

## ОРИГИНАЛЬНЫЕ СТАТЬИ ORIGINAL ARTICLES

<https://doi.org/10.57256/2949-0715-2025-4-4-31-38>



### PREVALENCE OF CARDIOVASCULAR RISK FACTORS AMONG INDIVIDUALS WITH NORMOTENSION, PREHYPERTENSION, AND HYPERTENSION

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#### ABSTRACT

**Background.** Hypertension is a leading global health burden and a major risk factor for cardiovascular disease and premature mortality. Prehypertension, particularly in young adults, often goes unrecognized but predicts future hypertension. Both modifiable factors – diet, physical activity, tobacco use, and stress – and non-modifiable factors – age, sex, and family history – affect blood pressure. Early detection is essential for prevention.

**Aim.** To assess the prevalence of normotension, prehypertension, and hypertension, and their associated risk factors among adults in a tertiary medical institution in Jaipur, India.

**Materials and methods.** A cross-sectional study was conducted over 6 months among 700 participants aged 18–60 years at Rajasthan University of Health Sciences College of Medical Sciences and Associated Hospitals, Jaipur. Blood pressure was measured according to Ministry of Health and Family Welfare guidelines. Socio-demographic, anthropometric, and lifestyle data were collected. Statistical analysis was performed using SPSS v. 16, with  $p < 0.05$  considered significant.

**Results.** Of 700 participants (56 % male; mean age –  $22.77 \pm 6.67$  years), 65.0 % were normotensive, 34.9 % prehypertensive, and 0.02 % hypertensive. Prehypertension was more common in males, urban residents, physically inactive individuals, and those with obesity, central obesity, high salt intake, tobacco or alcohol use, or moderate-to-severe stress. Family history of hypertension was more frequent in prehypertensive and hypertensive participants.

**Conclusion.** Prehypertension is prevalent among young adults and is strongly associated with modifiable lifestyle factors and family history. Early identification and targeted lifestyle interventions are crucial to prevent progression to hypertension and reduce long-term cardiovascular risk.

**Key words:** *blood pressure, hypertension, lifestyle modification, prehypertension, risk factors*

**For citation:** Tyagi A., Kacker S., Saboo N., Kumar M. Prevalence of cardiovascular risk factors among individuals with normotension, prehypertension, and hypertension. *Baikal Medical Journal*. 2025; 4(4): 31-38. <https://doi.org/10.57256/2949-0715-2025-4-4-31-38>

## РАСПРОСТРАНЁННОСТЬ ФАКТОРОВ РИСКА СЕРДЕЧНО-СОСУДИСТОЙ ПАТОЛОГИИ СРЕДИ ЛИЦ С НОРМОТЕНЗИЕЙ, ПРЕДГИПЕРТЕНЗИЕЙ И ГИПЕРТЕНЗИЕЙ

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### АННОТАЦИЯ

**Актуальность.** Гипертензия является одной из основных проблем здравоохранения в мире и основным фактором риска сердечно-сосудистых заболеваний, а также преждевременной смертности. Предгипертензия, особенно у молодых людей, часто остаётся нераспознанной, но является предиктором развития гипертензии в будущем. На артериальное давление влияют как модифицируемые факторы (питание, физическая активность, курение и стресс), так и немодифицируемые факторы (возраст, пол и семейный анамнез). Раннее выявление заболевания крайне важно для профилактики.

**Цель.** Оценить распространённость нормотензии, предгипертензии и гипертензии, а также связанных с ними факторов риска среди взрослых в третичном медицинском учреждении в Джайпуре, Индия.

**Материалы и методы.** Исследование проводилось в течение 6 месяцев среди 700 участников в возрасте 18–60 лет в Медицинском колледже Раджастханского университета медицинских наук и ассоциированных больницах в Джайпуре. Артериальное давление измерялось в соответствии с рекомендациями Министерства здравоохранения и благополучия семьи. Были собраны социально-демографические, антропометрические данные и данные об образе жизни. Статистический анализ проводился с использованием SPSS v. 16, при этом  $p < 0,05$  считалось значимым.

