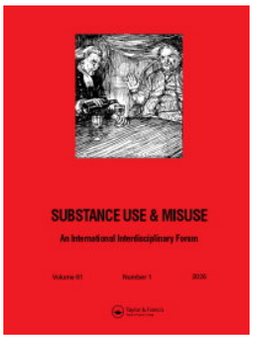

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ORIGINAL ARTICLE

Exploring the Influence of Maternal Behavioural Activation and Inhibition on Predicting Fetal Alcohol Exposure

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ABSTRACT

Background: Prenatal alcohol exposure (PAE) can cause adverse physical and neurocognitive fetal development. Numerous underlying mechanisms of PAE-risk have been hypothesized; however, these have predominantly focused on health-, interpersonal-, and social-related factors. Evidence suggests that stable personality traits, such as behavioral activation (BA) and behavioral inhibition (BI) may contribute toward risk of alcohol misuse. We posit that BA and BI may therefore increase risk of PAE. The potential of BA and BI to underpin both pre- and during-pregnancy alcohol use was thus explored in a sample of UK-based pregnant and recently-pregnant mothers. *Methods:* Participants ($n=1371$) completed an anonymous online questionnaire, containing the Behavioral Inhibition System/Behavioral Activation System scale; ("BIS/BAS") and the Alcohol Use Disorders Identification Test – Consumption ("AUDIT-C"); completed twice to reflect both pre- and during-pregnancy alcohol use. *Results:* In the initial regression model, the BIS/BAS subfactor "Fun Seeking" remained significant in predicting pre-pregnancy alcohol use ($\beta = 0.119$, $p<0.001$) after correcting for other PAE-risk factors (maternal age, pregnancy intention, educational attainment, and mental wellbeing status). In the second regression model, "Fun Seeking" also emerged as a significant predictor ($\beta = 0.120$, $p<0.001$) of alcohol use during pregnancy, even after correcting for pre-pregnancy alcohol use and participant demographics ($\beta = 0.088$, $p=0.005$). *Conclusions:* Fun seeking played a small yet significant role in PAE-risk. It therefore appears that targeting malleable personality traits during PAE-prevention interventions, alongside aggravating health, personal, and interpersonal factors, may minimize the risk of alcohol-exposed pregnancies.

KEYWORDS
Behavioral activation; behavioral inhibition; prenatal alcohol use; prenatal alcohol exposure

via the mechanism of prenatal alcohol exposure (PAE), prenatal alcohol use can be associated with deleterious effects on fetal development, including neural tube defects, low birth weight, and increased risk of miscarriage. Moreover, PAE is the cause of Fetal Alcohol Spectrum Disorder (FASD); a neurodevelopmental condition associated with a constellation of symptoms including challenges with language, memory, learning, behavior; as well as physical impairments. The condition is considered the most common cause of neurodiversity in the Western world, globally affecting an estimated 7.7 per 1000 population (Lange et al., 2017). However, FASD is likely to be more prevalent in regions where rates of alcohol-exposed pregnancies are markedly higher than the global average of 9.8%; including in Ireland (60.4%), Denmark (45.8%), and the UK (41.3%) (Popova et al., 2017). Indeed, estimates using UK-based data determined 6% of children born between 1991 and 1992 met the criteria for FASD; rising to 17% on correcting for missing data (McQuire et al., 2019).

The costs attributed toward the care and support of individuals with FASD has been estimated at $1.8 million Canadian dollars per person per annum; with UK population-based estimates totaling over £2 billion per annum (Moore & Riley, 2015). To reduce the risk of alcohol-exposed pregnancies and the resultant personal, social, health and economic burden of FASD, identifying mechanisms that can significantly influence alcohol during pregnancy is necessary. This holds especially true in the development of alcohol use prevention interventions, created to target and ameliorate the most potent factors that can increase PAE risk, in turn maximizing the interventions' effectiveness. Indeed, a web of PAE risk factors have been previously described (see McQuire et al., 2020 for review), including maternal age, educational attainment, unplanned pregnancies, pre-pregnancy substance misuse, limited access to health care, and social deprivation. Addressing such factors, most notably improving access to contraception; increasing perceived social support; reducing risky health behaviors; and managing cravings have been incorporated in past PAE and FASD prevention interventions, such as the Canadian interventions *Breaking the Cycle* (Motz et al., 2006) and the *Changing High-Risk Alcohol Use and Increasing Contraception Effectiveness* study ("CHOICES"; Floyd et al., 2007).

There is also growing evidence suggesting that psychological factors also contribute toward PAE risk. Indeed, increased

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stress, depressive, and anxiety symptoms, potentially inflated during the perinatal period (Fairbrother et al., 2015), can contribute toward alcohol and substance misuse during pregnancy (Leis et al., 2012; Pentecost et al., 2021). For example, recent data from the National Survey on Drug Use and Health indicated that a major depressive episode during pregnancy significantly increased the likelihood of PAE, even after correcting for age, race, marital status, and employment status (Chapman et al., 2024). While less investigated, past trauma has also been posited as contributing toward PAE. For example, a dose-response relationship was identified between the number of adverse childhood experiences and higher odds of PAE, with mothers with a history of over four adverse childhood experiences 4.87 times more likely to have an alcohol-exposed pregnancy when compared to mothers without histories of adverse childhood experiences (Frankenberger et al., 2015).

