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"C:\Users\Dr.Deepjyoti Saikia\Downloads\New folder (9)\.env\Scripts\python.exe" "C:\Users\Dr.Deepjyoti Saikia\Downloads\New folder (9)\main.py"
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NFHS-5 COMPREHENSIVE CARDIOMETABOLIC RISK ANALYSIS
Primary Aim + 6 Specific Objectives
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BLOCK 0: DATA LOADING, CLEANING & HARMONISATION

Master HTN dataset : 571 subgroups | N = 2,752,255
Master BG dataset : 571 subgroups | N = 2,752,255
States : 29
Variables : ['Age', 'Caste/tribe', 'Religion', 'Residence', 'Schooling']

Phenotype rows (HTN): 2,196 | N: 2,752,234

PRIMARY AIM: $\text{WHR} \geq 0.85 \rightarrow \text{HYPERTENSION \& BLOOD GLUCOSE}$

OUTCOME: HYPERTENSION

— Model 1 – Unadjusted: HYPERTENSION ~ WHR —

	OR	95% CI Lo	95% CI Hi	p	Sig
const	0.073	0.072	0.074	0.0	***
p_WHR	2.953	2.862	3.046	0.0	***
McFadden R ² = 0.0692 AIC = 61692.5					

— Model 2 – BMI-Adjusted: HYPERTENSION ~ WHR + BMI —

	OR	95% CI Lo	95% CI Hi	p	Sig
const	0.062	0.061	0.063	0.0	***
p_WHR	1.562	1.512	1.613	0.0	***
p_BMI	9.429	9.109	9.761	0.0	***
McFadden R ² = 0.3101 AIC = 45734.0					

— Model 3 – Fully Adjusted: HYPERTENSION ~ WHR + BMI + Residence —

	OR	95% CI Lo	95% CI Hi	p	Sig
const	0.061	0.060	0.062	0.0	***
p_WHR	1.556	1.506	1.607	0.0	***
p_BMI	9.757	9.420	10.106	0.0	***
is_Rural	1.061	1.050	1.072	0.0	***
McFadden R ² = 0.3119 AIC = 45610.7					

OUTCOME: BG DYSREGULATION (>140 mg/dL)

— Model 1 – Unadjusted: BG DYSREGULATION (>140 mg/dL) ~ WHR —

	OR	95% CI Lo	95% CI Hi	p	Sig
const	0.043	0.042	0.044	0.0	***
p_WHR	2.587	2.486	2.692	0.0	***
McFadden R ² = 0.0489 AIC = 42470.8					

— Model 2 – BMI-Adjusted: BG DYSREGULATION (>140 mg/dL) ~ WHR + BMI —

	OR	95% CI Lo	95% CI Hi	p	Sig
const	0.037	0.036	0.037	0.0	***
p_WHR	1.321	1.267	1.376	0.0	***
p_BMI	10.339	9.897	10.801	0.0	***
McFadden R ² = 0.2904 AIC = 31688.7					

— Model 3 – Fully Adjusted: BG DYSREGULATION (>140 mg/dL) ~ WHR + BMI + Residence —

	OR	95% CI Lo	95% CI Hi	p	Sig
const	0.036	0.035	0.037	0.0	***
p_WHR	1.315	1.262	1.370	0.0	***
p_BMI	10.760	10.293	11.249	0.0	***
is_Rural	1.071	1.057	1.085	0.0	***
McFadden R ² = 0.2927 AIC = 31588.2					

OUTCOME: VERY HIGH BG (>160 mg/dL)

— Model 1 – Unadjusted: VERY HIGH BG (>160 mg/dL) ~ WHR —

	OR	95% CI Lo	95% CI Hi	p	Sig
const	0.015	0.015	0.016	0.0	***
p_WHR	3.339	3.148	3.542	0.0	***
McFadden R ² = 0.0523 AIC = 28741.3					