**Результаты.** Из 700 участников (56 % мужчин; средний возраст –  $22,77 \pm 6,67$  года) 65,0 % имели нормотензию, 34,9 % – предгипертензию и 0,02 % – гипертензию. Предгипертензия чаще встречалась у мужчин, городских жителей, физически неактивных лиц, а также у лиц с ожирением, центральным ожирением, повышенным потреблением соли, курением или употреблением алкоголя, и у лиц с умеренным или тяжёлым стрессом. Семейный анамнез артериальной гипертензии чаще встречался у лиц с предгипертензией и гипертензией.

**Заключение.** Предгипертензия распространена среди молодых людей и тесно связана с модифицируемыми факторами образа жизни и семейным анамнезом. Раннее выявление и целенаправленные изменения образа жизни имеют решающее значение для предотвращения прогрессирования гипертензии и снижения долгосрочного сердечно-сосудистого риска.

**Ключевые слова:** артериальное давление, гипертензия, модификация образа жизни, предгипертензия, факторы риска

**Для цитирования:** Тьяги А., Какер С., Сабу Н., Кумар М. Распространённость факторов риска сердечно-сосудистой патологии среди лиц с нормотензией, предгипертензией и гипертензией. *Байкальский медицинский журнал*. 2025; 4(4): 31-38. <https://doi.org/10.57256/2949-0715-2025-4-4-31-38>

## INTRODUCTION

Blood pressure is a critical physiological parameter that represents the force exerted by circulating blood on the arterial walls and varies during the cardiac cycle. **Systolic blood pressure (SBP)** is the maximum pressure recorded during ventricular systole, primarily depending on cardiac output and arterial compliance. **Diastolic blood pressure (DBP), on the other hand,** represents the minimum pressure during diastole and depends on total peripheral resistance [1]. Stiffening of the arteries with age results in higher systolic pressure, whereas changes in vascular diameter and blood viscosity affect diastolic pressure.

According to the **Ministry of Health and Family Welfare**, adult blood pressure is categorized as **normal (< 120/80 mmHg)**, **prehypertensive (130–139/85–89 mmHg)**, and **hypertensive ( $\geq$  140/90 mmHg)**. Prehypertension is considered a precursor state increasing the risk of progression to overt hypertension if lifestyle interventions are not adopted [2].

Hypertension is a major **public health concern worldwide**, significantly contributing to **cardiovascular morbidity and mortality**. It includes coronary artery disease, stroke, heart failure, and renal complications. Globally, about 1 billion people are estimated to suffer from elevated blood pressure. This accounts for approximately 13.5 % of all premature deaths. In India, the prevalence of hypertension is steadily rising due to **urbanization, sedentary lifestyles, dietary changes, and increasing life expectancy** [3].

The **risk factors for hypertension** can be broadly classified into **non-modifiable** (age, gender, family history) and **modifiable** factors (obesity, physical inactivity, high salt intake, tobacco and alcohol use, and stress). Modifiable factors play a key role in the transition from normotension to prehypertension and eventually hypertension. Among these, **overweight and obesity** lead to the activation of the **renin-angiotensin-aldosterone system** and sympathetic overactivity, causing vasoconstriction and sodium retention. **Excess salt intake** increases extracellular fluid volume and blood pressure, while **tobacco use** and **psychological stress** exacerbate vascular reactivity [4].

**Prehypertension and hypertension are often asymptomatic**, earning them the title of “silent killers”. Early identification of individuals at risk through community-based screening and assessment of associated risk factors is vital for reducing the future burden of cardiovascular disease. Lifestyle modifications, including **weight management, increased physical activity, dietary salt reduction, and stress management**, have been shown to significantly reduce the risk of hypertension progression.

## MATERIALS AND METHODS

This observational study was conducted to investigate the prevalence of normotension, pre-hypertension, and hypertension, along with associated risk factors, within the working population of the Rajasthan Uni-

versity of Health Sciences (RUHS) College of Medical Sciences and Associated Hospitals, Jaipur.

### Study population and setting

The study was carried out over a six-month period at the RUHS campus and its associated hospitals in Jaipur. The target population comprised a diverse group of employed individuals aged 18 to 60 years, including medical and paramedical students, teaching and non-teaching staff, security personnel, and laborers.

### Sample size calculation

The sample size was determined based on preliminary data indicating the mean and standard deviation of the primary outcome variable. Using a standard formula with a 95 % confidence interval and 80 % statistical power, a minimum sample of 636 subjects was calculated. To account for a projected 10 % dropout rate, the final sample size was set at 700 participants, selected from a total study universe of approximately 1300 eligible individuals.