Aside from stress, affective symptoms, and traumatic histories, other psychological mechanisms underpinning PAE have seldom been explored; notably, stable personality traits such as behavioral inhibition and behavioral activation. The biopsychological theory of personality, put forward by Grey (1970), posits that behavioral inhibition ("BI") and behavioral activation ("BA") operate as two independent neurological systems that control a person's interactions with their environment. They postulate that BI is activated upon punishment and frustration, resulting in anxious and avoidant behavior, whereas the BA system is activated through goal-seeking and desire for reward, as well as relief from punishment and negative consequences (Grey, 1970; Knyazev, 2004). Maladaptive BA can manifest as poor inhibitory control, which may result in disinhibition when opportunities to seek reward appear (Knyazev & Slobodskaya, 2006). Indeed, heightened BA has been noted in those with substance use disorders (Zuckerman, 1993) and has been theorized to exist as a personality trait nested with sensation-seeking and impulsivity (Cadoret et al., 1985; Pickering and Gray, 1999); known to be exhibited in those with addiction, alcoholism, and substance misuse (Dom et al., 2006; Tomko et al., 2016). Moreover, both clinical and subclinical substance use populations have demonstrated significant positive relations between BA and alcohol use intensity (Ganesh et al., 2018; Wardell et al., 2012, respectively).

Less established is the relation between BI and alcohol and substance misuse. On the one hand, given that BI is associated with increased anxiety and avoidance (Caseras et al., 2003), it could be argued that inhibitory behavior can contribute toward self-medicating with substances to temporally alleviate negative mood symptoms (Simons et al., 2010). On the other, it is also associated with risk-aversion and negative expectancies (Bach, 2015), which may result in avoidance of adverse health behaviors such as substance use (Simons et al., 2010). Both BA and BI may collectively map onto motivational and reinforcement pathways toward alcohol (Corr, 2002), or, in other words, both systems work synergistically with one another to increase alcohol and substance use risk. Past investigations have supported this notion, whereby elevated BI was associated with heavy alcohol consumption only when heightened BA was concurrently reported (Keough & O'Connor, 2014). However, current neurological findings remain unclear regarding the link between BI and substance misuse (Hildebrandt et al., 2021), and recent empirical studies have indicated no significant relationship between self-reported ratings on BI and alcohol use intensity over a two-week period (Dali et al., 2023). Thus, evidence regarding the link between BI and increased alcohol and substance use remains inconsistent.

While the healthcare-, social-, and personal-related factors highlighted by McQuire et al. (2020) likely contribute to PAE risk, individual differences in personality may also play a significant role in predicting PAE likelihood. To date, the role of BA and BI in contributing toward PAE is unknown. The current study therefore aimed to explore this in a large sample of currently or recently pregnant women, recruited from the UK, who took part in an anonymous online questionnaire. There are two main hypotheses;

i. After correcting for maternal age, educational attainment, pregnancy planning, and mental wellbeing, higher BA will positively predict pre-pregnancy alcohol use, while higher BI will negatively predict pre-pregnancy alcohol use;
ii. After correcting for maternal age, educational attainment, pregnancy planning, and mental wellbeing, higher BA will positively predict during-pregnancy alcohol use, while higher BI will negatively predict during-pregnancy alcohol use.

Methods

Participants and procedure

The current study sought to recruit currently pregnant individuals, or individuals who had been pregnant after 2016, to participate in an anonymous online questionnaire. Data were collected between July 2020 to December 2020 as part of a larger project investigating the efficacy of an online-delivered intervention to improve participant awareness of PAE-related fetal risks (see Keating et al., 2025 for a detailed description of the study's recruitment procedure). All data used in the current study came from the pre-intervention wave of data collection. In short, a total of 1663 participants accessed the questionnaire, of whom 1536 (92%) consented to participate. Exclusion criteria included those under the age of 18; those who had not been pregnant since April 1st 2016; and those with limited English skills. The date of April 1st, 2016 was chosen as a cutoff point due to changes in policy and healthcare guidance on PAE in the UK (Department of Health, 2016). There was no restriction placed on whether it was the participants' first pregnancy.

Recruitment took place online *via* social media platforms including Facebook, Twitter, and LinkedIn. The study was advertised *via* an online poster and promoted on various sites on these platforms, for example Facebook "Mums" and "Mums-to-be" groups. Appropriate organizations (e.g., Mumsnet, National Childbirth Trust, Maternal Mental Health Alliance and FASD Network UK) were also invited to

advertise the study. The questionnaire took approximately 20 min to complete with an option to enter in a gift card prize draw upon completion. Ethics approval was received from the University of Edinburgh Health in Social Science Department's Ethics Committee (CLIN754).

Measures

Alongside the following measures, participants were asked to provide demographic information, including their age, ethnicity, marital status, highest educational attainment, and pregnancy planning.

