ORIGINAL ARTICLE

Geographical differentials in Hypertension and Diabetes among Indian Population

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ABSTRACT

Background: Non-communicable diseases (NCDs) represent the world's largest public health challenge, causing 43 million deaths globally in 2021 — 75% of all non-pandemic-related deaths. India bears a disproportionate share, contributing ~14.5% of global NCD deaths, with mortality from NCDs rising sharply from 37.9% in 1990 to 61.8% in 2016. Key contributors include cardiovascular diseases and stroke (45%), chronic respiratory diseases (22%), cancers (12%), and diabetes (3%). **Aims & Objectives:** To examine the prevalence and trends of diabetes and hypertension across regional, state, and district levels in India using national survey data. **Methodology:** Secondary data from NFHS-4 and NFHS-5 were analysed to assess the distribution and burden of hypertension and diabetes at sub-national levels, accounting for socio-economic, demographic, and epidemiological variations. Descriptive statistics, including bivariate and multivariate analyses, were performed to examine the prevalence and associated factors of NCDs. **Results:** Both high blood sugar and high blood pressure showed increasing prevalence across successive national health surveys. Despite over 220 million estimated hypertensives in India, only 12% had blood pressure under control. Significant regional and state-level disparities were identified. **Conclusion:** Sub-national analysis is essential for designing context-specific NCD interventions. District-level data enables policymakers to prioritise resources and address the diverse socio-cultural and epidemiological drivers of NCDs across India.

KEYWORDS

Hypertension; Diabetes Mellitus; Noncommunicable Diseases; Epidemiology; Health Surveys; India; Health Status Disparities.

CONCEPTUAL FRAMEWORK

The study is guided by the Social Determinants of Health (SDH) framework, which explains how socio-demographic factors such as education, wealth status, age, gender, and region influence the risk of Non-Communicable Diseases (NCDs). These distal determinants shape behavioral risk factors including tobacco use, alcohol consumption, dietary practices, and physical inactivity, which subsequently contribute to the development of hypertension and diabetes. The framework

also recognizes the role of biological aging in increasing vulnerability to NCDs. Using multivariate analysis, the study identifies the relative influence of social and behavioral determinants on NCD prevalence across districts in India, thereby enabling a deeper understanding of regional and socio-economic disparities in health outcomes.

Aims & Objectives

- To examine the prevalence and geographical distribution of hypertension and diabetes across states and districts in India using NFHS-4 (2015–16) and NFHS-5 (2019–21) data.
- To assess temporal changes and socio-demographic and behavioural determinants associated with hypertension and diabetes among Indian adults.
- To identify regional and district-level disparities in hypertension and diabetes for informing targeted public health planning and policy interventions.

MATERIAL & METHODS

Study Type & Study Design: This study follows a cross-sectional analytical design using secondary data from two successive rounds of the National Family Health Survey (NFHS)-4 (2015–2016) and NFHS-5 (2019–2021) to estimate the prevalence and determinants of Non-Communicable Diseases (NCDs), particularly hypertension and diabetes, in India. Appropriate sampling weights provided by NFHS were applied to ensure representative estimates at national, state, and district levels.

Study Setting: The study was conducted across all states and union territories of India using nationally representative NFHS datasets. Regional analysis was performed according to the standard geographical divisions adopted by NFHS for comparative analysis.

Study Population: The study population comprised eligible women aged 15–49 years and men aged 15–54 years who participated in the biomarker component of NFHS-4 and NFHS-5. The biomarker schedule included measurements of blood pressure and random blood glucose levels.

Study Duration: The analysis covers two survey periods: NFHS-4 (2015–2016) and NFHS-5 (2019–2021), providing a comparative perspective spanning approximately five years.

Sample Size Calculation: As this is a secondary data analysis study, no independent sample size calculation was performed. NFHS-4 and NFHS-5 were designed with large, nationally representative sample sizes specifically to enable district-level estimates. These rounds were selected because their expanded sample frames, unlike previous iterations, permit estimation of health indicators at the district level.

Inclusion Criteria: All eligible women aged 15–49 years and men aged 15–54 years who participated in the NFHS-4 or NFHS-5 biomarker module and provided valid blood pressure and/or blood glucose measurements were included.

Exclusion Criteria: Respondents who did not provide biomarker measurements, those outside the eligible age range, and records with missing or implausible values were excluded from the analysis.

Strategy for Data Collection: This study utilises publicly available secondary data from NFHS-4 and NFHS-5, conducted by the International Institute for Population Sciences (IIPS), Mumbai, under the Ministry of Health and Family Welfare, Government of India. Both surveys employed a stratified two-stage cluster sampling design to ensure national and state-level representativeness. To ensure comparability across rounds, district boundaries were harmonised: where boundaries remained consistent, NFHS-5 data were used directly; where district reconfigurations occurred, NFHS-5 data were re-coded and aggregated to align with NFHS-4 district definitions.

Working Definition: Blood pressure was measured using a digital blood pressure monitor (IIPS, 2017). Three readings per respondent were taken at five-minute intervals; the mean of all three was used in all analyses. **Hypertension** was defined as mean systolic blood pressure (SBP) ≥140 mm Hg or mean diastolic blood pressure (DBP) ≥90 mm Hg. Random blood glucose was measured by finger-stick with a digital glucometer. **High blood glucose** was defined as a random blood glucose level of 141–160 mg/dl, and **very high**

blood glucose as ≥161 mg/dl (IIPS, 2017). To establish prevalence categories for district-level comparisons, the range of male prevalence for both conditions was divided into four equally sized quartiles; the resulting cut-off points were then applied to categorise female prevalence, ensuring a consistent comparative framework across genders.

Ethical Issues & Informed Consent: This study uses publicly available, anonymised secondary data from NFHS-4 and NFHS-5. No primary data collection was undertaken. The original surveys were conducted with appropriate ethical approvals from the Institutional Review Board of IIPS, Mumbai, and informed consent was obtained from all respondents at the time of data collection. Since the dataset is de-identified and freely accessible for research purposes, no additional ethical clearance was required for this analysis.

Data Analysis – Software: Descriptive statistics, including bivariate and multivariate (logistic regression) analyses, were performed to examine the prevalence and associated factors of NCDs. Regions were categorised according to the standard geographical divisions established by the NFHS for consistent comparative analysis. All statistical analyses were conducted using STATA (version 12). District-level geographic maps illustrating NCD prevalence were generated using QGIS software.

