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Impact of Menstrual Irregularities and Blood Pressure on Mental Health in Hypertensive Women

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ABSTRACT

Objective: Hypertension affects 1.28 billion people worldwide, with a prevalence of 29.8% in India and 25.2% in rural Tamil Nadu. Menstrual irregularities affect 30 to 40 percent of women globally, and they are becoming more prevalent in India, where lifestyle and cultural factors may exacerbate the issue. These abnormalities are often linked to anxiety, depression, and stress, which makes public health problems worse. This study examines these overlapping challenges with a focus on Tamil Nadu, specifically in the Madurai district, where healthcare facilities could discover it difficult to address women's need for mental and reproductive health.

Methods and Materials: The risk of stress was over doubled among uncontrolled blood pressure patients with menstrual irregularities, particularly in those who were overweight and had a family history of the condition ($p < 0.001$). For postmenopausal women, the risks of stress and depression were more than five times greater (AOR = 5.536, 5.55), while more education seemed to be protective, lowering the odds of anxiety and depression (AOR = 0.082, 0.150). A strong positive correlation ($r_s = 0.622$, $p < 0.01$) was observed between SBP and DBP.

Findings: Intervention group's means were reduced and the difference between groups in splitting ($F=86.33$, $p<0.05$) and paranoid ideation ($F=65.47$, $p<0.05$) were significant.

Conclusion: Blood pressure concerns and irregular menstruation exacerbate mental health problems in hypertensive women. Early diagnosis and culturally sensitive interventions including integrated support and education can empower these women to build resilience and improve their overall health.

Keywords: Menstrual Irregularities, Hypertension, Blood pressure, Depression, Anxiety.

Introduction

Hypertension is a chronic condition which is strongly associated with uncontrolled blood pressure (BP), accounts for half of all cardiovascular deaths worldwide and causes approximately 10 million deaths per year (Hegde et al., 2022). Over recent decades, hypertension has surged in low- and middle-income countries, affecting over 1.28 billion people globally and with a prevalence of 29.8% in India and 25.2% in rural Tamil Nadu (Sundarrajan et al., 2022). A review of research reveals that the women who experience high blood pressure and irregular menstrual periods are more likely to experience mental health problems such as, depression, anxiety and stress (DAS) (Attia et al., 2023).

According to an American Heart Association study (2023) on 58,056 women in the U.K. Biobank, anxiety and depression raised the risk of serious cardiovascular events, like heart attacks and strokes, by almost 35%. Additionally, people who were genetically predisposed to stress experienced the onset of their first cardiovascular risk factor, such as hypertension, about 1.5 years before others who were not genetically predisposed to stress (American Heart Association, 2023). But according to the study, there is still uncertainty about the relationships between menstrual cycle traits and cardiovascular outcomes.Among its limitations were its observational approach to clinical and sociodemographic variables as well as the lack of standardized instruments for evaluating mental illnesses such as DAS.

In culturally stigmatized settings like Tamil Nadu, menstrual irregularities frequently go unaddressed, raising mental health risks for hypertensive women. Ahad *et* al. (2023) observed that stigma surrounding mental health and reproductive health misconceptions can increase anxiety and depression among women with irregular cycles (Ahad et al., 2023), including those with polycystic ovary syndrome (PCOS)(Attia et al., 2023). This current study examines DAS conditions using the standardised psychological instruments among hypertensive women attending tertiary healthcare centre in Madurai, Tamil Nadu, accounting for the effects of menstrual irregularities and socio-cultural challenges. The study intends to promote culturally sensitive healthcare therapies catered to these women in recognition of these research gaps.

Through biological, psychological, and social lenses, this study investigates the intricate relationships among women in Madurai, Tamil Nadu, between blood pressure regulation, irregular menstruation, and mental health outcomes. In a biological sense, blood pressure and mental state are influenced by hormonal variations, especially those of estrogen and progesterone, while stress is increased by vascular alterations brought on by hypertension and dysregulation of the Hypothalamic-Pituitary-Adrenal (HPA) axis (Steptoe & Kivimäki, 2012). Psychologically, chronic stress and health-related anxiety associated with blood pressure and menstruation complications can exacerbate depression and anxiety (Chida & Steptoe, 2009; Grigsby et al., 2020; Steptoe & Kivimäki, 2012). Social stigma related to mental and reproductive health, together with cultural norms and restricted access to treatment, contribute to these women's stress levels and aggravate mental health symptoms (Thara *et* al.,2010; Aneshensel *et* al, 1992). Thus, the current study establishes a biopsychosocial model which highlights the ways in which the body, mind, and culture interact to influence health outcomes. The following presents the main objectives of this study:

1. To compare mental health outcomes including depression, anxiety and stress using Hamilton depression rating scale, Hamilton anxiety rating scale and Perceived stress scale respectively among hypertensive women with and without menstrual irregularities.
2. To identify socio-demographic, clinical, and socio-cultural factors that contribute to mental health risks in hypertensive women.
3. To explore the role of blood pressure control in moderating these mental health outcomes.