The alcohol use disorders identification test – consumption ("AUDIT-C"; Bush et al., 1998)

The AUDIT-C (Bush et al., 1998) is a three-item measure that assesses alcohol use regularity, quantity, and frequency of binge drinking episodes (Saunders et al., 1993). The measure has been previously validated for use in pregnant populations (Dawson et al., 2005) and has been found to have both excellent psychometric properties and good sensitivity/specificity to detect problem drinking during pregnancy (95% and 85% respectively; Burns et al., 2010). The AUDIT-C was administered twice, whereby participants were first asked to respond to the measure thinking back to their alcohol use prior to pregnancy (e.g., *"Before you found out you were pregnant, how often did you have a drink containing alcohol?"*) and then respond to the measure regarding their alcohol use during pregnancy (e.g., *"During your pregnancy, how often did you have a drink containing alcohol?"*). All items were rated on a 5-point Likert scale (e.g., 1 = "Never", 5 = "4+ times a week"), with scores ranging from 3 to 15 for both pre-pregnancy and during pregnancy AUDIT-C scores. Higher scores indicating higher frequency and volume of alcohol intake.

Behavioral Inhibition system/behavioural activation system scale ("BIS/BAS"; Carver & White, 1994)

The BIS/BAS is a 20-item measure that assesses behavioral inhibition and activation, rated on a 4-point Likert scale (1 = "Very True for Me", 4 = "Very False for Me"). The measure consists of three behavioral activation subfactors; "Fun Seeking", four items reflecting a desire for new experiences (e.g., *"I crave excitement and new sensations"*), "Reward Responsiveness", five items reflecting the anticipation of rewards (*"It would excite me if I won a contest"*), and "Drive", four items reflecting goal-orientated behavior (e.g., *"I go out of my way to get things I want"*). The measure also consists of a seven-item inhibition subfactor, "Behavioral Inhibition", assessing the anticipation of punishment (e.g., *"I worry about making mistakes"*). The measure has demonstrated good psychometric properties (Jorm et al., 1998) and correlates strongly with other measures of stable personality traits, such the "Big Five" personality dimensions (Smits & Boeck, 2006).

Participant mental health

In order to reduce participant burden, participants were asked to rate their general mental wellbeing *via* the single item, *"In the last five years, how has your general mental health been?"*), which was rated on a 5-point Likert scale (1 = "Poor", 5 = "Excellent").

Data cleaning and statistical analysis

Data were first screened for incomplete responses. From the original 1536 participants who consented to participate, 24 participants were found to either exit out of the questionnaire immediately after consenting or indicated that they did not meet the study's inclusion criteria and were thus excluded (e.g., they were pregnant prior to April 2016). A further 44 participants met the inclusion criteria but did not complete any of the demographics nor the psychometric measures, and 96 were found to have completed the demographics but none of the psychometric measures. Such participants were also removed from the dataset, giving a final sample size of 1371.

After cleaning the data, data was first evaluated for distribution normality. All psychometric scores (i.e., pre- and during-pregnancy AUDIT-C; and all subscales of the BIS/BAS) were determined to be non-normally distributed by significant Shapiro-Wilk values, ranging from 0.534 (during-pregnancy AUDIT-C scores) to 0.978 (BAS: Fun Seeking subfactor); likely due to the test statistic's sensitivity toward large sample sizes (Uttley, 2019). Descriptive analysis of both the participant demographics and psychometric measures was then conducted. To confirm associations between the participant demographic variables and the pre- and during-pregnancy AUDIT-C scores, a series of non-parametric tests were conducted. Specifically, a Mann-Whitney U test evaluated between-group differences on both AUDIT-C scores between those with planned and unplanned pregnancies; Jonckheere-Terpstra tests determined the main effects of mental health status and educational attainment on both AUDIT-C scores; and Spearman's rho correlations were conducted to identify any significant associations between participant age and AUDIT-C scores. Further Spearman's rho correlations were conducted to identify any significant correlations between pre- and during-AUDIT-C scores and the "Fun Seeking", "Drive", "Reward Responsiveness", and "Behavioral Inhibition" subfactors of the BIS/BAS. Effect sizes were calculated using the formula $r = z/\sqrt{(n)}$.

Two hierarchical multiple regression models were then conducted to establish the variance explained by participant demographics and BIS/BAS subscale scores on both pre-pregnancy AUDIT-C scores (regression model 1) and during-pregnancy AUDIT-C scores (regression model 2). To correct for the variance explained by participant demographics, maternal age, mental health status, level of education attainment, pregnancy planning were first entered into the model. Categorical variables were entered as dummy-coded binary indicator variables (i.e., 0 = reference category,

1 = comparison category). There were four levels of educational attainment; five levels of mental wellbeing status, and two levels of pregnancy planning (see Table 1 for overview of categories). For interpretability, reference categories reflected the highest category within each variable and were coded as 0 across all indicators. This was "excellent" scores on mental health status, "postgraduate" for educational attainment, and "planned" pregnancies). All reference categories were omitted from the regression models. Age was inserted as a continuous variable. Scores across all subfactors on the BIS/BAS scales were then inserted. Lastly, for the second regression model, pre-pregnancy AUDIT scores were entered as a final step to establish if the BIS/BAS subfactor(s) remained significant predictors after accounting for pre-pregnancy alcohol use. To assess autocorrelation in the regression model's residuals and multicollinearity, a Durbin Watson statistic between 1.50 and 2.50 and variance inflation factors under 10 for each variable were considered acceptable (Uttley 2019; Ahsan et al., 2009). All analyses were conducted on SPSS version 27 (IBM Corp., 2020). Missing data was addressed *via* listwise deletion.

