure. This aligns with findings by Stewart et al. (2009), who reported a strong association between alcohol consumption and increased diastolic blood pressure in adolescents. Their study revealed alcohol-induced vascular changes that predominantly influence diastolic measures due to heightened peripheral resistance. These findings support the notion that diastolic blood pressure may be a more sensitive marker of cardiovascular stress in adolescent alcohol users. Conversely, systolic blood pressure did not exhibit significant differences across groups. Similar results were reported by Nguyen et al. (2012), who observed that systolic blood pressure in adolescents might remain stable unless alcohol consumption reaches extreme levels. This emphasizes the need to differentiate between acute and chronic alcohol effects, as systolic pressure may only rise with prolonged abuse.

The study revealed a strong positive correlation between anxiety and depression (r = 0.5664, p < .001), indicating a close relationship between these mental vulnerabilities among adolescents who abuse alcohol. This finding aligns with the work of Wang et al. (2018), who reported that alcohol use exacerbates co-occurring anxiety and depression by disrupting neurotransmitter systems, such as serotonin and dopamine. The study underscores how mental vulnerabilities often co-occur and may amplify each other under the influence of alcohol.

Limitations and Solutions

The possibility that respondents do not answer questions truthfully. The participants were encouraged to be as honest as they could when responding to the questions.

Limited generalizability. The results might not be applied to all population world-over.

Lack of reliable data and prior research studies on the topic. Extensive search of data to get the information was done. (Theofanidis & Fountouki, 2019)

Time constraint. Time was another factor that limited the study by distorting results through extent of the conclusions drawn, depending on the time of collecting the sample. The samples were collected at the recommended time of the day.

Conclusions

Based on the results, the high prevalence of alcohol abuse among adolescents is a potential risk factor for mental health vulnerabilities, including anxiety and depression, which significantly impact their overall well-being and development.

Based on the findings, it is concluded that adolescents who abuse alcohol show significantly higher cortisol levels compared to non-abusers. The t-test results confirm this association, indicating a possible link between alcohol use and stress hormone elevation among adolescents.

It is concluded that alcohol abuse among adolescents in Sheema Municipality leads to significant differences in diastolic blood pressure, but not in systolic blood pressure. Diastolic blood pressure was

significantly affected by alcohol use, with a statistically significant result. However, systolic blood pressure showed no significant variation across the groups analyzed.

Based on the findings, it is concluded that there is a statistically significant relationship between mental vulnerabilities and physio-biochemical alterations among adolescents who abuse alcohol in Sheema Municipality. Anxiety and depression were strongly correlated, indicating that these mental health issues often coexist. Anxiety was moderately associated with systolic blood pressure and weakly correlated with cortisol levels, while depression showed weaker but significant associations with these parameters. Cortisol levels demonstrated a moderate relationship with systolic blood pressure and a weak one with diastolic blood pressure, suggesting the physiological impact of chronic stress linked to alcohol abuse.

What is known about this subject already?

Adolescents who abuse alcohol are at a higher risk of developing mental health disorders such as depression, anxiety, and substance use disorders later in life.

Alcohol intake interferes with various physio-biochemical and metabolic processes of the body

What this research adds

Alcohol abuse during adolescence is linked to heightened risks of anxiety and depression.

The findings of elevated cortisol levels among alcohol-abusing adolescents.

The study found significant differences in physiological parameters among adolescents who abuse alcohol, with diastolic blood pressure significantly affected compared to systolic blood pressure.

Cortisol levels showed a moderate correlation with systolic blood pressure and a weak correlation with diastolic blood pressure

List of Abbreviations

DALY	Disability Adjusted life years.
GAD	Generalised Anxiety Disorder.
mmHg	Millimeters of mercury.
PH4	Patient Health questionnaire.
WHO	World Health Organization.
IAQ	Interviewer-administered questionnaire.
HPA	Hypothalamic-Pituitary-Adrenal axis
e.g	For example
OD	Optical Density
CV	Coefficient of Variation
g/dL	Grams per deciliter
SDGs	Sustainable Development Goals

Declarations

Ethics approval and consent to participate

To uphold the ethical considerations during the study, permission was obtained to conduct the study from Bishop Stuart University Research Ethical Committee (BSU-REC-2023-313) and Uganda National Council for Science and Technology (HS4976ES). An introductory letter from the Directorate of Graduate Studies Research and Innovations of Bishop Stuart University was given to enable the study to be conducted. Permission was also sought from the administration and leadership of Sheema Municipality to conduct the study in their area. The local council and village health team were involved to introduce the researcher to the participants.

The study participants' written informed consent was obtained by providing participants aged 18-19 years with consent forms. The permission form provided detailed information regarding the study's purpose, voluntary participation, advantages, the ability to withdraw from the study at any time without consequence, dangers, and discomforts. Measures to ensure confidentiality and privacy regarding

participants' identity protection and protection of information given were offered on the consent form allowing participants to make informed decisions (Amanyire et al., 2023).

Consent for publication
Not applicable

Availability of data and materials
Every piece of information required for this manuscript has been included. The corresponding author can be contacted if any clarifications are required.

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The authors have no competing interests

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