— Model 2 – BMI-Adjusted: VERY HIGH BG (>160 mg/dL) ~ WHR + BMI —

	OR	95% CI Lo	95% CI Hi	p	Sig
const	0.012	0.012	0.012	0.0	***
p_WHR	1.189	1.119	1.264	0.0	***
p_BMI	30.006	28.144	31.990	0.0	***
McFadden R ² = 0.4008 AIC = 18176.5					

— Model 3 – Fully Adjusted: VERY HIGH BG (>160 mg/dL) ~ WHR + BMI + Residence —

	OR	95% CI Lo	95% CI Hi	p	Sig
const	0.012	0.011	0.012	0.0	***
p_WHR	1.182	1.112	1.257	0.0	***
p_BMI	31.343	29.363	33.457	0.0	***
is_Rural	1.076	1.054	1.098	0.0	***
McFadden R ² = 0.4024 AIC = 18129.1					

OBJECTIVE 1: PRECISION IN RISK ASSESSMENT – WHR vs BMI

HYPERTENSION – 4-Group ORs (Ref: A – Normal BMI + Normal WHR)
 Group B [Normal BMI+High WHR (MUNW/NWC0) ☐]: OR=1.637 (95% CI: 1.620–1.655) ***
 Group C [High BMI+Normal WHR (MH0)]: OR=2.939 (95% CI: 2.901–2.977) ***
 Group D [High BMI+High WHR (Double Risk)]: OR=5.439 (95% CI: 5.379–5.499) ***
 McFadden R²=0.6452 | AIC=60588.9

BG DYSREGULATION – 4-Group ORs (Ref: A – Normal BMI + Normal WHR)
 Group B [Normal BMI+High WHR (MUNW/NWC0) ☐]: OR=1.620 (95% CI: 1.598–1.643) ***
 Group C [High BMI+Normal WHR (MH0)]: OR=2.893 (95% CI: 2.846–2.941) ***
 Group D [High BMI+High WHR (Double Risk)]: OR=4.973 (95% CI: 4.903–5.043) ***
 McFadden R²=0.5946 | AIC=42362.4

VERY HIGH BG – 4-Group ORs (Ref: A – Normal BMI + Normal WHR)
 Group B [Normal BMI+High WHR (MUNW/NWC0) ☐]: OR=1.625 (95% CI: 1.590–1.660) ***
 Group C [High BMI+Normal WHR (MH0)]: OR=2.995 (95% CI: 2.922–3.070) ***
 Group D [High BMI+High WHR (Double Risk)]: OR=5.026 (95% CI: 4.921–5.134) ***
 McFadden R²=0.4970 | AIC=29146.0

— Descriptive Risk Profile Across 4 Groups —

Group	HTN Mean%	BG Dysreg%	VeryHighBG
%			
N			
A: Normal BMI+Normal WHR (Ref)	6.93%	4.01%	1.73%

865,621				
B: MUNW/NWCO (Normal BMI+High WHR) ▯	10.74%	6.22%	2.69%	1,
138,123				
C: MHO (High BMI+Normal WHR)	17.32%	10.04%	4.34%	
313,981				
D: Double Risk (High BMI+High WHR)	27.72%	16.06%	6.94%	
434,509				

OBJECTIVE 2: QUANTIFY THE MUNW PHENOTYPE

MUNW women (reconstructed total): 1,138,123
Reference group (Normal BMI+Normal WHR): 865,621

MUNW mean HTN risk : 10.74% (SD=4.75%)
Reference HTN risk : 6.93% (SD=3.07%)

MUNW as % of total reconstructed population: 41.4%
(Note: MUNW is the single LARGEST phenotype group)
MUNW as % of ALL normal-weight women: 56.8%

— MUNW → Outcomes (Restricted to Normal-Weight Women Only) —

MUNW → HTN : OR=1.637 (95% CI: 1.620–1.655) p=0.0000 ***
MUNW → BG Dysreg : OR=1.620 (95% CI: 1.598–1.643) p=0.0000 ***

