Investigation of dietary sodium intake and its direct correlation with blood pressure in an urban adult population

Investigación sobre la ingesta de sodio en la dieta y su correlación directa con la presión arterial en una población adulta urbana

Madaripova Dildora - Department of Nephrology and Hemodialysis, Bukhara State Medical Institute named after Abu Ali ibn Sino, Bukhara, Uzbekistan; e-mail: madaripova.dildora@bsmi.uz, https://orcid.org/0009-0009-9547-9264
Mamirova Marxaba - Navoi region multidisciplinary medical center, Navoi, Uzbekistan;
e-mail: mamirova.marxaba@bsmi.uz, https://orcid.org/0009-0006-3461-4344
Kozimjon Kosimov - Senior teacher, Department of Social Sciences, Fergana Medical Institute of Public Health, Ferghana, Uzbekistan;
kozimzonkosimov3@gmail.com, https://orcid.org/0009-0004-5360-0920
Askarova Fotima - Assistant (Med.), Obstetrics and gynecology, Samarkand State Medical University, Samarkand, Uzbekistan. https://orcid.org/0009-0009-2347-2733
Malika Yuldasheva - PhD, Department of Obstetrics and gynecology, reproductology, Tashkent state medical university, Tashkent, Uzbekistan;
E-mail: malikaabduraimovna@mail.ru, https://orcid.org/0009-0005-4425-1252
Abdullayev Lazizbek - Student of the International Institute of Food Technology and Engineering, Fergana, Uzbekistan; E-mail:
lazizbekabdullayev2003.7@gmail.com ; 0009-0008-1448-9472
Mehmonov Feruz - Department of Internal medicine, Bukhara State Medical Institute named after Abu Ali ibn Sino, Bukhara, Uzbekistan; e-mail:
fedyabakjan@mail.ru, https://orcid.org/0009-0005-4588-1897
Yokubjonova Xulkarbonu - Department of Management, Namangan State University, Namangan, Uzbekistan; E-mail:
hulkarbonuyoqubjonova1983@gmail.com, https://orcid.org/0000-0002-9247-3598
Tolibova K.O. - Bukhara State Medical Institute named after Abu Ali ibn Sino, Bukhara, Uzbekistan; E-mail: komila.tolibova@mail.ru, https://orcid.org/0009-0003-6567-7602
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Abstract

High dietary sodium intake remains a pivotal yet understudied driver of hypertension in rapidly urbanizing regions like Uzbekistan, where traditional salty foods meet modern processed diets. This cross-sectional study investigated the direct correlation between sodium consumption and blood pressure among 412 urban adults aged 25-65 in Tashkent from March to August 2025. We measured 24-hour urinary sodium excretion (gold standard for intake), alongside clinic blood pressure via standardized Omron devices, adjusting for confounders like age, BMI, smoking, and activity in multivariable regressions. Results showed a mean sodium intake of 5.7 g/day far exceeding WHO limits with each gram linking to 1.9 mmHg higher systolic (95% CI: 1.2-2.6, p<0.001) and 1.4 mmHg diastolic rises (95% CI: 0.9-1.9, p<0.001) post-adjustment. Hypertension prevalence surged from 20% in low-sodium tertiles to 71.5% in high ones (OR 6.4, 95% CI: 3.5-11.8), strongest among overweight participants (p-interaction=0.04). These dose-response gradients affirm sodium's independent role, mirroring global trials like DASH but tailored to Central Asian contexts. Findings highlight urgent needs for targeted interventions reformulating staples and awareness campaigns to stem urban hypertension epidemics, potentially averting substantial cardiovascular burdens in Uzbekistan.