### Eligibility criteria

Participants were eligible for inclusion if they were between 18 and 60 years of age and provided written informed consent. Notably, individuals who reported alcohol use or smoking were not excluded, as these were considered relevant risk factors for analysis. Exclusion criteria were designed to minimize confounding effects and included pregnancy, a history of chronic illnesses (e.g., ischemic heart disease, stroke, or acute/chronic kidney disease), and current use of any anti-hypertensive medication, such as diuretics, angiotensin-converting enzyme inhibitors, beta-blockers, or calcium channel blockers.

### Ethical approval

The study protocol received approval from the Institutional Ethics Committee of RUHS-CMS (Approval No. EC/P-62/2021). Prior to enrollment, written informed consent was obtained from every participant.

### Statistical analysis

All statistical analyses were performed using SPSS version 16.0 (SPSS Inc., USA). The normality of continuous data was assessed using the Shapiro – Wilk test. Descriptive data for continuous variables are presented as mean  $\pm$  standard deviation (SD). For comparative analyses between categorical groups, Pearson’s t-test was employed. A *p*-value of less than 0.05 was considered statistically significant for all tests.

## RESULTS

The present observational study was conducted among 700 participants aged 18–60 years (mean age –  $22.77 \pm 6.67$  years) at the RUHS College of Medical Sciences and Associated Hospitals in Jaipur. Of these, 395 (56 %) were male and 305 (44 %) were female, with the majority living in urban areas (62.4 %), fol-

**TABLE 1**  
**ANTHROPOMETRIC PARAMETERS AND BLOOD PRESSURE CHARACTERISTICS OF THE STUDY POPULATION**

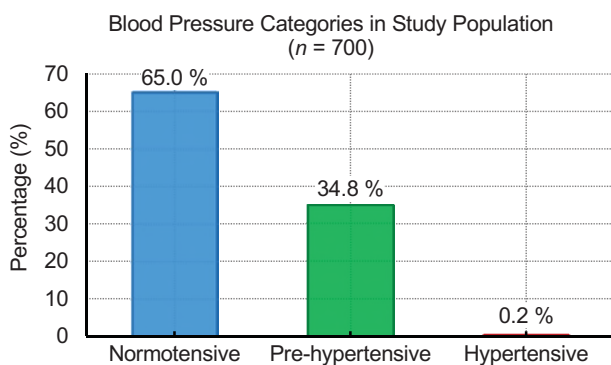
Parameters	Mean $\pm$ SD
Age, years	22.77 $\pm$ 6.67
Height, cm	166.90 $\pm$ 7.62
Weight, kg	59.30 $\pm$ 11.20
Body mass index, kg/m <sup>2</sup>	21.17 $\pm$ 3.63
Waist circumference	87.4 $\pm$ 13.3
Hip circumference	94.9 $\pm$ 13.6
Waist-to-hip ratio	0.92 $\pm$ 0.002
Systolic blood pressure, mmHg	118.48 $\pm$ 8.15
Diastolic blood pressure, mmHg	78.46 $\pm$ 5.96

lowed by semi-urban (17.8 %) and rural (19.7 %) regions. Most of the participants were unmarried (91 %), and 85 % were college students (Table 1).

Participants ( $n = 700$ ) were predominantly young (mean age – 22.77 years) with normal body mass index (21.17 kg/m<sup>2</sup>). The mean SBP (118.48 mmHg) and DBP (78.46 mmHg) were within the normal range, while the anthropometric indices (waist circumference – 87.4 cm, hip circumference – 94.9 cm, waist-to-hip ratio – 0.92) indicated a balanced fat distribution.

### Prevalence of blood pressure categories

The distribution of participants based on their blood pressure status, according to the criteria of the Ministry of Health and Family Welfare is summarized in Figure 1.



**FIG. 1.** Distribution of blood pressure categories among 700 participants in the study

Most of the participants (65 %) were **normotensive**. Approximately 34.8 % of them were **prehypertensive**, indicating a substantial proportion at risk for developing hypertension. Only a very small fraction (0.2 %) were **hypertensive**, reflecting a low prevalence of hypertension in this population. Overall, the graph highlights that most of the study population

had normal blood pressure, while about one-third were at an elevated risk.