MUNW → Very High BG : OR=1.625 (95% CI: 1.590–1.660) p=0.0000 ***

— MUNW Risk Characterisation by Sociodemographic Subgroup (HTN) —

Age	: OR=1.822 (CI:1.780–1.865) ***
Residence	: OR=1.580 (CI:1.545–1.615) ***
Caste/tribe	: OR=1.591 (CI:1.551–1.632) ***
Religion	: OR=1.585 (CI:1.550–1.622) ***
Schooling	: OR=1.609 (CI:1.566–1.653) ***

☐ Estimated MUNW women across 29 states: 927,241

Top 5 states by MUNW prevalence:

Jammu&Kashmir	: MUNW=55.6%	N≈47,182	HTN=11.1%
Arunachal_Pradesh	: MUNW=47.7%	N≈4,928	HTN=19.9%
West_Bengal	: MUNW=45.8%	N≈37,810	HTN=11.9%
Meghalaya	: MUNW=45.4%	N≈23,740	HTN=15.0%
Assam	: MUNW=44.9%	N≈60,330	HTN=12.9%

OBJECTIVE 3: MEASURE THE BMI SUPPRESSION EFFECT

Suppression Definition:

A suppressor variable is one that, when added to a model, INCREASES the absolute coefficient of the target predictor (WHR).

In contrast, a confounders REDUCE it.

If β_{WHR} INCREASES when BMI is added $\rightarrow$ BMI SUPPRESSES WHR's true effect

If β_{WHR} DECREASES when BMI is added $\rightarrow$ BMI CONFOUNDS WHR's true effect

Here: BMI acts as a CONFOUNDER (attenuates WHR coefficient)

$\rightarrow$ Quantifying this ATTENUATION shows HOW MUCH BMI masks WHR's true signal

WHR β (unadjusted) = 1.0827 $\rightarrow$ OR = 2.953

WHR β (BMI-adjusted) = 0.4459 $\rightarrow$ OR = 1.562

BMI β (in adjusted model) = 2.2438 $\rightarrow$ OR = 9.429

β attenuation from BMI = 1.0827 - 0.4459 = 0.6368

% attenuation of WHR effect = 58.8%

☐ INTERPRETATION:

BMI statistically MASKS 58.8% of WHR's true hypertension risk signal.

Unadjusted OR of 2.953 falls to 1.562 when BMI is included,
suggesting WHR-BMI overlap confounds standard risk models.

Proportion of WHR effect INDEPENDENT of BMI: 41.2%

Proportion of WHR effect SHARED with BMI: 58.8%

BG Dysregulation – BMI suppression of WHR β : 70.7%

OR (unadj): 2.587 $\rightarrow$ OR (adj): 1.321

OBJECTIVE 4: REGIONAL DISPARITIES ACROSS INDIAN STATES

State Rankings – WHR High % (Top 10 and Bottom 10)

State	WHR%	HTN%	BG%	MUNW%	Region
Jammu&Kashmir	83.8%	11.1%	4.1%	55.6%	North
Sikkim	72.0%	25.5%	7.8%	43.7%	Northeast
West_Bengal	70.6%	11.9%	11.9%	45.8%	East
Punjab	69.9%	18.8%	7.0%	34.2%	North
Arunachal_Pradesh	68.5%	19.9%	8.6%	47.7%	Northeast
Kerala	67.3%	12.7%	10.5%	37.1%	South
Assam	66.8%	12.9%	8.6%	44.9%	Northeast
NCR Delhi	65.4%	16.0%	6.2%	32.8%	North
Haryana	64.2%	12.6%	7.1%	33.5%	North
Manipur	62.7%	13.9%	7.1%	38.2%	Northeast
... Bottom 10 ...					
Uttar_Pradesh	55.2%	11.7%	5.8%	33.8%	North
Tamil Nadu	53.1%	12.8%	11.1%	26.6%	South
goa	51.4%	13.1%	10.7%	26.0%	West
Andhra_Pradesh	48.8%	13.7%	10.8%	24.0%	South
Mizoram	46.1%	11.1%	8.0%	34.0%	Northeast
Gujarat	44.5%	11.3%	9.2%	23.3%	West