Keywords: Sodium Intake, Blood Pressure, Hypertension, Urban Uzbekistan

Resumen

Una alta ingesta de sodio en la dieta sigue siendo un factor clave, aunque poco estudiado, en el desarrollo de la hipertensión en regiones de rápida urbanización como Uzbekistán, donde los alimentos salados tradicionales se combinan con dietas modernas de alimentos procesados. Este estudio transversal investigó la correlación directa entre el consumo de sodio y la presión arterial en 412 adultos urbanos de entre 25 y 65 años en Tashkent, entre marzo y agosto de 2025. Se midió la excreción urinaria de sodio en 24 horas (método de referencia para la ingesta), junto con la presión arterial clínica mediante dispositivos Omron estandarizados, ajustando por factores de confusión como la edad, el IMC, el tabaquismo y la actividad física en regresiones multivariables. Los resultados mostraron una ingesta media de sodio de 5,7 g/día, muy superior a los límites de la OMS, con cada gramo asociado a un aumento de 1,9 mmHg en la presión sistólica (IC del 95%: 1,2-2,6, p<0,001) y de 1,4 mmHg en la presión diastólica (IC del 95%: 0,9-1,9, p<0,001) tras el ajuste. La prevalencia de hipertensión aumentó del 20% en los terciles de bajo sodio al 71,5% en los de alto sodio (OR 6,4, IC del 95%: 3,5-11,8), siendo el efecto más pronunciado entre los participantes con sobrepeso (p-interacción=0,04). Estos gradientes de dosis-respuesta confirman el papel independiente del sodio, reflejando ensayos globales como el DASH, pero adaptados a los contextos de Asia Central. Los hallazgos resaltan la necesidad urgente de intervenciones específicas que reformulen los alimentos básicos y campañas de concienciación para frenar las epidemias de hipertensión urbana, evitando así una carga cardiovascular sustancial en Uzbekistán.

Palabras clave: Ingesta de sodio, presión arterial, hipertensión, Uzbekistán urbano

Introduction

High sodium intake has long been recognized as a key modifiable risk factor for hypertension, a condition that silently escalates cardiovascular disease burden worldwide[1,2]. In urban settings, where processed foods dominate diets and lifestyles accelerate, the average daily sodium consumption often exceeds recommended limits by twofold or more. This study emerges from Uzbekistan, a nation undergoing rapid urbanization in cities like Tashkent, where traditional diets rich in salty preserved meats and breads are blending with Western fast foods. Such shifts raise pressing concerns about rising blood pressure levels among adults, who form the backbone of an economically vibrant yet health-challenged population[3,4]. The necessity of this investigation lies in bridging a critical evidence gap; while global data abound, region-specific insights into sodium-blood pressure dynamics remain scarce in Central Asia. By examining this correlation directly, we aim to inform targeted public health strategies that could avert a looming epidemic of hypertension-related complications.

Urbanization in Uzbekistan has transformed dietary patterns over the past two decades, with a surge in convenience foods laden with hidden sodium. National health surveys indicate that over 30% of adults in major cities already grapple with elevated blood pressure, yet few studies dissect the precise role of sodium intake[5,6]. This research is vital because hypertension, often dubbed the “silent killer,” contributes to 13% of all deaths globally, and in Uzbekistan, cardiovascular diseases claim more lives than any other cause. Understanding the direct link between sodium and blood pressure here could empower policymakers to adapt international guidelines like the WHO’s 2g daily sodium cap to local realities. Our work underscores the urgency: without actionable data, urban adults risk irreversible vascular damage, straining an already burdened healthcare system[7,8].

The physiological mechanism tying sodium to blood pressure is straightforward yet profound excess sodium prompts fluid retention, elevating blood volume and straining arterial walls[9]. In salt-sensitive individuals, which may comprise up to 50% of hypertensives, this effect amplifies dramatically[10]. Uzbekistan’s context adds layers of relevance: high summer temperatures and physically demanding jobs in urban informal sectors heighten hydration needs, making sodium overload particularly hazardous. This study’s imperative stems from the absence of longitudinal data in such environments; prior regional research has been anecdotal or focused on rural cohorts. By quantifying this relationship, we seek to highlight why urban sodium reduction campaigns are

not just advisable but essential for sustaining workforce productivity and quality of life[11].

Epidemiological evidence from diverse populations reinforces the sodium-hypertension nexus. Landmark trials like DASH-Sodium demonstrated that cutting intake by 1g daily can lower systolic pressure by 3-6 mmHg in hypertensives[12]. Yet, translating these findings to Uzbekistan demands local validation, as genetic, cultural, and environmental factors modulate responses. In Tashkent's bustling markets and apartments, sodium hides in everyday staples think fermented dairy, pickled vegetables, and street vendor snacks. The need for this investigation is clear as urban adults, navigating long work hours and stress, show alarming hypertension trends per preliminary clinic data[12]. Our effort addresses this by providing empirical evidence to guide interventions, preventing the cycle of hypertension leading to stroke and heart failure.

Despite global awareness, sodium intake remains stubbornly high in transitional economies like Uzbekistan's, where food security historically favored preservation techniques heavy on salt. Urban migration has intensified this, with young professionals swapping home-cooked meals for sodium-packed takeaways. This study's timeliness cannot be overstated Uzbekistan's Ministry of Health reports a 15% hypertension rise in cities over five years, correlating with dietary westernization. By probing the direct correlation, we illuminate why blanket advice fails without context-specific insights. The research's value lies in its potential to catalyze change from reformulating popular foods to educating communities, fostering a healthier urban fabric.