### Analysis of risk factors associated with prehypertension and hypertension

The association between various risk factors and prehypertension was evaluated, with the results for non-modifiable and modifiable factors detailed in Tables 2 and 3, respectively.

Among non-modifiable factors, a positive correlation was observed between advancing age and the prevalence of prehypertension, despite the study population being predominantly (78.4 %) young adults aged 18–22 years. Furthermore, male gender was associated with a significantly higher proportion of prehypertensive states compared to females. Participants from urban residences also demonstrated a greater prevalence of prehypertension than their rural counterparts, a finding that may reflect differences in lifestyle and dietary habits.

Modifiable lifestyle factors revealed several significant associations. Nearly half (46.2 %) of the cohort was classified as physically inactive, and this group exhibited a markedly higher prevalence of prehypertension, underscoring physical inactivity as a key risk factor. Anthropometric measures further indicated a strong correlation between prehypertension and obesity. Both elevated body mass index and central obesity, defined by a waist-to-hip ratio  $> 0.95$  in males and  $> 0.85$  in females, were frequently observed among prehypertensive participants.

Psychosocial assessment using the Perceived Stress Scale indicated that individuals reporting moderate to severe stress scores were significantly more likely to be prehypertensive. This is consistent with the known physiological mechanism whereby chronic stress stimulates sympathetic activity, leading to transient elevations in blood pressure. Finally, the use of tobacco and alcohol was associated with a trend toward higher blood pressure, aligning with the established vascular effects of nicotine and alcohol.

TABLE 2

## ASSOCIATION OF NON-MODIFIABLE RISK FACTORS WITH BLOOD PRESSURE STATUS

Study parameters	n	Normal (%)	Prehypertension (%)	Hypertension (%)
<b>Age Group, years</b>				
18–22	478	369 (52.7 %)	109 (15.57 %)	–
23–27	140	58 (8.2 %)	82 (11.71 %)	–
28–32	28	13 (1.85 %)	15 (2.14 %)	–
33–37	5	1 (0.14 %)	4 (0.57 %)	–
38–42	21	6 (0.85 %)	15 (2.14 %)	–
43–47	13	4 (0.57 %)	8 (1.14 %)	1 (0.14 %)
48–52	11	4 (0.57 %)	6 (0.85 %)	1 (0.14 %)
53–57	2	–	2 (0.28 %)	–
58–60	2	–	2 (0.28 %)	–
<b>Gender</b>				
Male	395	255 (36.4 %)	139 (19.85 %)	1 (0.14 %)
Female	305	203 (29 %)	101 (14.42 %)	1 (0.14 %)
<b>Family history of hypertension</b>				
No	288	174 (24.8 %)	113 (16.1 %)	1 (0.14 %)
Yes	412	257 (36.7 %)	154 (22 %)	1 (0.14 %)

TABLE 3

## ASSOCIATION OF MODIFIABLE RISK FACTORS WITH BLOOD PRESSURE STATUS

Study parameters	n	Normal (%)	Prehypertension (%)	Hypertension (%)
<b>Body mass index, kg/m<sup>2</sup></b>				
< 18.5 (underweight)	149	90 (12.9 %)	59 (8.4 %)	–
18.5–24.9 (normal)	447	238 (34.0 %)	208 (29.7 %)	1 (0.1 %)
25.0–29.0 (overweight)	82	48 (6.9 %)	33 (4.7 %)	1 (0.1 %)
30.0–34.0 (obese)	22	16 (2.2 %)	6 (0.9 %)	–
<b>Tobacco use</b>				
No	659	478 (68.2 %)	181 (25.8 %)	–
Yes	41	27 (3.8 %)	12 (1.7 %)	2 (0.3 %)
<b>Alcohol consumption</b>				
No	526	289 (41.2 %)	237 (33.9 %)	2 (0.3 %)
Yes	174	98 (14.0 %)	76 (10.9 %)	–
<b>Stress level</b>				
Mild	135	71 (10.1 %)	64 (9.1 %)	–
Moderate	558	249 (35.6 %)	309 (44.6 %)	–
Severe	4	2 (0.3 %)	2 (0.3 %)	–
<b>Physical activity</b>				
Active	324	156 (22.2 %)	166 (23.7 %)	2 (0.3 %)
Sedentary	376	256 (36.6 %)	118 (16.9 %)	–
<b>Salt intake (per day)</b>				
> 5 g	360	162 (23.1 %)	196 (28.0 %)	2 (0.3 %)
< 5 g	340	160 (22.9 %)	180 (25.7 %)	–