Karnataka	43.2%	13.2%	7.3%	23.7%	South
Telangana	42.5%	14.5%	7.8%	22.7%	South
Maharashtra	42.1%	12.2%	5.9%	24.5%	West
Madhya_Pradesh	39.0%	11.9%	5.6%	24.2%	Central

— Regional Summary —

	States	WHR_mean	HTN_mean	BG_mean	MUNW_mean
Region					
Central	2	47.64	13.77	5.68	29.62
East	4	62.21	10.97	8.49	38.47
North	7	64.93	12.85	5.91	37.66
Northeast	8	61.39	15.53	8.10	41.82
South	5	50.98	13.40	9.49	26.80
West	3	45.99	12.23	8.60	24.60

— Kruskal-Wallis Test – Regional Differences —

WHR High % : H=12.806, p=0.0253 (significant)
HTN % : H=7.006, p=0.2202 (ns)
BG Dysreg % : H=12.966, p=0.0237 (significant)

State-level Pearson r (WHR_High ~ HTN): r=0.314, p=0.0976

State-level Pearson r (WHR_High ~ BG): r=-0.017, p=0.9315

— Scheduled Tribe Subgroup – Central Obesity & Risk —

Tribal states (n=29)

WHR High: mean=59.0% (range 39.3%–87.6%)
 HTN: mean=13.4%
 BG Dysreg: mean=6.8%
 Tribal vs Non-Tribal WHR: t=0.464, p=0.6454

OBJECTIVE 5: DIAGNOSTIC UTILITY – WHR vs BMI vs INTEGRATED MODEL

Model	AUC	Sens%	Spec%	LR+	LR-
WHR $\geq$ 0.85 alone	0.5366	35.0%	71.9%	1.247	0.9038
BMI $\geq$ 25 alone	0.5703	52.0%	58.0%	1.238	0.8275
WHR + BMI	0.5712	53.9%	56.5%	1.240	0.8153
WHR + BMI + MUNW	0.5743	50.0%	60.9%	1.278	0.8212

Δ AUC (adding WHR to BMI): +0.0010
 Δ AUC (adding MUNW term): +0.0031

Estimated Population HTN Prevalence: 13.4%
 PPV (WHR alone): 16.2% $\rightarrow$ NNS = 6.2
 PPV (BMI alone): 16.1% $\rightarrow$ NNS = 6.2
 PPV (WHR+BMI): 16.1% $\rightarrow$ NNS = 6.2

NRI (adding WHR to BMI-only model):

Events NRI : -1.7%
 Non-Events NRI: +1.6%
 Total NRI : -0.1%

Integrated Discrimination Improvement (IDI): 0.000278
 (WHR adds discriminative information)

OBJECTIVE 6: DIAGNOSTIC GAPS – WAIST-CENTRIC vs WEIGHT-CENTRIC CARE
 Focus: Rural, Tribal, and Low-Education Subgroups

Variable N_MUNW	SubGroup	WHR%	OW%	MUNW%	HTN%	
Residence	Rural	58.7%	22.9%	35.7%	12.6%	147,793
Residence	Urban	62.1%	32.5%	34.7%	14.1%	62,020
Caste/Tribe	Other backward class	58.8%	26.3%	34.3%	13.3%	77,531
Caste/Tribe	Scheduled caste	59.6%	24.3%	35.4%	12.8%	41,557
Caste/Tribe	Scheduled tribe	59.0%	20.2%	36.4%	13.4%	33,

556	Education	10-11 years complete	58.0%	25.0%	33.6%	10.8%	29,
381	Education	12 or more years complete	59.1%	26.5%	35.7%	9.5%	52,
487	Education	<5 years complete	62.1%	28.0%	36.6%	18.8%	11,
373	Education	No schooling	63.6%	25.2%	38.8%	19.7%	51,
454							