Methods and Materials

Study Design and Participants

The cross-sectional study, conducted between December 25, 2020, and December 24, 2021, involved 307 male and female hypertension patients aged 18 and over were selected by random sampling. Socio-demographic and mental health data were obtained from participants through face-to-face interviews using semi-structured questionnaires and validated psychological instruments while the clinical information was taken from hospital records on that specific day. The study was

conducted at the Alpha Hospital and Research Centre, a renowned outpatient tertiary care centre with a focus on endocrinology and diabetes that is accessibly situated in Madurai, Tamil Nadu. Regular follow-ups were convenient for patients because the location was easily accessible from the surrounding areas. Hospital doctors conducted a medical evaluation at the start of each patient visit and then laboratory-assisted biochemical testing was conducted. Patients then met with the researcher for a brief interview (lasting 7–10 minutes) after providing written consent. This approach helped ensure complete data collection, minimizing sampling gaps.

If any patients showed signs of a fever or cold during the screening, the hospital officials promptly directed them to a nearby government facility for a follow-up RT-PCR (Reverse Transcription Polymerase Chain Reaction) test. By doing this, the study facility was able to avoid the additional complications of COVID-19 testing and concentrated entirely on follow-up appointments and new cases. This strategy made the process more efficient while lowering the risk of exposure and preserving the study's safe environment for all patients, medical personnel and the researcher.

The estimate of the sample size was based on pilot research with 40 hypertension patients (who were not included in the main study), in which 27.5% of the patients had DAS symptoms. The sample size (n) was determined by applying the Central Limit Theorem (Viswesvaran et al., 1999) and the formula N = (Z^2 x p x (1-p))/d^2. This formula has a 5% margin of error and a 95% confidence interval (Z = 1.96). A minimum of 307 samples was required, rounded down. Out of the total 307 patients, 201 were female patients and among them 101 of them had irregular menstruation. Attaining 80% power with a p-value < 0.05, the sample size was optimized to identify noteworthy distinctions in stress, depression, and anxiety outcomes between women with hypertension and those without irregular menstruation.

Inclusion criteria involved individuals willing to participate in the research, while those with known severe mental health issues as according to ICD-10 Classification of Mental and Behavioural disorders (The): Diagnostic Criteria for Research (ICD-10 DCR) (WHO, 1993) were excluded from the study.

Instruments

Participants were interviewed using semi-structured questionnaires to collect clinical and sociodemographic data. Clinical information was gathered, such as blood pressure (SBP, DBP), BMI, menopausal status, pre- and post-menstrual symptoms, insomnia, physical activity, food, and family history of hypertension. According to the Indian standard treatment guidelines set by the Ministry of Health & Family Welfare (2016), hypertension is classified as a systolic blood pressure of 140 mm Hg or a diastolic pressure of 90 mm Hg or higher. Blood pressure was measured with participants seated and at rest, taking three readings at intervals to ensure reliability (Thakre et al., 2022). Age, marital status, level of education, and employment were among the sociodemographic variables that were documented.

The Hamilton Depression Rating Scale (HAM-D), Hamilton Anxiety Rating Scale (HAM-A), and Perceived Stress Scale (PSS) are three validated measures that were used to measure mental health conditions. HAM-D was utilized to assess the occurrence and intensity of depression throughout the previous week (Carrozzino et al., 2020). Cronbach's alpha for the HAM-D 17 items was 0.92, according to research done by Dedeken et al., (2020), suggesting a good degree of internal consistency. HAM-A 14 items is a technique used for measuring symptoms of anxiety (Dedeken et al., 2020). Cronbach's alpha of 0.893 indicates that the scale has a high degree of internal consistency (Kummer et al., 2010). The Perceived Stress Scale (PSS) is a tool for measuring perceived stress (Cohen et al.,1983). With a Cronbach's alpha of 0.85, the scale demonstrated strong internal consistency (Lee, 2012).

Data Analysis

The statistical analysis was done using IBM SPSS Statistics software version 23. The Shapiro-Wilk test was used to assess normality. As the data was not normally distributed, the risk factors were evaluated using non-parametric tests. Mann-Whitney U test was used to analyse the between-group comparisons of mental health outcomes. The Kruskal-Wallis H test was used for multiple group comparisons. Spearman's correlation coefficients assessed relationships between SBP, DBP, and mental health indicators. Multiple imputation method was used to handle the missing data pertaining

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to clinical and mental health metrics which were assumed to be missing at random while managing with the elderly or severe hypertensive patients. These measurements were imputed based on correlations with other variables including age, marital status, and socioeconomic status. A sensitivity study that contrasted the imputed data with the full case analysis was then conducted, and the results indicated that imputation had no distinct effect on the relationship between hypertension and mental health outcomes.

Confidence intervals (CIs) are usually not given in non-parametric tests since they evaluate rank-based differences rather than effect sizes. Instead, the degree of group differences can be presented using effect size measures such Rank-Biserial correlation for Mann-Whitney, although AORs with CIs are still useful for assessing odds in logistic regression.

According to a review of the research (Amu et al., 2021), sociodemographic and clinical characteristics associated with the relevant mental health outcomes (DAS) as well as important predictors including age, income, education, blood pressure, BMI, family history etc. could be confounding factors. Bivariate analyses were used to verify the relationships between these variables and outcomes related to mental health. To isolate the influence of primary variables on mental health outcomes, the multivariate logistic regression model was fitted with these chosen confounders to correct odds ratios. This method yielded a less biased and more clear assessment of relationships because the adjusted odds ratios (AORs) took possible confounding factors into consideration.