Flow Diagram

NFHS-4 (2015–16) & NFHS-5 (2019–21) datasets
↓
Selection of eligible respondents (Women 15–49 years; Men 15–54 years)
↓
Extraction of biomarker and socio-demographic variables
↓
Data cleaning and application of sampling weights
↓
Descriptive and bivariate analysis
↓
Multivariate logistic regression analysis
↓
District-level categorization and GIS mapping
↓
Interpretation of regional, state, and district-level prevalence patterns

RESULTS

Analysis of NFHS 4 (2015-16) and NFHS 5 (2019-21) on background characterstics: A comparison of findings from NFHS-4 (2015-2016) and NFHS-5 (2019-2021) reveals a significant increase in the prevalence of both diabetes and hypertension among both women and men in India. While both sexes experienced a rise, the increase was more pronounced among males. The gender gap in diabetes prevalence widened from 2.2 percentage points in NFHS-4 to 2.9 percentage points in NFHS-5. Similarly, for hypertension, this gap expanded from 3.8 percentage points to 4.7 percentage points over the same period. The increase was more pronounced among males across both conditions, with the gender gap in diabetes widening from 2.2 to 2.9 percentage points and in hypertension from 3.8 to 4.7 percentage points (Table 1).

Age-stratified prevalence increased monotonically across all groups in both rounds (Table 1). A notable concern is the observed rise even in the 15–24-year age groups. While urban populations maintained higher absolute rates, the increase in diabetes among rural women and hypertension among rural men exceeded urban counterparts, narrowing the rural–urban gap for women's diabetes from 1.7 to 1.3 percentage points, though the gap for hypertension widened slightly across both sexes.

Educational attainment demonstrated a significant inverse relationship with the prevalence of both conditions in NFHS-5, with rates declining progressively from no education to higher education for both sexes. In particular, hypertension and diabetes prevalence among women was nearly halved between the two extremes of educational attainment. This gradient was less consistent in NFHS-4, where men with primary and higher education showed an irregular upward trend.

Religious affiliation also influenced NCD prevalence (Table 1). Among women, Christians and Sikhs recorded the highest burdens of diabetes and hypertension, respectively; a similar pattern held for men.

Between survey rounds, diabetes rose most sharply among Muslim women and Hindu men, while hypertension increased most among Sikh women and Christian men, with Muslim men showing no change in hypertension.

A clear positive association was observed between wealth quintile and the prevalence of both conditions (Table 1). Notably, the increase between survey rounds was more pronounced in lower quintiles: diabetes rose most in the poorest quintile among women, and in the poor and poorest quintiles among men. This inverse pattern in the rate of increase suggests that NCD burden is accelerating disproportionately among economically disadvantaged groups.

Given that approximately 69% of the Indian population resides in rural areas, these trends underscore the urgency of targeted NCD prevention strategies in rural settings.

Comparison of state level prevalence of Hypertension and Diabetes in NFHS 4 and 5: In NFHS-5, wide inter-state variation was evident for both conditions (Table 2). Sikkim recorded the highest hypertension prevalence in both sexes (25.5% women; 35.3% men), while Rajasthan and Ladakh had the lowest. For diabetes, Tripura led among women and Dadra & Nagar Haveli among men. Despite an overall upward trend, diabetes declined in seven states among women and eight among men, and hypertension fell in 11 states for both sexes. Chhattisgarh, Jammu & Kashmir, and Nagaland showed reductions in diabetes for both sexes, while eight states including Assam, Gujarat, Haryana, and Rajasthan recorded hypertension declines in both.

District wise analysis: Table 3 presents the distribution of districts across four prevalence categories for hypertension and diabetes by sex. Across all four indicators, a clear upward shift is observed from NFHS-4 to NFHS-5, with districts moving into higher categories. The key patterns by indicator are summarised below.

Hypertension among Women: In NFHS-5, the majority of districts (62%) fall in the moderate category (II), up from 50.2% in NFHS-4, with a net addition of 76 districts. Districts in the low and very high categories declined, indicating a general upward shift toward moderate-to-high prevalence.

Hypertension among men: A similar upward shift is seen among men, with the share of districts in the moderate and high categories rising from 53% to 56% and from 11% to 18%, respectively, and a corresponding decline in the low category.

Blood Glucose level among women: Districts in the low and moderate categories declined between rounds while the high and very high categories gained, with 90 districts added in the very high category (above 9.65%) alone, indicating a marked increase in diabetes burden among women.

Blood Glucose level among men: The most striking change was in the very high category (16.72%+), which increased nearly eightfold from 9 to 48 districts, while the low category (category I) declined from 35% to 27% of all districts.

Zonal patterns from Annexure 1 reveal that districts shifted toward higher diabetes categories in almost all zones. In the Central zone, Chhattisgarh was an exception, with all six districts moving down to category II, while Madhya Pradesh, Uttar Pradesh, and Uttarakhand collectively added 15 and 6 districts in categories III and IV, respectively.

In the Eastern region (Annexure 2), the major shift was a reduction of 18 districts in the low category and addition of 15 in the very high category, with Odisha and West Bengal together contributing 11 districts to category IV, signalling a growing high-burden cluster.

In the North-East, districts increased across categories III and IV, led by Assam (12 additional districts in category III) and Tripura, which gained three districts in category IV. In contrast, the Northern region remained relatively low-prevalence, with 86% of districts in categories I and II, though Himachal Pradesh added four districts to category III. Southern states showed the most pronounced upward shift: the combined share of categories III and IV rose from 29% to 53%, with Tamil Nadu contributing 8 of the 14 districts in category IV. The Western region followed a similar but more modest trend, with the combined share of categories III and IV rising to 21%, driven by Maharashtra and Gujarat.

Overall, the number of districts in the very high diabetes category (category IV) increased from

9 to 48 between NFHS-4 and NFHS-5, and the number of states with such districts rose from 6 to 21. Tamil Nadu (8 districts), West Bengal, and Odisha (6 each) accounted for the largest concentrations in category IV, with Eastern and Southern states predominating. Category III expanded by 52% (from 89 to 136 districts across 28 states), led by Assam (14 districts). Correspondingly, categories I and II collectively lost 145 districts.

Men with high blood pressure: Annexure 3 shows a clear upward shift in hypertension among men, with the share of districts in categories III and IV rising by 58% and 28%, respectively, and a commensurate decline in category I.