Table 1. Overview of participant demographics.

Characteristic	N	%
Age		
19 to 25	73	5.4
26 to 35	848	61.9
36 to 50	443	32.5
Ethnicity		
White (UK)	1233	89.9
White (Other)	112	8.2
Other	26	1.9
Marital Status		
Single	63	4.6
Married	918	67
Co-habiting	307	22.4
Other	33	2.4
Employment Status		
Employed full-time	422	30.8
Employed part-time	380	27.7
Maternity leave	297	21.7
Student	36	2.6
Self-employed	81	5.9
Unable to work	19	1.4
Unemployed	125	9.1
Highest Educational Attainment		
Secondary school	211	15.4
Vocational training/other	146	10.6
Undergraduate Degree	488	35.5
Postgraduate Degree	521	38.0
Mental Health Status		
Excellent	125	9.1
Very Good	382	27.9
Good	430	31.4
Fair	348	25.1
Poor	86	6.3
Pregnancy Planning		
Planned	1141	83.2
Unplanned	230	16.8
Year of Pregnancy		
2016	141	10.3
2017	143	10.4
2018	276	20.1
2019	400	29.2
Pregnant at time of study involvement (2020)	410	29.9

Results

Descriptive statistics

Participant demographics and psychometric measure score distributions are shown in Tables 1 and 2. The sample had an age range between 19 to 50 (mean = 33.34, SD = 4.80) and were largely white (98.1%), married (67%), educated to a university level (67.2%), and had a planned pregnancy (83.2%). Moreover, 410 (29.9%) were pregnant at the time of recruitment, with 676 (49.3%) of participants experiencing pregnancy within two years of study involvement. Self-reported mental health varied across the sample, with 9.1% reporting their mental health over the past five years was excellent, 59.3% reporting good to very good mental health, and 31.4% reporting fair to poor mental health.

AUDIT-C scores were noted to decrease from an average score of 4.31 (SD = 2.35) to 0.320 (SD = 0.645) from pre- to during-pregnancy, indicating a general decrease in alcohol consumption upon pregnancy recognition. Both pre- and during-pregnancy versions of the AUDIT-C were found to have internal consistencies approaching acceptable levels (α = 0.686, α = 0.705). The subfactors of the BIS/BAS also varied in internal consistency, from poor (BAS: Reward Responsiveness subscale; α = 0.587) to good (BIS: Behavioral Inhibition subscale; α = 0.802).

Relations between demographics and pre- and during-pregnancy alcohol use

Unplanned pregnancies

Mann-Whitney U tests revealed that those who reported having an unplanned pregnancy rated themselves

Table 2. Overview of psychometric measure scores.

	N	Mean	SD	Range	α
AUDIT-C					
Pre-pregnancy score	1356	4.31	2.35	0 – 11	.686
During-pregnancy score	1353	.320	.645	0 – 7	.705
BIS/BAS (Behavioral Activation)					
Fun Seeking subfactor	1368	10.81	2.07	5 – 16	.672
Reward Responsiveness subfactor	1370	16.66	1.81	11 – 20	.587
Drive subfactor	1368	10.65	2.13	4 – 16	.783
Total Behavioral Activation score	1364	38.11	4.81	23 – 52	.812
BIS/BAS (Behavioral Inhibition)					
Behavioral Inhibition subfactor	1368	23.03	3.43	10 – 28	.802

Note. AUDIT -C: The Alcohol Use Disorders Identification Test – Consumption; BIS/BAS: Behavioral Inhibition System/Behavioral Activation System Scale; SD: Standard Deviation.

significantly higher on both pre-pregnancy ($U = -5.55$, $p < 0.001$, $r = 0.150$) and during-pregnancy ($U = -3.49$, $p < 0.001$, $r = 0.100$) AUDIT-C scores when compared to those having a planned pregnancy.

Mental health status

A Jonckheere-Terpstra test revealed no significant trends in lower mental health status on increased pre-pregnancy ($J = 329896.0$, $z = -1.72$, $p = 0.085$, r =, 047) nor during-pregnancy ($J = 338656.0$, $z = -0.555$, $p = 0.569$, $r = 0.020$) AUDIT-C scores.

Educational attainment

A further Jonckheere-Terpstra test revealed a significant trend of lower educational attainment and increased alcohol use pre-pregnancy ($J = 298795.0$, $z = -2.13$, $p = 0.033$, $r = 0.060$) and during-pregnancy ($J = 338566.0$, $z = -4.18$, $p < 0.001$, $r = 0.114$) AUDIT-C scores.

Age

Participant age was found to be significantly positively correlated with alcohol use during pregnancy (ρ = 0.170, $p < 0.001$, 95% confidence intervals [-0.070, 0.040]) but not pre-pregnancy (ρ = −0.015, $p = 0.578$, 95% confidence intervals [0.213, 0.316]).