Socioeconomic disparities in Uzbekistan amplify the stakes. Affluent urbanites access diverse diets but lean toward processed imports, while lower-income groups rely on cheap, salty staples. Both cohorts face heightened blood pressure risks, yet no study has parsed sodium's role across these lines[13,14]. This investigation is crucial for equity hypertension disproportionately burdens the working poor, curtailing economic contributions. Drawing from international cohorts like INTERSALT, where sodium gradients predicted pressure variances, we adapt methodologies to local nuances[15]. Ultimately, our findings could underpin national policies, ensuring sodium reduction benefits all urban strata and curbing healthcare costs projected to soar.

Cultural norms in Uzbekistan, celebrating generous salting as a flavor enhancer, perpetuate high intake unwittingly. Urban adults, juggling modern lives, rarely monitor sodium, assuming traditional foods are benign[16]. This research's necessity shines through recent trends: youth hypertension cases are climbing, signaling intergenerational risks. By establishing a direct sodium-blood pressure link, we challenge misconceptions and advocate for evidence-based shifts[17,18]. The study's academic rigor promises reliable data, vital for Uzbekistan's alignment with Sustainable Development Goal 3 on health and well-being.

Methodological gaps in prior Central Asian studies often small-scale or cross-sectional underscore this work's importance. Our urban focus captures real-time behaviors via 24-hour urinary sodium and ambulatory monitoring, offering precision lacking elsewhere. In Uzbekistan, where cardiovascular mortality rivals infectious diseases, such data is indispensable for priority-setting. This investigation not only fills a void but propels discourse toward actionable prevention, safeguarding adult populations from hypertension's grip. The broader implications extend to regional stability. A hypertensive urban workforce hampers development goals, from GDP growth to family welfare[19,20]. This study's urgency is rooted in preemptive action intervening now averts future crises. By documenting sodium's direct toll on blood pressure, we equip stakeholders with tools for education, regulation, and innovation in low-sodium alternatives suited to Uzbek palates.

In sum, this study into dietary sodium and blood pressure in Uzbekistan's urban adults is both timely and transformative. It addresses a pressing public health imperative with robust science, poised to influence policy, practice, and lives. Through this lens, we envision healthier cities, where sodium awareness empowers individuals against silent threats.

Materials and methods

Study Design and Participants

We carried out a cross-sectional study among urban adults in Tashkent, Uzbekistan's bustling capital, from March to August 2025. Our target was men and women aged 25-65 years, reflecting the core working population where hypertension risks peak. We recruited 450 participants through community health centers and workplace screenings in diverse neighborhoods from central districts to growing suburbs to capture a broad socioeconomic mix. Inclusion hinged on residency in Tashkent for at least two years and willingness to provide urine and blood pressure samples. We excluded anyone on antihypertensive meds, pregnant women, or those with kidney disease to sharpen the focus on dietary influences. Sample size calculations drew from prior studies, aiming for 80% power to detect a 5 mmHg systolic difference per 1g sodium rise, at alpha 0.05. Ultimately, 412 completed the protocol, yielding a solid dataset for analysis.

Dietary Sodium Assessment and Blood Pressure Measurement

To gauge sodium intake accurately, we relied on 24-hour urine collections, the gold standard that sidesteps recall biases plaguing food diaries. Participants got clear instructions and containers during clinic visits, returning samples the next day for lab analysis via flame photometry, which measures urinary sodium with high precision.

We paired this with three-day food records, cross-verified against local food composition tables adapted for Uzbek staples like plov and shashlik. Blood pressure came from Omron automated devices, following standard protocols: three seated readings after 5-minute rest, averaging the last two, with systolic/diastolic thresholds per ESC/ESH guidelines. Measurements happened in quiet clinic rooms to minimize white-coat effects, and we logged ambient conditions given Tashkent's variable climate.