Annexure 4 reveals marked regional variation. Tamil Nadu (20 districts) and Punjab (16) led category III, while Arunachal Pradesh (3) and Delhi (2) dominated the very high category (IV). Central states led category II, with Uttar Pradesh contributing 46 and Madhya Pradesh 34 districts. Southern states were disproportionately represented in higher categories, while the Western and Northern regions remained predominantly in lower categories, with the exception of Punjab.

Zonal shifts were most pronounced in the Central, Eastern, and Southern regions. In the Central zone, districts in UP and MP moved substantially into category II. Assam showed high vulnerability, with 9 of its 16 districts in category III and 3 in category IV. The Southern region had 55% of districts in category II and 38% in category III, with no districts in category IV, while the Western region remained largely in categories I and II.

Figure-1 District wise prevalence of blood pressure among men in India, 2015-16 & 2019-21

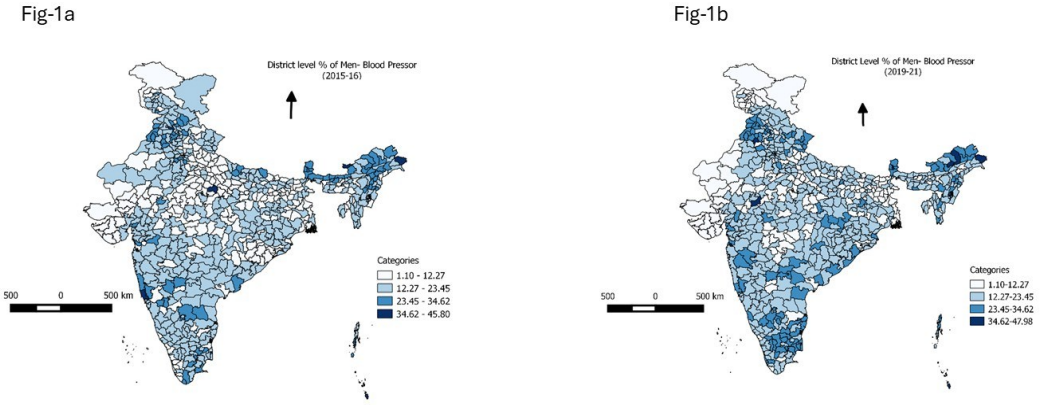


Figure 2: District wise prevalence of blood sugar among men in India, 2015-16 & 2019-21

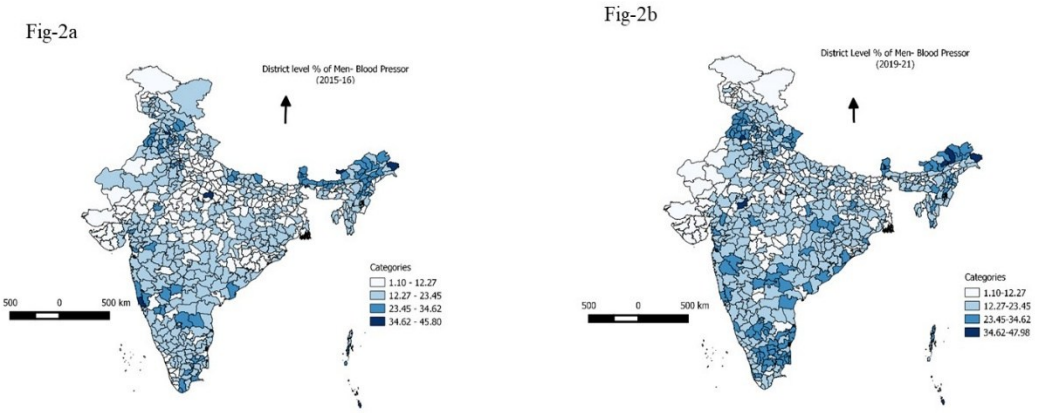


Figure 3: District wise prevalence of blood pressure among women in India, 2015-16 & 2019-21.

Fig-3a

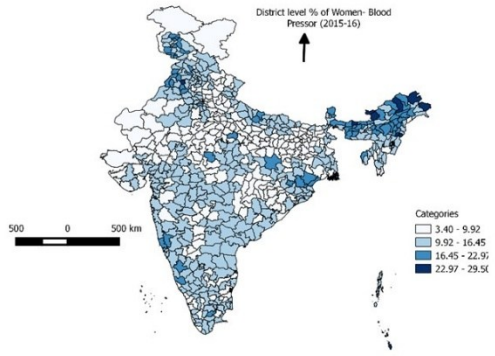


Fig-3b

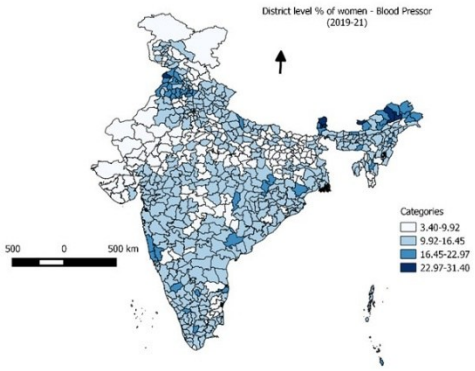


Figure-4 District wise prevalence of blood sugar among women in India, 2015-16 & 2019-21

Fig-4a

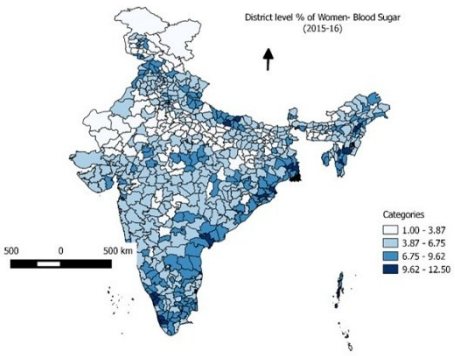
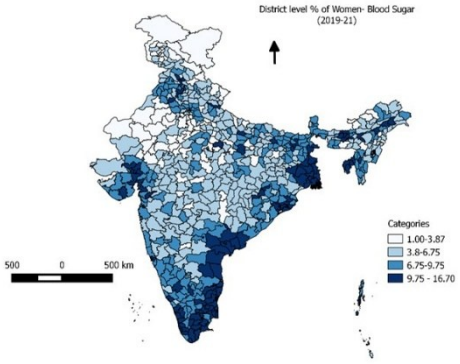