Relations between BA, BI, and pre- and during-pregnancy alcohol use

Correlations between BA, BI, pre-, and during-pregnancy AUDIT scores are shown in Table 3. In short, pre-pregnancy AUDIT-C score was found to significantly positively correlate with the "Drive" (ρ = 0.093, $p < 0.001$, 95% confidence intervals [0.038, 0.147]) and "Fun Seeking" (ρ = 0.134, $p < 0.001$, 95% confidence intervals [0.079, 0.187]) subfactors of the BAS. No other significant correlations emerged. Moreover, the BAS subfactor "Fun Seeking" was the only subfactor to significantly positively correlate with during-pregnancy AUDIT-C score (ρ = 0.064, $p = 0.019$, 95% confidence intervals [0.009, 0.118]).

Table 3. Spearman correlation matrix of the pre- and during-pregnancy AUDIT scores, and the BIS/BAS subfactors.

	1	2	3	4	5	6
1. Pre-Pregnancy AUDIT-C	/	.265***	.093***	.134***	.047	.002
2. During-Pregnancy AUDIT-C		/	.010	.064*	.004	.024
3. Behavioral Activation Scale: Drive			/	.445***	.463***	−0.109***
4. Behavioral Activation Scale: Fun Seeking				/	.435***	−0.131***
5. Behavioral Activation Scale: Reward Responsiveness					/	.131***
6. Behavioral Inhibition						/

Note. AUDIT-C: Alcohol Use Disorders Identification Test – Condensed.
*$p < 0.05$.
***$p < 0.001$.

Influence of behavioural activation and behavioural Inhibition on pre-pregnancy alcohol use

The degree of variance explained by behavioral activation and inhibition on pre-pregnancy AUDIT-C scores was assessed using a hierarchical multiple regression model (see Table 4). To control for any variance explained by participant demographics, participant age, educational attainment, pregnancy planning, and 5-year mental health status were entered into the model first. All BIS/BAS subfactors, "Fun Seeking", "Reward Responsiveness", and "Drive", and "Behavioral Inhibition" were then inserted. A Durbin Watson value of 1.94 indicated non-significant autocorrelation between the residuals. From the initial model [F (9, 1333) = 4.75, $p < 0.001$, adj. R^2 = 0.025], lower participant educational attainment at secondary school level (β = 0.062, $p = 0.045$) and unplanned pregnancies (β = 0.881, $p < 0.001$) were found to significantly predict pre-pregnancy alcohol use. On inserting the BIS/BAS subfactors into the model ([F (13, 1333) = 5.66, $p < 0.001$, adj. R^2 = 0.043], "Fun Seeking" emerged as the only significant predictor (β = 0.119, $p < 0.001$) explaining 1.8% of the variance, whereas the contributions of "Reward Responsiveness", "Drive", and "Behavioral Inhibition" were non-significant.

Influence of behavioural activation and behavioural Inhibition on during-pregnancy alcohol use

The hierarchical multiple regression model was rerun with during-pregnancy AUDIT-C scores (see Table 5). A similar Durbin-Watson value as the previous regression model (2.02) indicated little autocorrelation between the residuals. The initial participant demographic model [Model 1; F (9, 1329) = 7.86, $p < 0.001$, adj. R^2 = 0.044] revealed significant contributions of increased participant age (β = 0.157, $p < 0.001$), unplanned pregnancies (β = −0.136, $p < 0.001$), and higher educational attainment (e.g., secondary school; β = −0.125, $p = 0.021$) toward alcohol use during pregnancy. On inserting the BIS/BAS subfactors into the model [Model 2; F (13, 1329) = 6.58, $p < 0.001$, adj. R^2 = 0.052], "Fun Seeking" again emerged as the only significant predictor (β = 0.120, $p < 0.001$) explaining 0.8% of the variance, with no significant contributions of the "Reward Responsiveness", "Drive", and "Behavioral Inhibition" subfactors. A final model was run, inserting pre-pregnancy AUDIT scores [Model 3; F (14, 1329) = 13.66, $p < 0.001$, adj. R^2 = 0.118]. Pre-pregnancy alcohol use emerged as a significant predictor (β = 0.264, $p < 0.001$), alongside "Fun Seeking" scores (β = 0.088, $p = 0.005$), and all participant demographics outside of all mental wellbeing status categories.

Table 4. Hierarchical multiple regression model with pre-pregnancy AUDIT-C scores as the dependent variable.

Predictor Variable	B	β	t	VIF	Adj. R^2	ΔR^2	*F*
Model 1 (Participant Demographics entered)†							
Constant	3.63		6.85***		.025		4.75***
Mental Health Status (Reference category: "Excellent")							
"Very Good"	−0.258	−0.049	−1.13	3.09			
"Good"	−0.271	−0.054	−1.12	2.89			
"Fair"	.120	.022	.485	1.65			
"Poor"	−0.159	−0.017	−0.477	1.32			
Educational Attainment (Reference category: "Postgraduate")							
Secondary School	.406	.062	2.00*	1.31			
Undergraduate	.182	.037	1.22	1.26			
Trade/vocational/other	.256	.034	1.15	1.20			
Age	.015	.031	1.08	1.10			
Pregnancy Planning (Reference category: Planned)							
Unplanned	.881	.140	4.99***	1.07			
Model 2 (Behavioral activation/inhibition entered)							
Constant	1.50		1.98*		.043	.018	5.66***
Mental Health Status (Reference category: "Excellent")							
"Very Good"	−0.230	−0.044	−0.943	3.02			
"Good"	−0.268	−0.053	−1.08	3.33			
"Fair"	.137	.025	.524	3.28			
"Poor"	−0.098	−0.010	−0.278	1.88			
Educational Attainment (Reference category: "Postgraduate")							
Secondary School	.437	.067	2.15*	1.36			
Undergraduate	.209	.043	1.42	1.27			
Trade/vocational/other	.289	.038	1.30	1.08			
Age	.023	.047	2.02*	1.12			
Pregnancy Planning (Reference category: Planned)							
Unplanned	.850	.135	4.84***	1.36			
Behavioral Inhibition	.018	.027	.851	1.49			
Behavioral Activation: Drive	.087	.079	1.15	1.45			
Behavioral Activation: Fun Seeking	.136	.119	3.70***	1.56			
Behavioral Activation: Reward Responsiveness	.059	.045	.176	1.48			