Findings and Results

Menstrual irregularities in hypertensive women (n = 101) and those without (n = 100) were the two groups of participants. With the majority being post-menopausal, the median age was 41.86 years (± 8.3 SD).

Table 1

Comparative Analysis of Stress, Depression, and Anxiety Across Socio-demographic and Clinical Factors in Hypertensive Female with Menstrual Irregularities Patients.

Variables	Category	N (%)	Stress		Depression		Anxiety	
			Median (IQR1, IQR3)	U/H score	Median (IQR1, IQR3)	U/H score	Median (IQR1, IQR3)	U/H score
Group	Hypertensive Patients without Menstrual Irregularities	100 (49.8)	18 [13,22]	4480	12 [9,18]	4618.5	22 [19,24]	4618
	Hypertensive Patients with Menstrual Irregularities	101 (50.2)	16[12,21]		12 [8,17]		22 [17,24]	
Socio-demographic factors								
Mean Age (years)	41.86 ± 8.3							
Age (years)	18-23	55 (54.5)	15 [12,21]	2.357	12 [8.5,14.5]	0.784	22 [19,25]	1.635
	24-40	35 (34.7)	17 [13,22.5]		13 [5,17.5]		21 [14,22.5]	
	41-60 & above	11 (10.9)	15 [13,21.5]		16 [9,19.5]		23 [16,23.5]	
Marital Status	Single	27 (26.7)	15 [11,20]	853	12 [2.5,16.5]	893	20 [8.5,23]	728
	Married	74 (73.6)	16.5 [13,22]		12.5 [8,17]		22* [19,24]	
Educational Qualification	No formal Education to middle school	55 (54.5)	19 [14,22]	5.789	13 [8.5,17]	7.091	22 [19,24]	3.854
	High School	7 (6.9)	14 [10,20]		8 [2.5,9]		11 [4.5,21.5]	
	Diploma and above	39 (38.6)	15 [11,19.5]		11 [8,17]		22 [18.5,24]	

Occupation	Unemployed	61 (60.4)	15 [12,21]	1.463	11.5 [7,15]	2.385	21 [17,24]	0.934
	Daily Wage and Business	18 (17.8)	16 [11,22]		12.5 [5,17]		21 [16,22]	
	Others	22 (21.7)	16.5 [12,21.5]		13 [8.5,17]		22 [17,24]	
Employment Status	Housewife /Student	61 (60.4)	15 [12,21]	1078	11 [8,16]	1123.5	22 [19,24]	1060
	Employed	40 (39.6)	17.5 [12.5,22]		13 [7.5,17.5]		21 [15.5,23]	
Economic status	Upper class	23 (22.8)	17 [13.5,15]	1.128	12 [8,16]	0.549	22 [21,24]	0.712
	Middle class	57 (56.4)	16 [12,21]		12 [8,17]		21 [15,24]	
	Lower class	21 (20.8)	15 [11,21]		13 [5, 18]		22 [12,23]	
Clinical Profile								
Blood Pressure	Controlled	26 (25.7)	20 [16,23]	653	12 [8,17]	922	21.5 [16,24]	979
	Uncontrolled	75 (74.3)	15** [13.5,20]		12 [8,17]		22 [19,24]	
Menstrual Symptoms (MS)	Pre- MS	29 (16.8)	15 [11,21]	3.562	9 [5,16]	4.672	19 [10,23]	1.987
	Peri- MS	55 (28.7)	16 [13,20]		12 [11,17]		22 [20,24]	
	Post- MS	84 (54.5)	16 [12,21.5]		5.5 [12,17]		22 [15.5,24.5]	
Menopausal status	Absent	74 (73.3)	17 [12,22]	901	12 [8,17]	953	21.5 [16,24]	979
	Present	27 (26.7)	15 [13.5,20]		12 [8,7]		22 [19,24]	
BMI	Underweight	55 (54.5)	15 [11,20.5]	8.526	13 [8,17]	2.786	22 [17.5,24]	1.674
	Normal	21 (20.8)	13*** [11,16]		11 [8,14]		21 [11,23]	
	Overweight/ Obese	25(24.8)	21 [16,23]		12 [9,19]		22 [19,24]	
APA	Absent	63 (62.4)	16 [12,22]	1159	12 [8,17]	1151	22 [18.5,24]	1097
	Present	38 (37.6)	16.5 [13,21]		13 [8,17]		21.5 [16,23]	
ADH	Absent	62 (61.4)	15 [12,21]	1053	12 [5,17]	1186	21.5 [17,24]	1200.5
	Present	39 (38.6)	17 [14.5,22]		12 [8,16.5]		22 [17.5,23.5]	
Insomnia	Absent	53 (52.5)	15 [12,20]	1011	11 [6,14]	1048.5	22 [15,24]	1258.5
	Present	43(47.5)	19 [13,23]		13 [9,18]		22 [18.5,23.5]	
Family History	Absent	40 (39.6)	13.5 [11,18]	754.5	11 [8,16.5]	1097	21 [15.5,24]	1063

	Present	61 (60.4)	19*** [14,22]		13 [8,17]		22 [19,24]	
Complications	Absent	53 (52.5)	14 [11,19]	752	12 [7,17]	1159	22 [17,24]	1151
	Present	48 (47.5)	20.5*** [15,22.5]		12 [8.5,18]		22 [17,23.5]	

Note: *p < 0.05, **p < 0.01, ***p < 0.001; U scores – Mann Whitney U test scores, H scores - Kruskal-Wallis H test, IQR - Interquartile Range.