## DISCUSSION

This observational study assessed the prevalence of normotension, prehypertension, and hypertension and their associated risk factors within the 18–60-year-old population affiliated with RUHS College of Medical Sciences, Jaipur. The investigation was conducted within the Department of Physiology, with a final cohort of 700 participants (395 males, 305 females) aged 18 to 25 years.

Table 1 presents the anthropometric profile of the study population. The mean ( $\pm$  SD) height and weight of participants were  $166.9 \pm 7.62$  cm and  $59.3 \pm 11.2$  kg, respectively. The mean waist circumference and hip circumference were  $87.4 \pm 13.3$  cm and  $94.9 \pm 13.6$  cm.

These findings are consistent with those reported in similar studies. Our results align with S. Rao et al. [5], who documented a mean height of  $168.3 \pm 64.0$  cm, weight of  $64.5 \pm 10.0$  kg, waist circumference of  $77.9 \pm 8.1$  cm, and a waist-to-hip ratio of  $0.88 \pm 0.10$ . Similarly, T. Midha et al. [6] reported a comparable mean waist circumference of  $78.9 \pm 11.0$  cm. The anthropometric data from N. Karmakar et al. [7] also show a similar profile, with a mean height of  $115.95 \pm 7.80$  cm, weight of  $67.39 \pm 10.50$  kg, waist circumference of  $74.1 \pm 8.7$  cm, and a waist-to-hip ratio of  $0.89 \pm 0.80$ .

Figure 1 summarizes the blood pressure data and prevalence rates observed in the present study. The mean systolic and diastolic blood pressures were  $118.48 \pm 8.15$  mmHg and  $78.46 \pm 5.96$  mmHg, respectively. The prevalence of normotension, prehypertension, and hypertension was 65 %, 34.85 %, and 0.02 %.

These hemodynamic values are consistent with those reported by R. Jayanthi et al. [8] ( $116.22 \pm 13.07$  and  $74.34 \pm 8.74$  mmHg) and S. Singh et al. [9] ( $124.0 \pm 15.0$  and  $83.4 \pm 9.5$  mmHg). Regarding prevalence, the proportion of prehypertensive individuals in our cohort (34.85 %) aligns with findings from R. Jayanthi et al. [8] (33.85 %) and falls within the range of hypertension/prehypertension rates reported by R. Godara et al. [11] and D.R. Bharati et al. [12] (22.0 and 50.7 %, respectively). In contrast, the prevalence of normotension in our study (65 %) was lower than the 89 % reported by U. Kumar et al. [10], while our hypertension rate (0.02 %) was substantially lower than the rates reported by all cited studies, including U. Kumar et al. [10] (11 %) and R. Jayanthi et al. [8] (5.1 %).

The analysis of risk factors revealed several significant associations. A family history of hypertension was reported in 22.0 % of prehypertensive, 36.7 % of normotensive, and 0.14 % of hypertensive individuals. This distribution differs from the findings of Z. Pilakadavath et al. [13], who reported a much higher prevalence (76.4 %) among prehypertensive subjects.

As summarized in Table 3, the modifiable risk factors analyzed were obesity, physical inactivity, stress, and alcohol and tobacco use. Analysis of dietary salt intake revealed that the prevalence of prehyperten-

sion was 28.0 % in subjects consuming more than five grams of salt per day, which was similar to the prevalence of 25.7 % in those consuming less than five grams per day. This finding contrasts with R.B. Singh et al. [14] and C. Bullen et al. [15], who reported that the prevalence of normotension and prehypertension in high salt consumers ( $> 5$  g/day) was 18.1 and 82.0 %, respectively, compared to 22.5 and 84.7 % in low salt consumers.