Note. B = unstandardized beta coefficient; β = standardized beta coefficient; VIF: variance inflation factor.
*$p < 0.05$.
**$p < 0.01$.
***$p < .001$.
†Categorical predictors were dummy-coded using binary indicator variables (0 = reference category, 1 = comparison category). Coefficients presented represent differences in AUDIT-C scores relative to the reference category for each variable.

Discussion

Aligned with past investigations in substance use disorder (Ganesh et al., 2018) and nonclinical (Wardell et al., 2012) populations, behavioral activation (BA) contributed significantly toward alcohol use in the sample; specifically, the "Fun Seeking" subfactor of the BIS/BAS. Predictive stability of fun seeking was also observed across both pre-pregnancy alcohol use and alcohol use beyond pregnancy recognition, whereas other BA components, Drive and Reward Responsiveness, did not explain significant variance in alcohol use scores. Indeed, past investigations have noted a unique role of fun seeking in explaining both alcohol and substance misuse (Franken & Muris, 2006; O'Connor et al., 2009); with some speculating that fun seeking exists as the main risk factor toward adverse health behaviors, whereas drive and reward responsiveness instead buffer risk (Studer et al., 2016). Moreover, fun seeking is associated with sensation seeking (Franken & Muris, 2006). Sensation seeking's role in substance misuse has been theorized since the 1980s (Brennan et al., 1986) and has been supported in past behavioral (Lac & Donaldson, 2021), neuropharmacological (Wiesbeck et al., 1996), and neurophysiological (Wei et al., 2023) studies. Thus, results from the current study indicate that mothers who express elevated fun/sensation seeking may be at a higher risk of alcohol use during pregnancy.

Conversely, on insertion into the regression models, behavioral inhibition (BI) did not significantly predict pre- nor during- pregnancy alcohol use; concurrent with much of the past literature identifying non-significant associations between BI and problem drinking (e.g., Dali et al., 2023). On the one hand, it could be theorized that prepartum mothers will be especially risk-averse during the pregnancy period and will consciously make positive health choices to minimize potential fetal harm; in turn, causing ratings on BI to be inversely associated with PAE. However, on the other, the personality trait likely exists on the same continuum as sensation-seeking, whereby behavior is either inhibited (BI) or disinhibited (fun seeking). Thus, no significant explanatory power was observed by BI in the regression models once variance explained by "Fun Seeking" scores were accounted for.

Fun seeking however only predicted a small degree of variance in PAE (i.e., 0.8%). In contrast, unplanned pregnancies, educational attainment, and increased maternal age together explained over four times the degree of variance (4.4%), with pre-pregnancy AUDIT scores explaining nearly seven times the variance (6.6%) in during-pregnancy AUDIT scores. This suggests that personality traits are not as potent in predicting PAE-risk when compared to others factors; notably pre-pregnancy alcohol use behaviors. Such findings shadow past evidence, highlighting individuals with histories

Table 5. Hierarchical multiple regression model with during-pregnancy AUDIT-C scores as the dependent variable.