Fig-4b



Multivariate analysis of socio-demographic determinants of diabetes and hypertension (Tables 4 and 5) consistently confirmed the patterns described above. Age was the strongest predictor: respondents aged 35 years and above had approximately 7–8 times higher odds of hypertension and 5–6 times higher odds of diabetes compared to those aged 15–19 years, across both survey rounds and both sexes. Rural residence was associated with marginally but significantly lower odds of both conditions in NFHS-5 for both men and women. Educational attainment showed contrasting associations by sex: higher education was protective among women (OR 0.728 for hypertension; OR 0.895 for diabetes in NFHS-5), while educated men were more likely to report hypertension, with no significant association for diabetes. Muslim women had higher odds of both conditions in both rounds, whereas Muslim men had significantly lower odds in NFHS-5. Wealth quintile was positively associated with prevalence for both sexes, with the highest quintile showing approximately 1.26 times higher odds of hypertension among women compared to the poorest. Frequent alcohol consumption was strongly and consistently associated with hypertension in both sexes (OR approximately 1.6 for women and 1.7 for men in NFHS-5), though its association with diabetes was inconsistent. Regionally, western and southern India had lower odds of hypertension compared to the north, while the north-east had higher odds for both conditions, particularly diabetes among women.

Table 1: Percentage of different Non-Communicable Diseases by socio-demographic characteristics in India 2015-16 & 2020-21.

Socio-demographic characteristics	NFHS-4 (2015-16)				NFHS-5 (2019-21)			
	Women (%)		Men (%)		Women (%)		Men (%)	
	Diabetes	HTN	Diabetes	HTN	Diabetes	HTN	Diabetes	HTN
Age of respondent								
15-19 years	2.0	2.8	2.8	3.4	2.6	3.35	3.0	4.0
20-24 years	2.6	4.4	3.7	7.3	3.29	4.71	5.2	8.7
25-29 years	3.7	6.9	5.4	11.5	4.7	6.67	7.0	11.3
30-34 years	5.3	10.6	7.8	16.0	7.17	10.36	9.9	17.0
35 and more years	10.5	20.4	13.5	24.7	13.07	21.48	17.6	26.9
Place of residence								
Urban	6.9	12.0	8.8	16.6	8.4	12.9	11.8	18.2
Rural	5.2	10.4	7.4	13.7	7.1	11.2	9.7	15.4
Educational Attainment								
No education	6.8	14.1	8.3	15.5	9.19	16.6	12.6	18.0
Primary	6.6	13.2	9.2	16.6	9.64	15.0	12.3	17.5
Secondary	5.2	9.3	7.6	13.8	6.85	9.9	10.1	16.0
Higher	4.9	7.9	8.0	16.4	5.59	8.1	9.1	16.0
Religion								
Hindu	5.7	10.6	7.9	14.8	7.38	11.45	10.4	16.9
Muslim	6.0	12.1	8.4	13.1	8.18	12.52	10.7	13.1
Christian	7.8	13.2	8.7	14.7	9.42	13.31	11.1	18.6
Sikh	6.0	15.5	7.5	23.6	7.22	18.51	7.8	25.3
Other	5.2	11.6	8.9	17.1	6.34	11.86	10.3	15.5
Wealth Quintile								
Poorest	4.3	9.3	6.5	10.5	6.55	10.31	9.6	12.4
Poor	4.9	9.9	6.5	11.7	6.78	10.78	9.9	14.3
Middle	5.5	10.4	7.6	14.6	7.5	11.82	9.8	17.4
Higher	6.8	12.3	8.9	17.2	8.37	12.55	11.1	17.7
Highest	7.3	12.6	9.6	18.0	8.33	13.19	11.8	19.5
Alcohol Consumption								
No drinks	5.8	10.9	7.6	12.9	7.51	11.68	9.7	14.2
Almost everyday	4.9	19.9	10.0	27.3	7.44	23.92	14.2	31.0
Once a week	6.3	19.8	9.0	19.7	8.51	20.99	13.2	25.3
Less than once a week	5.8	15.9	8.5	17.0	7.32	17.25	12.7	19.7
Any form of smoking Tobacco								
No	5.8	11.0	7.8	14.5	7.5	11.7	10.0	15.9
Yes	8.4	15.4	8.7	16.6	7.7	14.9	13.4	19.4
Any form of smokeless Tobacco								
No	5.7	10.7	7.9	14.7	7.5	11.7	10.5	15.9
Yes	7.7	15.3	8.1	15.1	8.8	16.5	10.3	18.7
Region								
North	4.9	11.5	6.6	16.4	8.23	13.02	10.7	19.9
Central	5.1	9.4	7.2	11.6	11.39	12.58	14.7	14.7
East	5.9	10.3	9.2	12.4	6.38	13.75	11.8	24.9
Northeast	5.6	17.1	7.3	20.1	7.62	12.67	9.9	16.8
West	5.3	11.5	6.8	16.1	5.78	9.86	8.2	12.6
South	7.3	11.7	9.5	16.9	6.75	12.62	10.0	17.9
Total	**5.8**	**11.0**	**8.0**	**14.8**	**7.5**	**11.7**	**10.4**	**16.4**

Table:2 Percentage of state level hypertension and diabetes in India year 2015-16 & 2020-21.

States	Women NFHS 4		Men NFHS 4		Women NFHS 5		Men NFHS 5	
	Diabetes	HTN	Diabetes	HTN	Diabetes	HTN	Diabetes	HTN
Andaman and nicobar	9.3	11.6	16.5	29.9	10.6	15.4	11.7	23.4
Andhra pradesh	8.2	12.5	9.8	17.5	10.7	13.4	13.5	19.3
Arunachal pradesh	4.8	16.7	7.6	22.6	5.6	18.9	8.6	26.8
Assam	5.2	18.0	6.6	20.8	8.3	12.2	11.7	14.8
Bihar	4.2	8.2	6.7	11.0	7.5	8.9	9.4	11.0
Chandigarh	5.6	11.0	6.9	14.4	11.2	14.3	11.6	24.9
Chhattisgarh	5.7	10.0	9.7	13.2	5.2	14.4	7.5	21.3
Dadra and nagar havel	4.7	9.5	8.7	12.5	8.7	8.7	20.8	10.4
Daman and diu	5.5	10.2	8.8	11.3	NA	NA	NA	NA
Goa	8.9	11.6	12.3	14.9	10.2	12.5	15.1	18.2