Regarding physical activity, the prevalence of normotension and prehypertension among physically active participants was 22.28 and 23.71 %, respectively. Among sedentary participants, the prevalence was 14.28 % for normotension and 16.67 % for prehypertension. This trend is consistent with R.B. Singh et al. [14] and S. Yadav et al. [16], who reported corresponding rates of 17.9 and 15.3 % in active individuals, and 16.5 and 18.9 % in sedentary individuals.

Concerning tobacco use, 3.8 % of tobacco users were normotensive, 1.7 % were prehypertensive, and 0.28 % were hypertensive. These proportions differ from those reported by R.B. Singh et al. [14] and S. Yadav et al. [16], who found that 9.2 % of tobacco users were normotensive, 10.2 % were prehypertensive, and 10.7 % were hypertensive. The overall prevalence of alcohol consumers in our study was 24.85 %, a result similar to the 19.2 % reported by K.R. Thankappan et al. [17]. Furthermore, the prevalence of modifiable risk factors in our population aligns with the broader literature, including R. Ibekwe [18], M.R. Akpa et al. [19], who reported rates for smoking, alcohol consumption, and obesity of 15.8 %, 43.4 %, and 18.8 %, respectively. Finally, our data on the distribution of risk factors are consistent with V. S. Choudhary et al. [20], who reported that modifiable and non-modifiable risk factors each accounted for 15.3 % of the risk in their study.

## LIMITATIONS

The age group (18–60 years) predominantly included younger individuals, affecting prevalence estimates. The study was conducted in a single institute and hence results cannot be generalized. Cross-sectional design limits the ability to assess cause-effect relationships.

## CONCLUSION

Prenhypertensive individuals demonstrated a higher prevalence of modifiable risk factors – including smoking, alcohol use, physical inactivity, elevated body mass index, and central obesity – compared to their normotensive counterparts. A clear gradient of increasing risk factor burden was observed across the blood pressure spectrum, from normotension to prehypertension and hypertension, indicating a progressive risk profile. Furthermore, a family history of hypertension, a non-modifiable risk factor, was significantly more common among prehypertensive and hypertensive individuals than among

normotensives, underscoring the role of genetic predisposition. Although the number of hypertensive subjects in this cohort was limited, this group exhibited a confluence of multiple risk factors, reinforcing the concept of compounded risk associated with several concurrent contributors.

## ACKNOWLEDGEMENTS

The authors sincerely acknowledge the support of the Rajasthan University of Health Sciences College of Medical Sciences and Associated Hospitals, Jaipur, for facilitating this study. They thank all the participants for their time and cooperation. And they are also grateful to the faculty, staff, and research assistants who contributed to data collection, management, and analysis, reviewed the manuscript, and offered valuable inputs for data interpretation and final editing.

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**Conflict of interest**

The authors declare no apparent or potential conflict of interest related to the publication of this article.

**Funding source**

The authors declare no external funding for the study and publication of the article.

**Authors' contribution**

Ankita Tyagi – conceptualization of the study; collection and analysis of the data; creation of the manuscript draft; design and execution of research work, including statistical analysis and interpretation of results.

Sudhanshu Kacker – guidance in study design; critical review of the manuscript and valuable inputs for data interpretation and final editing.

Neha Saboo – guidance in study design; critical review of the manuscript and valuable inputs for data interpretation and final editing.

Munesh Kumar – guidance in study design; critical review of the manuscript and valuable inputs for data interpretation and final editing.

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Received 28.10.2025  
Accepted 09.11.2025  
Published 10.12.2025

**Конфликт интересов**

Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

**Источник финансирования**

Авторы декларируют отсутствие внешнего финансирования для проведения исследования и публикации статьи.

**Вклад авторов**

Анкита Тьяги – разработка концепции исследования; сбор и анализ данных; подготовка рукописи; дизайн и выполнение исследовательской работы, включая статистический анализ и интерпретацию результатов.

Судханшу Какер – руководство разработкой дизайна исследования; критическое рецензирование рукописи и ценный вклад в интерпретацию данных и окончательное редактирование.

Неха Сабу – руководство разработкой дизайна исследования; критическое рецензирование рукописи и ценный вклад в интерпретацию данных и окончательное редактирование.

Мунеш Кумар – руководство разработкой дизайна исследования; критическое рецензирование рукописи и ценный вклад в интерпретацию данных и окончательное редактирование.

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Получена 28.10.2025  
Принята 09.11.2025  
Опубликована 10.12.2025