Predictor Variable	B	β	t	VIF	Adj. R^2	ΔR^2	*F*
Model 1 (Participant Demographics entered)					.044		7.86***
Constant	−0.291		2.06*				
Mental Health Status (Reference category: "Excellent")							
"Very Good"	−0.114	−0.082	−1.76	2.97			
"Good"	−0.108	−0.079	−1.76	3.08			
"Fair"	−0.007	−0.005	−0.113	2.89			
"Poor"	.104	−0.040	−1.17	1.64			
Educational Attainment (Reference category: "Postgraduate")							
Secondary School	−0.125	−0.071	−2.31*	1.32			
Undergraduate	−0.091	−0.069	−2.30*	1.26			
Trade/vocational/other	−0.054	−0.027	−0.912	1.19			
Age	.021	.161	5.69***	1.10			
Pregnancy Planning (Reference category: Planned)							
Unplanned	.226	.133	4.81***	1.06			
Model 2 (Behavioral activation/inhibition entered)					.052	.008	6.58***
Constant	−0.474		−1.99*				
Mental Health Status (Reference category: "Excellent")							
"Very Good"	−0.108	−0.077	−1.66	3.02			
"Good"	−0.106	−0.078	−1.60	3.31			
"Fair"	−0.007	−0.005	−0.103	3.29			
"Poor"	−0.101	−0.039	−1.07	1.88			
Educational Attainment (Reference category: "Postgraduate")							
Secondary School	−0.134	−0.077	−2.46*	1.38			
Undergraduate	−0.092	−0.070	−2.34*	1.35			
Trade/vocational/other	−0.060	−0.029	−1.00	1.27			
Age	.022	.165	5.81***	1.21			
Pregnancy Planning (Reference category: Planned)							
Unplanned	.215	.127	4.58***	1.08			
Behavioral Inhibition	.001	.007	.228	1.36			
Behavioral Activation: Drive	.010	.034	1.05	1.49			
Behavioral Activation: Fun Seeking	.037	.120	3.72***	1.45			
Behavioral Activation: Reward Responsiveness	.009	.026	.777	1.56			
Model 3 ((Pre-pregnancy AUDIT score entered)					.118	.066	13.66***
Constant	−0.583		−2.47*				
Mental Health Status (Reference category: "Excellent")							
"Very Good"	−0.092	−0.066	−1.46	3.02			
"Good"	−0.087	−0.064	−1.40	3.31			
"Fair"	−0.017	−0.012	−0.249	3.29			
"Poor"	−0.092	−0.036	−1.01	1.87			
Educational Attainment (Reference category: "Postgraduate")							
Secondary School	−0.165	−0.094	−3.14**	1.36			
Undergraduate	−0.108	−0.082	−2.82**	1.27			
Trade/vocational/other	−0.079	−0.039	−1.38	1.21			
Age	.020	.152	5.56***	1.13			
Pregnancy Planning (Reference category: Planned)							
Unplanned	.155	.092	3.40***	1.10			
Behavioral Inhibition	.001	.002	.003	1.36			
Behavioral Activation: Drive	.016	.055	1.75	1.51			
Behavioral Activation: Fun Seeking	.027	.088	2.83**	1.46			
Behavioral Activation: Reward Responsiveness	.005	.013	.410	1.56			
Pre-Pregnancy AUDIT Score	.071	.264	9.96***	1.06			

Note. B = unstandardized beta coefficient; β = standardized beta coefficient; VIF: variance inflation factor.
*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.
†Categorical predictors were dummy-coded using binary indicator variables (0 = reference category, 1 = comparison category). Coefficients presented represent differences in AUDIT-C scores relative to the reference category for each variable.

of risky pre-pregnancy alcohol consumption were at a four-fold risk of continued alcohol use beyond pregnancy recognition (Tsang et al., 2022). Moreover, evidence suggests that unintended pregnancies are associated with decreased likelihood of following advice for healthy prenatal behaviors (O'Keeffe et al., 2016), potentially as a result of less secure fetal attachment (Watt et al., 2014), which may in turn increase the likelihood of the pregnancy becoming alcohol-exposed (McQuire et al., 2020). Moreover, increasing maternal age has been found to be associated with more frequent, but less intense, instances of alcohol consumption when compared with younger counterparts (Esper & Furtado, 2014). Given that messaging regarding the safety of PAE has been inconsistent in the UK until the release of the Chief Medical Officer's "no alcohol, no risk" advice in 2016 (Department of Health, 2016), increasing age may be associated with less awareness of such guidelines; thus, pregnancies to older mothers are at increased risk of alcohol exposure. Lastly, differing effects of educational attainment were found across the pre- and during-pregnancy AUDIT scores. Those with lower educational attainment, specifically at the high school level, reported higher alcohol

consumption pre-pregnancy compared to those who attained higher educational attainment (i.e., postgraduate education). Conversely, those with lower levels of educational attainment reported lower during-pregnancy alcohol use when compared with participants with postgraduate education. Such relation has been previously interpreted within the broader context of socioeconomic status (SES); as women with higher educational attainment are often more likely to fall within higher SES groups (Murakami et al., 2021). Similar to patterns associated with maternal age, women of higher SES have been found to drink more often but at lower intensities when compared to women of lower SES (McQuire et al., 2020).

There are several clinical implications. Modifying and reinforcing BA has been explored within the context of problem alcohol and substance use through cognitive behavioral therapy, which aims to both minimize engagement in risky and maladaptive behaviors and provide rewarding experiences outside of substance misuse *via* behavioral adaptation (Martínez-Vispo et al., 2018). Thus, results from the current study indicate that mothers, who report heightened sensation seeking and alcohol use during pregnancy, may benefit from such therapeutic interventions. Nevertheless, results also reinforce the need to address unintended pregnancies, higher educational attainment, maternal age, and pre-pregnancy alcohol consumption to reduce the likelihood of alcohol-exposed pregnancies. Indeed, improving access to contraceptives and improving their use are critical factors that require targeting to prevent alcohol-exposed pregnancies; as is exemplified in the *CHOICES* PAE and FASD prevention programme (Floyd et al., 2007). However, programmes akin to *CHOICES* have yet to be run outside of North America and, given the prevalence of alcohol-exposed pregnancies in the UK (41.3% and <15%, respectively; Popova et al., 2017), such programmes are critically needed. Moreover, results indicate that universal primary interventions targeting pre-conception alcohol use in women of child-bearing age may have benefits in reducing the likelihood of continued alcohol use if pregnancy occurs. Indeed, previous mass media campaigns targeting the general population found success in raising awareness of the risks of PAE, with the majority of participating non-expectant women (83%) indicating that they would be more likely to avoid alcohol completely if they became pregnant (Pettigrew et al., 2023).