Comparative Mental Health Outcomes in Hypertensive Women with and without Menstrual Irregularities

Table 1 shows that the hypertensive women without menstrual irregularities (median score of 18 [IQR: 13-22]) reports slightly higher stress (median score of 16 [IQR: 12-21]) than those with irregularities, while depression and anxiety levels are similar across both groups, with minimal variation in scores.

Stress, depression and anxiety Levels Across Groups

In Table 1, women with irregular menstruation reported significantly higher levels of stress in the uncontrolled blood pressure group, which had a median score of 20 [IQR:16-23] compared to the controlled blood pressure group's median score of 15 [IQR:13.5-20]; U score = 653, p < 0.01). On the other hand, stress levels were lower in the group without menstrual irregularities, especially in those with managed blood pressure. Hypertensive women with menstrual irregularities and associated complications reported higher stress levels (median = 20.5 [IQR:15-22.5]), U score = 752, p < 0.001). Women who were overweight or obese and had irregular menstruation also had significantly greater levels of stress (H score = 8.526, p < 0.001), highlighting the significance of weight in stress exacerbation. Stress levels were considerably greater among women with a family history of hypertension (U score = 754.5, p < 0.001). While there were no statistically significant variations in anxiety and depression levels between the variables of hypertension women with irregular menstruation and those without irregular menstruation (p > 0.05). In contrast to this, women who were overweight/obese or post-menopausal reported experiencing these conditions more frequently

To summarise Table 1 results, descriptive and non-parametric analyses reveal that hypertensive women without menstrual irregularities (n=100) show slightly higher stress than those with irregularities (n=101). Additionally, stress is elevated in irregular menstruation women with uncontrolled BP, hypertensive complications, obesity and a family history of hypertension. However, the majority of patients being post-menopausal and their median age was 41.86 years (± 8.3 SD).

Furthermore, the Rank-Biserial Correlation test was conducted using the key findings variable subgroups following the Mann-Whitney U and Kruskal Willis H tests. Whereas for the multiple comparison between the variable subgroups the Rank-Biserial correlation was performed after Dunn's Post Hoc.

Supplement 1: Rank-biserial correlation for comparisons of mental health factors (DAS) across various hypertensive patient subgroups (Key findings from Table 1) See Supplement 1.

Mental Health Risk Factors

Table 2 explores the mental health risks including depression, anxiety, and stress among hypertensive patients with menstrual irregularities with each part of the table heading relates to 95% Confidence Intervals (CIs).

With these assumptions met, the ANCOVA results were valid, leading to the conclusion that the intervention significantly reduced splitting and paranoid ideation in the intervention group. Table 2 presents the Results of One-way Analysis of Covariance (ANCOVA).

Table 2

Mental Health Risk Associated with Hypertensive patients with Menstrual Irregularities