Gujarat	5.8	11.4	7.6	14.3	9.1	10.6	9.9	13.9
Haryana	4.8	13.3	6.1	19.4	6.4	11.9	8.3	17.9
Himachal pradesh	5.9	14.4	6.8	23.4	6.9	11.2	7.8	17.7
Jammu and kashmir	5.6	16.1	6.3	15.5	4.0	11.0	3.8	9.9
Jharkhand	4.9	9.1	7.7	13.2	5.9	9.4	9.6	14.3
Karnataka	6.3	11.5	8.4	16.8	7.1	13.1	9.0	20.5
Kerala	8.7	9.2	13.1	11.5	10.8	11.9	11.8	18.2
Lakshadweep	11.1	14.2	13.3	10.9	9.1	9.9	13.6	16.9
Madhya pradesh	5.1	9.7	6.7	12.3	5.4	11.4	8.3	16.9
Maharashtra	5.0	11.5	5.9	17.7	6.0	12.3	9.2	17.9
Manipur	7.6	12.6	9.3	21.3	7.4	14.0	9.8	26.4
Meghalaya	4.3	14.1	6.4	12.9	5.9	14.3	12.1	18.3
Mizoram	8.6	12.2	10.3	18.5	7.9	12.6	10.6	22.6
Nagaland	7.2	16.8	9.7	23.6	5.4	13.5	7.5	20.6
Delhi	7.5	9.1	10.0	5.7	5.8	15.1	8.1	28.1
Odisha	7.3	11.9	10.7	13.8	8.8	13.3	11.4	18.2
Puducherry	7.3	12.2	7.5	17.2	9.9	10.5	10.9	20.5
Punjab	6.1	15.1	6.7	22.6	7.1	18.8	7.9	26.9
Rajasthan	3.5	8.5	5.7	13.4	3.5	8.2	4.9	11.4
Sikkim	6.7	18.4	8.9	30.9	7.8	25.2	8.8	35.3
Tamil nadu	7.1	11.6	9.7	17.6	11.3	12.5	12.7	24.0
Tripura	7.7	15.6	9.6	16.2	12.5	13.2	17.4	17.3
Uttar pradesh	5.0	9.2	7.1	11.1	5.7	11.0	7.7	14.9
Uttarakhand	6.1	12.0	8.8	18.3	6.1	13.8	12.2	25.9
West bengal	7.4	12.0	11.4	12.9	12.4	12.2	15.5	11.8
Telangana	6.9	13.2	6.0	19.8	8.1	15.0	12.8	25.0
Ladakh	NA	NA	NA	NA	3.18	10.31	4.39	7.8
Total	5.8	10.96	8.0	14.8	7.52	11.74	10.44	16.4

Table 3 Number of district by prevlace category of hypertension and diabetes among women and men, year 2015-16 & 2020-21.

Category	NFHS_4		NFHS_5	
	No. of District	%	No. of District	%
Hypertension among women (N=640)				
3.40-9.92	244	38.1	187	29.2
9.93-16.45	321	50.2	397	62.0
16.46-22.97	66	10.3	49	7.7
22.97+	9	1.4	7	1.1
Hypertension among men (N=640)				
1.10-12.27	220	34.4	157	24.5
12.28-23.45	339	53.0	357	55.8
23.46-34.62	74	11.6	117	18.3
34.62+	7	1.1	9	1.4
Diabetes among women (N=640)				
1.0-3.87	132	20.6	87	13.6
3.88-6.78	333	52.0	251	39.2
6.79-9.65	152	23.8	189	29.5
9.65+	23	3.6	113	17.7
Diabetes among men (N=640)				
0.60-5.97	221	34.5	172	26.9
5.98-11.35	321	50.2	284	44.4
11.36-16.72	89	13.9	136	21.3
16.72+	9	1.4	48	7.5
	640		640	

Table 4: Multivariate analysis for diabetes and hypertension among women by socio-demographic characteristics, 2015-16

Socio-demographic characteristics	Women				Men			
	Hypertension		Diabetes		Hypertension		Diabetes	
	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI

Age of respondent								
15-19 years®								
20-24 years	1.613***	(1.546-1.683)	1.221***	(1.157-1.289)	2.025***	(1.844-2.225)	1.231**	(1.093-1.387)
25-29 years	2.448***	(2.352-2.548)	1.659***	(1.576-1.746)	3.066***	(2.804-3.352)	1.710***	(1.528-1.913)
30-34 years	3.904***	(3.754-4.059)	2.508***	(2.386-2.635)	4.395***	(4.027-4.796)	2.648***	(2.38-2.946)
35 and more years	8.005***	(7.724-8.296)	4.949***	(4.737-5.171)	7.269***	(6.714-7.870)	4.508***	(4.108-4.947)
Place of residence								
Urban®								
Rural	0.992	(0.973-1.011)	0.943***	(0.919-0.968)	0.958*	(0.918-1)	0.981	(0.926-1.039)
Educational Attainment								
No education ®								
Primary	1.057***	(1.031-1.083)	1.078***	(1.042-1.115)	1.044*	(0.973-1.12)	1.111*	(1.013-1.217)
Secondary	0.960***	(0.94-0.981)	1.005	(0.976-1.035)	1.081**	(1.018-1.147)	1.062	(0.982-1.149)
Higher	0.776***	(0.75-0.803)	0.868***	(0.829-0.908)	1.196***	(1.11-1.288)	1.023	(0.926-1.131)
Religion								
Hindu®								
Muslim	1.301***	(1.272-1.331)	1.131***	(1.096-1.167)	0.933**	(0.881-0.987)	0.97	(0.899-1.046)
Christian	0.885***	(0.856-0.915)	1.051**	(1.003-1.1)	0.829***	(0.766-0.898)	0.958	(0.859-1.069)
Sikh	1.392***	(1.326-1.462)	1.109**	(1.031-1.193)	1.403V	(1.255-1.569)	1.182	(0.996-1.403)
Other	1.072**	(1.024-1.123)	0.920**	(0.857-0.988)	1.143**	(1.031-1.267)	0.914	(0.783-1.068)
Wealth Quintile								
Poorest®								
Poor	1.082***	(1.053-1.111)	1.142***	(1.1-1.186)	1.129***	(1.056-1.207)	1.052	(0.965-1.146)
Middle	1.176***	(1.144-1.209)	1.312***	(1.263-1.364)	1.349***	(1.26-1.444)	1.208***	(1.106-1.319)
Higher	1.343***	(1.303-1.383)	1.574***	(1.511-1.64)	1.584***	(1.474-1.701)	1.398***	(1.273-1.534)
Highest	1.447***	(1.399-1.497)	1.773***	(1.694-1.856)	1.724***	(1.595-1.865)	1.625***	(1.468-1.8)
Alcohol Consumption								
No drinks								
Almost everyday	1.605***	(1.442-1.787)	0.653***	(0.531-0.802)	1.788***	(1.655-1.932)	1.048	(0.937-1.171)
Once a week	1.406***	(1.319-1.498)	0.919	(0.828-1.02)	1.308***	(1.241-1.379)	0.985	(0.916-1.06)
Less than once a week	1.303***	(1.227-1.385)	1.038	(0.948-1.137)	1.181***	(1.12-1.245)	1.015	(0.946-1.089)
Any form of smoking Tobacco								
No®								
Yes	0.796***	(0.717-0.884)	1.182*	(1.039-1.344)	0.881***	(0.838-0.927)	0.957	(0.894-1.024)
Any form of smokeless Tobacco								
No®								
Yes	0.892***	(0.867-0.917)	1.125***	(1.083-1.168)	0.996	(0.953-1.041)	1.008	(0.951-1.068)
Region								
North®								
Central	0.888***	(0.866-0.91)	1.238***	(1.196-1.282)	0.749***	(0.707-0.793)	1.350***	(1.246-1.462)