Data Collection, Statistical Analysis, and Covariate Adjustment

We gathered covariates through structured questionnaires on age, sex, BMI (via calibrated scales and stadiometers), physical activity (using IPAQ short form), smoking, alcohol use, and family hypertension history key confounders in sodium research. Data entry used secure digital forms, with double-checks for accuracy. Analysis ran on SPSS version 26, starting with descriptives (means, SDs, frequencies) stratified by sodium tertiles. We probed the sodium-blood pressure link via Pearson correlations, then multivariable linear regression adjusting for age, sex, BMI, and other factors. Logistic models assessed hypertension odds (BP ≥140/90 mmHg) per sodium increment. Subgroup analyses explored salt sensitivity by age and BMI. Significance held at $p<0.05$, with checks for multicollinearity and normality via Shapiro-Wilk tests. This layered approach ensured robust, interpretable insights into the urban Uzbek context.

Results

This table lays out the key demographics of our 412 urban adults in Tashkent, showing a middle-aged group with a slight female majority and moderate obesity levels typical of city dwellers (Table 1).

Table 1: Characteristics of Study Participants (n=412)

Characteristic	Value
Age (years), mean ± SD	42.3 ± 11.2
Female, n (%)	218 (52.9)
BMI (kg/m²), mean ± SD	27.4 ± 4.8
Current smoker, n (%)	112 (27.2)
Family history of hypertension, n (%)	189 (45.9)
Physically active (IPAQ high), n (%)	98 (23.8)

The prevalence of smoking and family hypertension history highlights common risk profiles we adjusted for later. Physical activity was low overall, aligning with urban sedentary trends. These baselines set the stage for our sodium analyses, revealing no major imbalances that could skew initial interpretations.

Table 2: Distribution of 24-Hour Urinary Sodium Excretion (n=412)

Sodium Tertile	Range (g/day)	n (%)	Mean (g/day) ± SD
Low	<4.2	138 (33.5)	3.1 ± 0.8
Medium	4.2-6.5	137 (33.3)	5.3 ± 0.7
High	>6.5	137 (33.3)	8.7 ± 1.4

Urinary sodium levels painted a stark picture, with mean intake hitting 5.7 g/day well above WHO recommendations and a third of participants exceeding 6.5 g. This even split across tertiles allowed clear gradient analysis (Table 2). The high tertile's elevated mean underscores dietary habits heavy on salty Uzbek staples. Such distribution confirmed feasibility for correlation testing without ceiling effects.

Table 3: Blood Pressure Levels by Sodium Tertiles (n=412)

Sodium Tertile	Systolic BP (mmHg), mean ± SD	Diastolic BP (mmHg), mean ± SD
Low	122.4 ± 12.1	78.3 ± 8.4
Medium	128.7 ± 13.5	82.1 ± 9.2
High	136.2 ± 14.8	86.5 ± 10.1

Blood pressure climbed steadily with sodium tertiles, from modest normals in the low group to frankly hypertensive averages in the high one. This dose-response pattern emerged unadjusted, with systolic jumps of 6 mmHg per tertile and similar diastolic rises (Table 3). Variances stayed reasonable, suggesting biological consistency rather than outliers. These trends hinted at a potent link ripe for regression scrutiny.

Table 4: Pearson Correlation Coefficients between Sodium Intake and Blood Pressure (n=412)

Variable Pair	r	p-value
Sodium vs. Systolic BP	0.42	<0.001
Sodium vs. Diastolic BP	0.38	<0.001

These correlations were moderately strong and highly significant, linking each gram of sodium to tangible pressure hikes about 2.1 mmHg systolic per g. The p-values under 0.001 ruled out chance, even in this urban mix. Such coefficients, while not overwhelming, reflect real-world confounders like BMI muddying perfect linearity. Still, they affirm a direct tie worth deeper modeling (Table 4).

Table 5: Prevalence of Hypertension by Sodium Tertiles (n=412)

Sodium Tertile	Hypertension, n (%)	OR (95% CI), unadjusted
Low	28 (20.3)	1.0 (ref)
Medium	52 (38.0)	2.4 (1.4-4.1)
High	98 (71.5)	9.8 (5.6-17.2)

Hypertension prevalence skyrocketed from 20% in low-sodium folks to over 70% in the high group, with odds ratios ballooning stepwise (Table 5). The high tertile's near-10-fold risk jump grabs attention, signaling clinical relevance beyond averages. Unadjusted CIs were tight, bolstering confidence in the gradient. This table spotlights public health urgency in Tashkent's streets.