Variables	Depression	Anxiety	Stress

	COR (95% CI)	AOR (95% CI) Models 1	2	COR (95% CI)	AOR (95% CI) Models 1	2	COR (95% CI)	AOR (95% CI) Models 1	2
Socio-demographic Factors									
1.Age (years) 18-23 ® 24-40 41 & above	1.319 [0.526-3.311] 1.407 [0.334-5.932]	1.078 [0.174-6.660] 1.012 [0.088-11.60]		0.694 [0.282-1.706] 1.094 [0.257-4.659]	1.270 [0.344-4.691] 0.773 [0.112-5.348]		0.593 [0.233-1.511] 0.825 [0.191-3.574]	6.211 [0.039-1.125] 1.162 [0.172-7.830]	
2. Marital Status Single Married	1.390 [0.550-3.512]	0.602 [0.132-2.738]		1.390 [0.550-3.512]	1.581 [0.471-5.306]		2.305[0.901-5.898]	3.519 [0.856-14.478]	
4. Education Qualification No formal Education to middle school ® High School Diploma and above	0.372 [0.073-1.895] 0.361 [0.147-0.888]	0.199 [0.10-3.885] 0.313 [0.060-1.642]		0.150 *[0.026-0.858] 0.844 [0.342-2.081]	0.082* [0.009-0.769] 0.820 [0.253-2.659]		0.232 [0.046-1.174] 0.788 [0.309 - 2.006]	0.142 [0.014-1.415] 0.934 [0.251-3.472]	
5.Occupation Unemployed ® Daily Wage and Business Others	0.898 [0.248-3.248] 1.445 [0.514-4.066]	0.437 [0.034-5.620] 4.267 [0.701-25.970]		1.143 [0.309-4.234] 1.445 [0.514-4.066]	0.646 [0.107-3.903] 1.806 [0.493-6.619]		1.213 [0.309-4.761] 1.400 [0.480-4.084]	2.112 [0.285-15.632] 1.791 [0.404-7.944]	
6. Employment Status Housewife/Student ® Employed	1.384 [0.579-3.311]	1.649 [0.310-8.772]		0.940 [0.399-2.210]	0.706 [0.204-2.437]		0.553 [0.229-1.337]	0.477 [0.124-1.837]	
7.Socio-Economic Status Upper class ® Middle class Lower class	0.514 [0.166-1.591] 0.556 [0.145-2.129]	3.51 [0.059-2.104] 0.136 [0.014-1.331]		0.948 [0.332-2.701] 0.875 [0.246-3.115]	1.224 [0.331-4.526] 1.474 [0.295-7.361]		0.495 [0.146-1.675] 0.421 [0.103-1.723]	0.366 [0.069-1.952] 0.362 [0.051-2.562]	
Clinical Risk Factors									
8. Blood Pressure Controlled ® Uncontrolled	0.305 * [0.095-0.977]	0.093* [0.009-0.913]	0.308 [0.069-1.379]	1.197 [0.465-3.081]	3.959 [0.754-20.782]	1.696 [0.499-5.769]	0.261* [0.071-0.953]	0.171 [0.024-1.206]	0.135** [0.027-0.676]
9.Menstrual Symptoms (MS) Pre- MS ® Peri- MS Post - MS	0.503 [1.166-1.529] 1.406 [0.505-3.918]	19.883* [1.547-254.3] 5.450 [0.779-38.143]	3.167 [0.669-14.998] 1.355 [0.366-5.014]	4.267* [1.101-16.537] 1.684 [0.559-5.073]	6.775* [1.105-41.542] 1.404 [0.323-6.101]	5.536* [1.291-23.742] 1.889 [0.587-6.075]	5.55** [1.341-23.022] 2.167 [0.710-6.614]	3.978 [0.675-23.445] 1.928 [0.451-8.246]	6.040* [1.278-28.534] 1.928 [0.582-6.254]
10.Menopausal Status Absent ® Present	1.458 [0.544-3.909]	2.088 [0.369-11.803]	1.200 [0.363-3.968]	0.902 [0.352-2.308]	1.039 [0.315-3.422]	1.067 [0.387-2.945]	1.132 [0.417-3.072]	1.319 [0.313-5.560]	1.034 [0.334-3.200]
11.Complications Absent ® Present	4.138** [1.629-10.509]	6.489 [0.915-46.030]	2.470 [0.710-8.591]	1.244 [0.538-2.902]	1.791 [0.432-7.427]	1.499 [0.474-4.739]	1.063 [0.444-2.545]	0.629 [0.140-2.835]	0.910 [0.266-3.109]
8.BMI Underweight ® Normal Overweight/ Obese	0.519 [0.188-1.437] 13.714** [1.723-1.437]	0.569 [0.099-3.25] 6.924 [0.297-161.47]	0.372 [0.106-1.307] 6.104 [0.559-66.705]	0.727 [0.254-2.078] 1.150 [0.405-3.267]	0.923 [0.241-3.535] 0.858 [0.162-4.548]	0.837 [0.265-2.641] 0.736 [0.171-3.167]	1.026 [0.338-3.116] 1.299 [0.438-3.851]	1.411 [0.277-7.180] 0.920 [0.146-5.779]	0.957 [0.265-3.461] 0.902 [0.184-4.422]
9.APA Absent ® Present	1.227 [0.512-2.945]	2.914 [0.587-14.46]	1.034 [0.339-3.157]	1.008 [0.424-2.395]	1.346 [0.389-4.665]	1.126 [0.414-3.060]	0.907 [0.371-2.220]	1.835 [0.494-6.816]	1.110 [0.390-3.160]
10.AHD Absent ® Present	2.44[0.965-6.204]	1.069 [0.232-4.924]	1.733 [0.538-5.690]	1.071 [0.452-2.541]	2.295 [0.590-8.930]	1.233 [0.400-3.799]	0.962 [0.394-2.349]	0.232 [0.051-1.062]	0.360 [0.110-1.175]
11.Insomnia Absent ® Present	1.240 [0.538-2.902]	1.077 [0.228-5.086]	0.709 [0.232-2.170]	1.008 [0.424-2.395]	1.891 [0.622-5.745]	1.849 [0.718-4.764]	1.063 [0.444-2.545]	0.908 [0.281-2.935]	0.982 [0.352-2.712]
12. Family History Absent ® Present	3.341** [1.397-7.991]	4.381* [0.988-19.432]	3.446** [1.096-10.876]	1.286 [0.549-3.014]	1.354 [0.414-4.430]	1.165 [0.441-3.082]	1.477 [0.611-3.565]	1.838 [0.479-7.049]	2.025 [0.688-5.961]

Note: COR: Crude Odds ratio, AOR: Adjusted Odds ratio, Model 1: Fully adjusted regression model, Model 2: Partially adjusted regression model, CI: Confidence Interval, ®: Reference, APA: Adherence to Physical Activity, AHD: Adherence to Healthy Diet, Significant Value (P) *p < 0.05, **p < 0.01, ***p < 0.001

According to Table 2, the fully adjusted logistic regression model, women with hypertension who had completed a diploma or more had a decreased risk of anxiety (AOR = 0.150, 95% CI: 0.026-0.858) and with low depression (AOR = 0.082, 95% CI: 0.009-0.769). On the other hand, post-menopausal hypertension women had higher odds of stress and depression i.e. (AOR = 5.55, 95% CI: 1.341-23.022) for stress; (AOR = 5.536, 95% CI: 1.291-23.742) for depression. Though they reported higher levels of stress, hypertensive patients with uncontrolled blood pressure had considerably lower odds of depression (AOR = 0.093, 95% CI: 0.009-0.913).