East	0.930***	(0.904-0.956)	1.428***	(1.374-1.484)	0.777***	(0.727-0.830)	1.644***	(1.507-1.794)
Northeast	1.617***	(1.567-1.668)	1.349***	(1.288-1.413)	1.433***	(1.336-1.536)	1.458***	(1.315-1.616)
West	0.959**	(0.928-0.991)	1.119***	(1.068-1.173)	0.907**	(0.847-0.970)	1.248***	(1.134-1.373)
South	0.951***	(0.925-0.978)	1.457***	(1.404-1.513)	0.941*	(0.885-100)	1.570***	(1.443-1.709)

Note-level of significance: ***=p<0.01, **=<0.05, *=<0.1

Table 5: Multivariate analysis for diabetes and hypertension among women by socio-demographic characteristics, 2019-21.

Socio-demographic characteristics	Women				Men			
	Hypertension		Diabetes		Hypertension		Diabetes	
	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI
Age of respondent								
15-19 years®								
20-24 years	1.461***	(1.402-1.523)	1.364***	(1.294-1.438)	2.057***	(1.867-2.266)	1.581***	(1.388-1.800)
25-29 years	2.089***	(2.01-2.172)	1.982***	(1.887-2.082)	2.865***	(2.611-3.143)	2.332***	(2.065-2.634)
30-34 years	3.199***	(3.081-3.322)	3.010***	(2.87-3.156)	4.394***	(4.017-4.807)	3.396***	(3.021-3.818)
35 and more years	6.937***	(6.705-7.177)	5.783***	(5.541-6.036)	7.358***	(6.783-7.981)	6.243***	(5.627-6.926)
Place of residence								
Urban®								
Rural	0.927***	(0.909-0.945)	0.976*	(0.952-1.001)	0.920***	(0.878-0.963)	0.910**	(0.856-0.967)
Educational Attainment								
No education ®								
Primary	1.006	(0.982-1.03)	1.073***	(1.039-1.107)	1.061	(0.985-1.143)	1.054	(0.959-1.159)
Secondary	0.893***	(0.875-0.911)	1.070***	(1.042-1.098)	1.133***	(1.065-1.205)	1.076	(0.995-1.164)
Higher	0.728***	(0.705-0.751)	0.895***	(0.86-0.932)	1.133**	(1.051-1.223)	0.957	(0.867-1.058)
Religion								
Hindu®								
Muslim	1.113***	(1.087-1.14)	1.046**	(1.015-1.079)	0.821***	(0.77-0.876)	0.896*	(0.827-0.971)
Christian	1.175***	(1.141-1.211)	0.984	(0.945-1.024)	1.113**	(1.035-1.197)	0.988	(0.896-1.090)
Sikh	1.508***	(1.44-1.579)	0.935*	(0.875-0.999)	1.498***	(1.337-1.677)	0.858*	(0.722-1.02)
Other	1.345***	(1.288-1.404)	0.821***	(0.768-0.878)	1.229***	(1.109-1.363)	0.811*	(0.694-0.948)
Wealth Quintile								
Poorest®								
Poor	1.082***	(1.056-1.108)	1.060***	(1.028-1.094)	1.132***	(1.066-1.203)	1.038	(0.96-1.122)
Middle	1.160***	(1.132-1.189)	1.150***	(1.114-1.188)	1.249***	(1.174-1.329)	1.081*	(0.998-1.171)
Higher	1.211***	(1.18-1.244)	1.249***	(1.207-1.292)	1.329***	(1.245-1.42)	1.174***	(1.078-1.278)
Highest	1.262***	(1.224-1.3)	1.221***	(1.175-1.27)	1.472***	(1.368-1.585)	1.180**	(1.072-1.300)
Alcohol Consumption								
No drinks								
Almost everyday	1.585***	(1.419-1.772)	0.837*	(0.696-1.008)	1.706***	(1.574-1.849)	1.039	(0.93-1.161)

Once a week	1.416***	(1.322-1.518)	0.947	(0.852-1.053)	1.514***	(1.433-1.600)	1.014	(0.941-1.093)
Less than once a week	1.349***	(1.263-1.442)	0.967	(0.876-1.068)	1.261***	(1.189-1.337)	1.092**	(1.011-1.179)
Any form of smoking Tobacco								
No®								
Yes	1.032	(0.901-1.183)	1.127	(0.94-1.351)	0.929**	(0.881-0.979)	1.082*	(1.011-1.158)
Any form of smokeless Tobacco								
No®								
Yes	0.929	(0.868-0.995)	0.929	(0.847-1.02)	0.941*	(0.897-0.986)	0.895**	(0.841-0.953)
Region								
North®								
Central	0.933***	(0.903-0.964)	1.525***	(1.468-1.584)	1.000	(0.925-1.08)	1.400***	(1.271-1.542)
East	0.893***	(0.853-0.935)	0.905**	(0.852-0.962)	1.124	(1.011-1.249)	1.009	(0.871-1.168)
Northeast	0.986	(0.962-1.011)	1.055**	(1.022-1.09)	0.941	(0.887-0.999)	1.006	(0.929-1.090)
West	0.829***	(0.809-0.85)	0.878***	(0.849-0.907)	0.752***	(0.708-0.8)	0.850***	(0.783-0.923)
South	0.919***	(0.896-0.942)	0.963**	(0.932-0.996)	0.805***	(0.758-0.855)	1.013	(0.935-1.097)