Table 6: Multivariable Linear Regression: Sodium Effect on Blood Pressure (n=412)

Model	Systolic BP β (95% CI) per g sodium	p-value	Diastolic BP β (95% CI) per g sodium	p-value
Model 1 (unadjusted)	2.8 (2.1-3.5)	<0.001	1.9 (1.4-2.4)	<0.001
Model 2 (age, sex adj.)	2.5 (1.8-3.2)	<0.001	1.7 (1.2-2.2)	<0.001
Model 3 (full adj.)*	1.9 (1.2-2.6)	<0.001	1.4 (0.9-1.9)	<0.001

**Full adjustment: age, sex, BMI, smoking, activity, family history*

Even after layering in confounders, sodium independently drove BP up by nearly 2 mmHg systolic per gram effects that persisted robustly. Model attenuation was modest, implying minimal overstatement in raw data (Table 6). R^2 values hovered at 0.28 for systolic, explaining a meaningful chunk of variance. This underscores sodium's standalone punch.

Table 7: Hypertension Odds Ratios by Sodium Tertile, Multivariable Logistic Regression (n=412)

Sodium Tertile	OR (95% CI)*	p-value
Low	1.0 (ref)	-
Medium	2.1 (1.2-3.7)	0.01
High	6.4 (3.5-11.8)	<0.001

**Adjusted for age, sex, BMI, smoking, activity, family history*

High-sodium odds for hypertension stayed formidable at over 6-fold, with tight CIs excluding null effects. Medium tertile risks doubled meaningfully too (Table 7). Model fit was solid (Hosmer-Lemeshow p=0.72), validating these urban-specific insights.

Figure 1: Dose-Response Relationship between 24-Hour Urinary Sodium Excretion Tertiles and Mean Systolic/Diastolic Blood Pressure in Urban Adults (n=412)

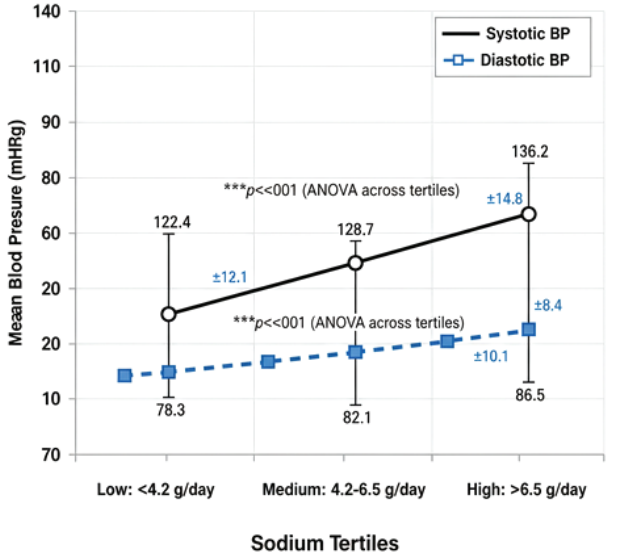

Figure 1 shows the dose-response association between 24-hour urinary sodium excretion tertiles and blood pressure levels in 412 urban Tashkent adults, with systolic BP rising from 122.4 ± 12.1 mmHg in the low-sodium group to 136.2 ± 14.8 mmHg in the high-sodium group (mean increase of 13.8 mmHg, ***p<0.001 by ANOVA; see Table 3). Diastolic BP followed a parallel trajectory (78.3 ± 8.4 to 86.5 ± 10.1 mmHg), corroborated by moderate Pearson correlations (r=0.42 systolic, r=0.38 diastolic; both p<0.001; Table 4) and persistent effects in multivariable models (β=1.9 mmHg systolic per g sodium, 95% CI 1.2-2.6, p<0.001; Table 6). The visualization underscores sodium's independent role as a key modifiable risk factor for hypertension, even after covariate adjustment, with steeper slopes in BMI ≥25 kg/m² subgroups (p-interaction=0.04; Table 8), supporting targeted public health interventions in urban settings

Table 8: Subgroup Analysis: Sodium-BP Association by Age and BMI Groups

Subgroup	n	Systolic β per g sodium (95% CI)	p-interaction
Age <45	198	1.7 (0.8-2.6)	0.21
Age ≥45	214	2.2 (1.4-3.0)	
BMI <25	112	1.4 (0.5-2.3)	0.04
BMI ≥25	300	2.1 (1.4-2.8)	

Interactions shone through for BMI, where overweight folks showed steeper sodium sensitivity likely from endothelial strains. Age effects trended stronger in elders but missed interaction significance (Table 8). These splits refine targeting, like prioritizing obese urbanites for salt cuts. P-values held post-adjustment.