Correlation Between Blood Pressure levels and Mental Health

Figure 1

Spearman Correlation Heatmap of Age, Blood Pressure, and Mental Health Variables (DAS) in Hypertensive Women.

	Age	*SBP*	*DBP*	*Stress*	*Depression*	*Anxiety*
Age	1					
SBP	0.01563	1				
DBP	0.028293	0.687497	1			
Stress	0.005412	-0.02091	-0.11837	1		
Depression	0.011413	-0.03844	-0.04504	0.186345	1	
Anxiety	0.122945	0.00586	-0.08182	0.103496	0.34323016	1

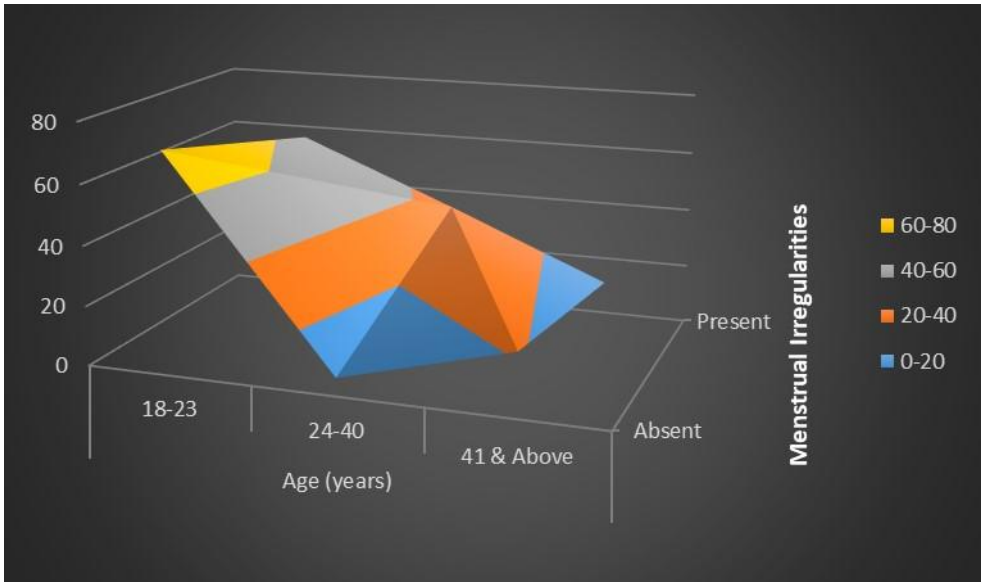
Note: SBP – Systolic Blood Pressure, DBP – Diastolic Blood Pressure

The Spearman correlation heatmap illustrates the relationships between age, SBP, DBP, stress, depression, and anxiety with colour gradients indicating correlation strength. Strong positive correlations (deep green) are seen between SBP and DBP (0.687), suggesting that higher systolic pressure aligns with higher diastolic pressure. Moderate positive correlations (light green / yellow) are observed between depression and anxiety (0.343) and depression and stress (0.186), indicating that increased depression levels correlate with higher anxiety and stress, though weaker than SBP-DBP. Weak to negligible correlations (light orange/pale yellow) show minimal associations, such as age with SBP (0.016) and DBP with anxiety (-0.082). Negative correlations (red) are very weak, such as stress with DBP (-0.118), showing a slight inverse relationship.

Menstrual Irregularities Across Age Groups

Figure 2

Reveals A trends in menstrual irregularities across different age groups.



Menstrual irregularities were most common in hypertensive women aged 24–40 (Fig. 2), with a range of 0–60%. Post-menopausal women aged 41 and above showed a dramatic drop in the frequency of abnormalities.