Note-level of significance: ***=p<0.01, **=<0.05, *=<0.1

Annexure-1 Number of district in each category of diabetes among men, year 2015-16 & 2020-21

Category	NFHS-4 (2015-16)		NFHS-5 (2020-21)		Percentage Change
	No. of District	% of District	No. of District	% of District	
0.60-5.97	221	34.5	172	26.9	-28.5
5.97-11.35	321	50.2	284	44.4	-13.0
11.35-16.72	89	13.9	136	21.3	34.6
16.72+	9	1.4	48	7.5	81.3
	640		640		

Annexure 2: Number of district in each category of diabetes by state among men, year 2015-16 & 2020-21.

State	Low (0.60-5.97)		Moderate (5.97-11.35)		High (11.35-16.72)		Very High 16.72+	
	NFHS-4	NFHS-5	NFHS-4	NFHS-5	NFHS-4	NFHS-5	NFHS-4	NFHS-5
Andaman and nicobar islands	1			2	1	1	1	
Andhra pradesh	3	1	5	1	3	9	2	2
Arunachal pradesh	6	5	8	7	2	4		
Assam	10	2	15	10	2	14		1
Bihar	20	8	14	23	3	5	1	2
Chandigarh			1			1		
Chhattisgarh	4	4	8	14	6			
Delhi		2	6	4	3	3		
Goa			1	1	1			1
Gujarat	8	6	16	12	2	7		1
Haryana	14	6	7	11		3		1
Himachal pradesh	4	7	8	1		4		
Jammu and kashmir	16	19	4	3	2			
Jharkhand	6	3	14	13	4	5		3
Karnataka	7	6	21	16	2	8		
Kerala		1	5	7	6	4	3	2
Lakshadweep					1	1		
Madhya pradesh	21	13	29	26		8		3
Maharashtra	15	10	18	22	2	2		1
Manipur	3	1	5	6		2	1	
Meghalaya	4	1	3	3		2		1

Mizoram			6	5	2	3		
Nagaland	1	3	7	8	3			
Odisha	2	2	19	14	9	8		6
Puducherry	1		1	2	2	1		1
Punjab	9	5	8	11	3	4		
Rajasthan	18	28	15	5				
Sikkim		1	4	3				
Tamil nadu	3	3	18	9	11	12		8
Telangana	5		5	3		6		1
Tripura	1		2		1	1		3
Uttar pradesh	32	31	30	34	9	5		1
Uttarakhand	4	4	8	5	1	2		2
West bengal	2		8	2	8	11	1	6
Dadra and nagar haveli			1					1
Daman and diu	1		1	1				1
Grand Total	221	172	321	284	89	136	9	48

Annexure-3 Number of district in each category of Hypertension among men, year 2015-16 & 2020-21.

Hypertension	NFHS-4		NFHS-5		Percentage Change
	No. of District	% of District	No. of District	% of District	
1.10-12.27	220	34.4	157	24.5	28.6
12.27-23.45	339	53.0	357	55.8	5.3
23.45-34.62	74	11.6	117	18.3	58.1
34.62+	7	1.1	9	1.4	28.5
	640		**640**		

Annexure -4 Number of district in each category of Hypertension by state among men, year 2015-16 & 2020-21.

State	Low (1.10-12.27)		Moderate (12.27-23.45)		High (23.45-34.62)		Very High (34.62+)	
	NFHS-4	NFHS-5	NFHS-4	NFHS-5	NFHS-4	NFHS-5	NFHS-4	NFHS-5
Andaman & nicobar islands			1	1	1	1	1	1
Andhra pradesh	1	2	9	7	3	4		
Arunachal pradesh	1		6	4	7	9	2	3
Assam	4	7	12	19	11	1		
Bihar	26	22	11	16	1			
Chandigarh			1			1		
Chhattisgarh	6		12	13		5		
Delhi	6		3	3		4		2
Goa			2	2				
Gujarat	13	11	11	12	2	3		
Haryana	1	3	16	16	4	2		
Himachal pradesh		1	6	11	5		1	
Jammu and kashmir	6	17	14	5	2			
Jharkhand	8	10	16	13		1		
Karnataka	5	2	21	20	4	8		
Kerala	10	2	4	10		2		
Lakshadweep	1			1				
Madhya pradesh	27	13	22	34	1	2		1
Maharashtra	3	10	27	21	3	4	2	
Manipur	1		8	5		4		
Meghalaya	3	1	4	5		1		
Mizoram		1	8	5		2		
Nagaland	1		4	7	6	4		
Odisha	15	2	15	26		2		
Puducherry			3	3	1	1		
Punjab			11	3	8	16	1	1
Rajasthan	17	19	16	14				
Sikkim					4	3		1
Tamil nadu	2	1	24	11	6	20		

Telangana			9	5	1	5		
Tripura	2	1	2	3				
Uttar pradesh	47	22	22	46	2	3		
Uttarakhand	2		11	5		8		
West bengal	10	8	7	10	2	1		
Dadra and nagar h.		1	1					
Daman and diu	2	1		1				
Grand Total	**220**	**157**	**339**	**357**	**74**	**117**	**7**	**9**

DISCUSSION

This study examined geographical differentials in the prevalence of hypertension and diabetes across Indian states and districts using NFHS-4 (2015–16) and NFHS-5 (2019–21) data. The findings confirm a significant upward trend in both conditions over the inter-survey period, with hypertension consistently more prevalent than diabetes across all sub-groups. This aligns with the wider NCD epidemiological transition in India, where NCDs now contribute over 61% of all deaths, with cardiovascular disease and diabetes among the leading contributors [1]. The National Noncommunicable Disease Monitoring Survey similarly documented high and regionally variable NCD risk factor burdens among Indian adults [2].