There are methodological limitations. First, significant contributions of maternal age, educational attainment, unplanned pregnancies, fun seeking, and pre-pregnancy alcohol use on PAE were observed, the level of variance explained in the regression model was relatively small (i.e., 11.9%). Indeed, the factors proposed to exacerbate PAE-risk are numerous, interwoven, and complex (McQuire et al., 2020); thus, capturing all underlying mechanisms is likely a significant challenge for a singular study. While a number of individual factors were explored here, the mothers' interpersonal factors (e.g., level of perceived support from others or alcohol use within the family), psychological factors (e.g., stress, histories of trauma, or fetal attachment), and health factors (e.g., access to prenatal health information or concurrent smoking/substance use) were not measured.

Second, the sample largely consisted of white, educated participants. It has been speculated that PAE can exist across the socioeconomic spectrum (Abernethy et al., 2018), as evidenced by a proportion of the tested population continuing to consume alcohol beyond pregnancy-recognition. However, as PAE prevalence within the current study was lower than the UK average (41.3%, Popova et al., 2017), it is likely that social advantage can buffer PAE-risk; thus, the findings cannot be reliably extrapolated to the wider UK population of pregnant women.

Third, despite the anonymous nature of the online questionnaire, self-reported PAE data may have been sensitive to recall and social-desirability biases; known to be a limitation of self-assessed PAE (Davis et al., 2010). Consequently, PAE prevalence within the sample was likely under-reported. While efforts have been made to identify alternative methods in PAE detection, chiefly ethanol metabolites derived from meconium and blood samples, findings on their sensitivity and specificity are inconsistent. Self-reported methodologies therefore remain the gold-standard measure of PAE (Henderson et al., 2023; Keating et al., 2024). It should also be acknowledged that a proportion of participants were postpartum for more than a year; thus, their responses may have been especially subject to recall bias. However, it has been speculated that postnatal women are more truthful and accurate in reporting their level of prenatal alcohol use when compared to prenatal women (Brunton & Dryer, 2024).

Fourth, several of the psychometric measures' subscales were found to have internal consistencies below the acceptable level (i.e., the BIS/BAS subfactors "Reward Responsiveness" and "Fun Seeking"; $\alpha = 0.587$; $\alpha = 0.672$, respectively; and the pre-pregnancy version of the AUDIT-C; $\alpha = 0.686$). While there has been evidence of the AUDIT-C and BIS/BAS total scale's psychometric validity (e.g., Dawson et al., 2005; Jorm et al., 1998), several other authors report subfactor alpha values similar to those found here (e.g., "Reward Responsiveness", $\alpha = 0.630$; Yu et al., 2011; AUDIT-C scores, $\alpha = 0.542$; Bazzo et al., 2015). Suboptimal internal consistency may have increased measurement error; attenuating the relations between the variables, leading to such relations being weakened and underestimated. Indeed, correlations between certain factors, such as pre-pregnancy alcohol use and fun seeking, were small in magnitude (i.e., $\rho = 0.134$). The findings reported here therefore should be interpreted with caution and warrant replication in other samples before firm conclusions can be drawn.

Fifth, no attentional checks were implemented within the online questionnaire. Consequently, is it possible that a proportion of the current study's data came from inattentive respondents. One approach to mitigate this issue is the use of instructed response items (IRIs); whereby participants are asked to respond in a specific way to selected items (e.g., "click *strongly agree*") (Gummer et al., 2021). IRIs assess whether respondents have read the items correctly; thus, facilitate researchers to exclude participant(s) who fail to pass such checks. It is recommended that future studies in

this field utilize attentional checks in online questionnaires in order to improve data quality.

Lastly, mental wellbeing was assessed with a single item measure to reduce participant burden. This limited opportunities to investigate specific negative affect states (e.g., depressive, and anxiety symptoms); known to play a significant role in predicting PAE likelihood (Leis et al., 2012; Pentecost et al., 2021). Moreover, given that participants were eligible if they were up to five years postpartum, the item had to worded in a way that it was applicable across this broad timeframe. The absence of significant associations between mental wellbeing and both AUDIT scores therefore likely reflect the limited sensitivity - and potentially limited temporal alignment - of a single-item measure to capture variance in participant wellbeing. We therefore recommend that future studies administer "gold-standard" measures of negative affect (e.g., the Warwick-Edinburgh Mental Wellbeing Scale; Tennant et al., 2007), with items amended to reflect the pregnancy period, when examining the predictors of prenatal alcohol exposure risk.

Conclusion

Fun seeking appears to play a small yet significant role in predicting both pre-pregnancy alcohol use, and the continuation of alcohol consumption past pregnancy recognition. This is the first study to identify contributing personality traits in aggravating PAE. However, it must be stressed that a myriad of potent personal, interpersonal, and health causal mechanisms also contribute toward alcohol-exposed pregnancy risk (McQuire et al., 2020), as evidenced in the current study; and such factors should continue to be targeted within PAE prevention interventions.

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The authors declare no conflicts of interest.

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