3.5 Mental Health Severity by BP Control

Figure 3

BP Status and DAS severities among HT patients with Menstrual Irregularities

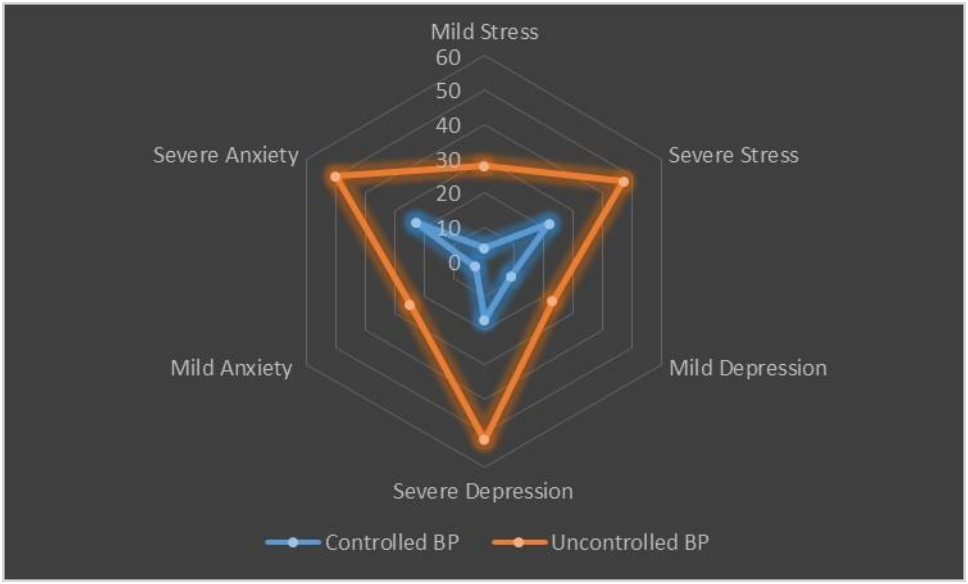
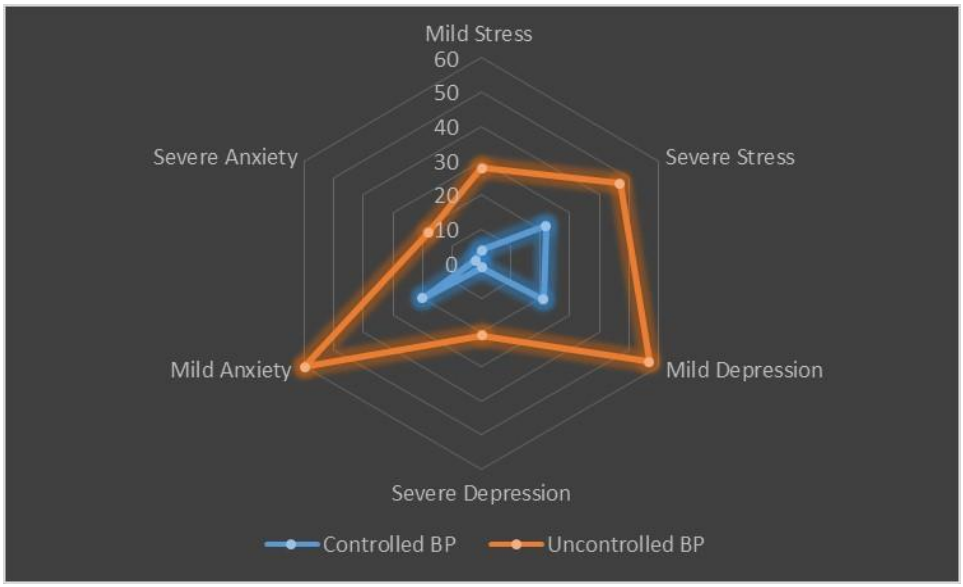


Figure 4

BP Status and DAS severities among HT patients without Menstrual Irregularities.



A comparison of mental health severity is shown in figures above. Severe anxiety, stress, and depression were more common among women with irregular menstruation who had uncontrolled blood pressure. Severe stress exceeded 50% and severe anxiety and depression were also higher in uncontrolled blood pressure than in the group with controlled blood pressure. Those with controlled blood pressure, in particular, showed much lower levels of anxiety and depression than did hypertensive women without irregular menstruation.

Discussion and Conclusion

The current study investigates the connection between women's mental health and hypertension in Madurai, with a special emphasis on the effects of irregular menstruation, blood pressure management, and sociocultural factors.

According to the study the hypertensive women without menstrual irregularities (median score of 18 [IQR: 13-22]) reports slightly higher stress (median score of 16 [IQR: 12-21]) than those with irregularities this could be due to contributing factors like uncontrolled blood pressure, postmenopausal status, obesity and a family history of hypertension. This primary finding supports Indian studies from Tamil Nadu (Sundarrajan et al., 2022) and Delhi (Singh & Pradhan, 2014), as well as international studies (Attia et al., 2023; Handy et al., 2022), which underscores the substantial impact of menstrual health on mental health outcomes.

Menstrual irregularities are more common in women with hypertension between the ages of 24 and 40, but are seen to decrease after the age of 41 and above. This is probably owing to age-related hormonal changes where the estrogen levels drop as women approach menopause, lowering the frequency of periods but raises the risks of cardiovascular disease and metabolic diseases (Lima et al., 2012). Women with hypertension experience mental health problems as a result of these hormonal changes, which also exacerbate depression and anxiety (Singh & Pradhan, 2014).

Uncontrolled blood pressure is a substantial contributor to mental health issues, as seen by the significant negative rank-biserial correlation (-0.330) between stress levels and controlled and uncontrolled blood pressure. The results of this clinical study are consistent with studies showing that untreated hypertension can raise stress levels, which have a detrimental impact on mental health (Niknam et al., 2022; Ojike et al., 2016).

Women who were overweight or obese had higher stress levels (mean rank of 68.96) than women who were normal weight, and there was a significant association between stress and BMI (-0.590). This is consistent with research that shows that being overweight increases the likelihood of mental health issues because of elements like obesity, social stigma, and metabolic issues (Sharma et al., 2021).