Rural MUNW mean: 35.68%

Urban MUNW mean: 34.68%

Scheduled Tribe MUNW: 36.4% HTN: 13.4% WHR High: 59.0%

Other castes MUNW: 34.8% HTN: 13.1% WHR High: 59.2%

— MUNW → HTN OR by Diagnostic Gap Subgroup —

Variable	SubGroup	OR	95% CI	Sig
Residence	Rural	1.587	(1.546-1.629)	***
Residence	Urban	1.562	(1.495-1.633)	***
Caste/tribe	Other backward class	1.571	(1.515-1.628)	***
Caste/tribe	Scheduled caste	1.624	(1.543-1.709)	***
Caste/tribe	Scheduled tribe	1.600	(1.522-1.681)	***

Schooling	10-11 years complete	1.595	(1.496-1.701)	***
Schooling	12 or more years complete	1.553	(1.471-1.639)	***
Schooling	<5 years complete	1.607	(1.473-1.753)	***
Schooling	No schooling	1.601	(1.538-1.666)	***

— Education Gradient in MUNW Risk —

Lower education → Higher MUNW-HTN OR? (Evidence for diagnostic gap)

10-11 years complete	: OR=1.595 ***
12 or more years complete	: OR=1.553 ***
<5 years complete	: OR=1.607 ***
No schooling	: OR=1.601 ***

GENERATING PUBLICATION-QUALITY FIGURES

- ☐ F01_primary_aim_phenotypes.png
 - ☐ F02_obj1_precision_ORs.png
 - ☐ F03_obj2_MUNW_heatmap.png
 - ☐ F04_obj3_suppression.png
 - ☐ F05_obj4_regional.png
 - ☐ F06_obj5_diagnostic.png
 - ☐ F07_obj6_diagnostic_gaps.png
 - ☐ F08_comprehensive_dashboard.png
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FINAL SUMMARY OF KEY RESULTS

PRIMARY AIM

WHR $\geq$ 0.85 $\rightarrow$ HTN (Unadj):	OR = 2.953	***
WHR $\geq$ 0.85 $\rightarrow$ HTN (BMI-adj):	OR = 1.562	***
WHR $\geq$ 0.85 $\rightarrow$ BG Dysreg (Unadj):	OR = 2.587	***
WHR $\geq$ 0.85 $\rightarrow$ BG Dysreg (BMI-adj):	OR = 1.321	***

OBJ 1 – PRECISION (4-Group ORs vs Reference Group A)

MUNW/NWCO (Normal BMI + High WHR) $\rightarrow$ HTN:	OR = 1.637	***
MHO (High BMI + Normal WHR) $\rightarrow$ HTN:	OR = 2.939	***
Double Risk (High BMI + High WHR) $\rightarrow$ HTN:	OR = 5.439	***

OBJ 2 – MUNW PHENOTYPE

Total MUNW women (estimated):	927,241
MUNW as % of all reconstructed:	41.4%
MUNW mean HTN risk:	10.74%
Reference (A) mean HTN risk:	6.93%
MUNW excess HTN risk:	+3.81%

OBJ 3 – BMI SUPPRESSION EFFECT

WHR β attenuation when BMI added (HTN): 58.8%
WHR β attenuation when BMI added (BG): 70.7%
WHR independent effect (after BMI): 41.2%

OBJ 4 – REGIONAL DISPARITIES

Highest WHR state: Jammu&Kashmir (83.8%)
Lowest WHR state: Madhya_Pradesh (39.0%)
WHR-HTN correlation: $r=0.314$, $p=0.0976$

OBJ 5 – DIAGNOSTIC UTILITY

AUC WHR alone: 0.5366 | Sensitivity=35.0% Specificity=71.9%
AUC BMI alone: 0.5703 | NNS=6.2
AUC WHR+BMI: 0.5712 | NNS=6.2
Total NRI (adding WHR to BMI): -0.1%
IDI: 0.000278

OBJ 6 – DIAGNOSTIC GAPS

Rural MUNW prevalence: 35.7% (significant hidden risk)
Scheduled Tribe WHR High: 59.0%
MUNW-HTN OR (Rural): 1.587 ***
MUNW-HTN OR (Scheduled Tribe): 1.600 ***

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