Age was the strongest predictor of both conditions, with respondents aged 35 and above facing approximately seven- to eightfold higher odds of hypertension and five- to sixfold higher odds of diabetes relative to the youngest age group. Age-related increases in blood pressure and metabolic dysfunction are well established, attributable to arterial stiffening, reduced insulin sensitivity, and accumulating behavioural risk [3,4]. Of particular concern is the rising prevalence in the 15–24 age group, suggesting earlier NCD onset that has been reported in other South Asian contexts [5].

Urban residence was associated with higher absolute NCD prevalence, reflecting physical inactivity, dietary transitions, and occupational stress. However, the rate of increase between NFHS rounds was greater in rural populations — particularly for diabetes among women and hypertension among men — narrowing the rural–urban gap for women's diabetes from 1.7 to 1.3 percentage points. This reflects an ongoing epidemiological transition in rural India driven by lifestyle changes in diet, physical activity, and substance use [6,7]. Recent analyses using NFHS-5 data confirm that rural Indian women are increasingly exposed to NCD risk factors previously concentrated in urban settings [8].

The inverse association between education and NCD prevalence among women is consistent with global evidence linking education to health literacy and preventive health behaviour [9]. The contrasting pattern among men — where higher education was associated with greater hypertension risk — may reflect occupational stress and sedentary lifestyles. The socioeconomic gradient is further evident in wealth quintile findings: while absolute prevalence was higher in wealthier groups, the rate of increase between rounds was greater among the poorest quintiles, suggesting accelerating burden among the economically disadvantaged — consistent with findings from Hosseinpoor et al. across low- and middle-income countries [10].

Frequent alcohol consumption showed a strong positive association with hypertension in both sexes, consistent with evidence on sympathetic nervous system activation and renin–angiotensin system dysregulation [11]. Tobacco use — both smoked and smokeless — was associated with NCDs particularly among women, a finding of growing importance given increasing smokeless tobacco use in several Indian regions [2].

Pronounced regional variation was a key finding of this study. Southern states, particularly Tamil Nadu and Karnataka, recorded high diabetes prevalence and the largest concentrations of very high-burden districts, consistent with the India State-Level Disease Burden Initiative's identification of these states as having the highest diabetes-attributable mortality [12]. Dietary patterns high in refined carbohydrates and a genetic predisposition to insulin resistance in South Asian populations may underlie this regional clustering [13]. The North-east emerged as a

high-burden zone for hypertension among men, with Sikkim, Arunachal Pradesh, and Assam showing disproportionate district-level clustering in higher prevalence categories, consistent with earlier regional descriptions [14]. Northern states (Rajasthan, J&K, Himachal Pradesh) maintained predominantly lower prevalence levels, though upward shifts were evident.

The district-level analysis reveals a dramatic escalation in very high diabetes burden: the number of districts in the highest prevalence category for men increased nearly fivefold from 9 to 48, with Eastern and Southern states emerging as epicentres. This granular geographic evidence is directly actionable for the NPCDCS, which operates through district-level NCD clinics but remains unevenly implemented across states [15].

In conclusion, this study presents district- and state-level evidence of a widening and geographically heterogeneous NCD burden in India, with hypertension and diabetes rising disproportionately in rural populations, economically disadvantaged groups, and specific regional clusters. These findings call for a reorientation of the NPCDCS toward decentralised, geographically targeted models. Priority actions include: equity-based resource allocation extending financial protection to the poorest quintiles; intensive metabolic screening in Southern and Eastern high-burden districts; strengthening NCD screening through rural primary health care and ASHA workers; and integrating alcohol and tobacco risk reduction into adolescent health programmes to address the rising NCD trajectory in the 15–24 age group.

Relevance and Contribution to Current Knowledge

This study makes several important contributions to the existing literature on NCDs in India. First, it is among the few analyses to directly compare NFHS-4 and NFHS-5 data at the district level for both hypertension and diabetes simultaneously, providing spatially disaggregated evidence that state-level analyses cannot offer. Second, the use of nationally representative data from two comparable survey rounds enables a robust assessment of trends over time, rather than relying on cross-sectional prevalence estimates alone. Third, the study documents the acceleration of rural NCD burden-a pattern that has significant implications for India's health system architecture, which historically has prioritised infectious disease control and maternal health in rural settings. Fourth, the district-level mapping of prevalence category shifts offers actionable intelligence for the National Programme for Prevention and Control of Non-Communicable Diseases (NP-NCD), enabling geographic targeting of screening and intervention resources. Finally, the multivariate analysis spanning both NFHS rounds extends the evidence base on sociodemographic and behavioural determinants of hypertension and diabetes in India, with particular attention to emerging inequalities in the lower wealth quintiles and in younger age cohorts.

Limitations of the Study

This study has several methodological limitations that should be considered when interpreting its findings. First, NFHS data are cross-sectional in design; consequently, causal relationships between sociodemographic determinants and NCD outcomes cannot be established. Second, hypertension and diabetes in NFHS are identified through a single blood pressure or blood glucose measurement, which may lead to misclassification compared with clinical diagnostic criteria based on multiple readings or fasting samples. Third, behavioural risk factors such as alcohol consumption and tobacco use are self-reported and are likely subject to social desirability bias, particularly among women. Fourth, NFHS biomarker data are restricted to specific age ranges (15-49 years for women and 15-54 years for men in NFHS-4; extended in NFHS-5), which means the study does not capture the full burden of these conditions in older age groups who carry the highest prevalence. Fifth, the absence of individual-level longitudinal tracking across survey rounds precludes assessment of incidence, progression, or remission of these conditions over time. Sixth, district-level estimates are based on pooled survey data and

may have limited precision for smaller districts with fewer sampled households. Despite these limitations, the large sample sizes, nationally representative design, and inter-round comparability of NFHS data ensure that the findings represent a robust and policy-relevant characterisation of NCD trends in India.

Authors Contribution

All authors have contributed equally.

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Nil

Conflict of Interest

There are no conflicts of interest.

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None.

Declaration Of Generative AI And AI Assisted Technologies In The Writing Process

During the preparation of this work, the authors used Claude.ai (Anthropic) as an AI-assisted technology to improve language, grammar, sentence structuring, academic writing quality, and manuscript organization. The tool was also used to assist in editing, summarization, and refining responses to reviewer comments. After using this tool/service, the authors carefully reviewed and edited the content as needed and take full responsibility for the accuracy, originality, and integrity of the content of this publication.

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