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Considering women with higher education levels tended to have greater mental health literacy, which helped them manage menopausal and reproductive symptoms more effectively, educational attainment was positively related with better mental health outcomes (Hossein Mirzaee Beni et al., 2022; Koyuncu et al., 2018). However, women in Tamil Nadu often normalize menopause due to cultural norms, which results in ignored symptoms and self-management practices like herbal remedies (Tariq et al., 2023). Menstrual and hypertension-related problems are stigmatized in society, which makes mental health problems worse and emphasizes the necessity for culturally competent interventions (Attia et al., 2023).

The Spearman correlation analysis revealed no significant relationship between blood pressure and mental health outcomes (DAS), despite the connections that were detected. Accordingly, blood pressure may have an impact on mental health, but the relationship is complex and it is difficult to prove causation because the study was cross-sectional. According to earlier studies, stress and hypertension are bidirectional, and this requires further exploration (Gordon & Mendes, 2021; Spruill, 2010).

Developing programs in healthcare centres that focus on stress management, counseling services, and personalized lifestyle interventions, like weight management including exercise, yoga, meditation, and dietary adjustments could provide mental health support, especially for those with BMI concerns and a family history of hypertension. Cultural and Social Stigma: In Madurai, implement culturally aware family education programs to normalize discussions around women's health. In addition to encouraging early treatment for menopause and mental health conditions, working with local leaders could contribute to mainstream discussions on hypertension and mental health. Health Literacy and Awareness: Educational initiatives in tertiary care should focus on the connections between mental health and hypertension. Workshops, culturally appropriate materials, and visual aids should be used to simplify the message and promote effective management of both conditions. Accessibility barriers: Create outreach at Madurai's tertiary healthcare centres with mobile units for routine blood pressure and mental health monitoring in underprivileged areas, guaranteeing continued care access, taking motivation from Tamil Nadu's public initiative program, “Makkalai Thedi Maruthuvam”. Socioeconomic Challenges: To address financial barriers, the study suggests providing subsidized healthcare for hypertensive women and incorporating social work services in tertiary care to assist patients in accessing welfare programs. Psycho-social Stressors: Include stress management and family-centred counselling in tertiary care. Collaborating with non-governmental organizations could help community organizations that offer menopausal and hypertensive women psychosocial support.

By addressing these challenges and implementing the suggested solutions, the study’s findings could lead to improved health outcomes for hypertensive women in Madurai, eventually enhancing their quality of life and well-being.

The single-centre design of the study limits the generalizability of its findings, which could not fully represent the broader population. Furthermore, a number of participants reported significant health conditions that would have impacted their stress, depression, and anxiety (DAS) levels, including severe hypertension problems, uncontrolled blood pressure, and irregular menstruation. It is possible that the study's timing during the COVID-19 epidemic affected the results related to mental health as well. Despite these drawbacks, the study's meticulous methodology offers insightful information about the relationship between DAS and hypertension by analyzing the combined effects of irregular menstruation, hypertension, and psychiatric symptoms on mental health in a diverse tertiary healthcare setting in Madurai, Tamil Nadu. Future studies should focus on longitudinal research to elucidate the causality and direction of relationships between menstrual irregularities blood pressure, and mental health outcomes. Treatment for hypertensive women with mental health issues may be informed by clinical studies examining the effectiveness of integrated therapies. Mechanistic research into hormonal, cardiovascular, and psychological pathways would also help us better understand the way these variables interact and affect women's health over time.

The biopsychosocial model established by the current study emphasizes the way in which the body, mind, and culture interact to affect health outcomes. The study summarizes the key findings of menstrual irregularities

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and uncontrolled blood pressure significantly contribute to the mental health burden in hypertensive women, with stress, anxiety, and depression being more severe in these populations. Socio-demographic factors, such as education and menopausal status, further influence these mental health outcomes. In the current study, biological, psychological, and social mechanisms are integrated to interpret the findings. Biologically, the hormonal imbalances and hypertension interact to influence mental health in hypertensive women, considering the dual impact of both conditions on stress regulation and brain function. Psychologically, exploring the role of DAS and coping strategies in exacerbating the impact of hypertension and menstrual irregularities on mental health, considering the cyclical nature of women's health and the way the mental health could worsen during periods of hormonal change. Socially, the study explored the societal and cultural factors in Tamil Nadu, such as education, financial support and stigma around menstrual health, can affect women's experiences of hypertension and mental health. This multi-faceted approach provides a thorough understanding of the complex relationships between blood pressure control, menstrual irregularities, and mental health thus focusing on a culturally adapted interventions which provides support in improving health outcomes for hypertensive women, particularly in settings where mental health issues may be stigmatized or neglected.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. This study was approved by the Internal Research and Review Board (IRB), Ethical Clearance (EC), Biosafety and Animal Welfare Committee of Madurai Kamaraj University, Madurai (Registration ID: EC/MKU/20-21/039) on 11th December 2020. Prior to their inclusion in the study, each participant gave written informed consent. The World Medical Association Declaration of Helsinki was followed in the ethical conduct of this study.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contributed to this study.

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