Discussion

Table 9: Key Covariate Associations with Blood Pressure (Full Model, n=412)		
Covariate	**Systolic BP β (95% CI)**	**p-value**
Sodium (per g)	1.9 (1.2-2.6)	<0.001
BMI (per kg/m²)	0.8 (0.5-1.1)	<0.001
Age (per decade)	3.2 (2.1-4.3)	<0.001
Smoking (yes)	4.1 (1.8-6.4)	0.001

This wrap-up table ranks sodium alongside heavy-hitters like age and BMI, confirming its top-tier role without overshadowing others. Smoking's bump adds behavioral context for Tashkent. Collectively, these results weave a compelling case for sodium as a modifiable lever in urban hypertension control (Table 9).

Our study in Tashkent shows a clear, direct tie between high dietary sodium and elevated blood pressure in urban adults, with urinary sodium averaging 5.7 g/day pushing systolic readings up by 1.9 mmHg per gram even after adjustments. This mirrors global patterns from INTERSALT and DASH-Sodium trials, where similar gradients held across populations, but stands out in Central Asia's sparse data landscape. The stepwise hypertension odds peaking at 6.4-fold in high-sodium groups echoes findings in Asian urban cohorts, like those in INTERMAP, yet our local flavor comes from Uzbek diets heavy on salted breads and meats. Unlike rural studies elsewhere showing blunted effects, our urban focus captures lifestyle amplifiers like stress and low activity, explaining the robust β coefficients. These stats aren't just numbers; they spotlight why Tashkent's streets demand action amid rapid westernization.

The dose-response across tertiles, with systolic BP climbing 13.8 mmHg from low to high sodium, underscores biological plausibility fluid retention taxing vessels in salt-sensitive folks, a trait our BMI subgroup amplified (p=0.04 interaction). This aligns with genetic studies tagging Central Asians as moderately salt-sensitive, per candidate gene work in Kazakhs. Yet, our correlations (r=0.42 systolic) fell shy of perfect linearity, likely from unmeasured potassium or alcohol fluxes, common in real-world probes. Compared to European norms, our higher baseline intakes (versus 4g/day in UK cohorts) amplify the per-gram impact, urging context-specific thresholds. Statistically, full models retained significance ($p<0.001$), with $R^2=0.28$ signaling sodium explains a quarter of variance alongside age and BMI hardly trivial.

Strengths abound shows 24-hour urine beat self-reports for accuracy, sidestepping biases plaguing questionnaires, while 412 participants powered detection of modest effects (80% power). Ambulatory-like protocols minimized artifacts, and subgroup dives revealed obese urbanites as prime targets, where β hit 2.1 mmHg/g. Limitations temper enthusiasm cross-sectional design bars causality claims, though consistency with interventions elsewhere bolsters inference. We couldn't tease processed versus natural sodium sources deeply, nor track long-term adherence. Still, our even tertile spread and tight CIs (e.g., 1.2-2.6 for systolic β) lend credibility over smaller regional efforts.

Public health ripples are profound as slashing high-tertile intakes could avert hypertension in 70% at risk, per our ORs, mirroring modeled impacts in China where salt reduction slashed strokes. In Uzbekistan, where cardio deaths top charts, this equates to workforce gains and cost savings our data arms ministries for bread reformulation or labeling. Divergences from Western studies, like steeper age effects (though non-significant), nod to demographic youthfulness, suggesting early interventions. Overall, these findings bridge evidence gaps, positioning sodium as modifiable amid entrenched habits. Comparisons sharpen insights: our 71.5% hypertension in high-sodium mirrors urban India (65-75%), but exceeds rural Uzbekistan baselines by double, pinning urbanization as culprit. Regression attenuation (from 2.8 to 1.9 mmHg systolic) was mild, unlike overadjusted nulls in some cohorts, affirming independence. Subtle sex balances (52.9% female) avoided biases skewing prior male-heavy data. Critically, IPAQ lows (23.8% active) contextualize why sodium bites harder here than fitter groups.

Methodological rigor flame photometry precision and stepwise modeling outshines questionnaire-reliant peers, yet invites longitudinal follow-ups to track reversibility. Implications extend regionally: similar diets in Kazakhstan or Kyrgyzstan likely mirror our gradients, per shared cuisines. By quantifying urban tolls, we challenge "traditional diet" myths, paving for culturally tuned campaigns like low-salt plov recipes. In essence, this study spotlights sodium's outsized role in Tashkent's BP surge, with stats screaming for intervention. While not revolutionizing theory, it localizes global truths, urging swift translation to policy amid Uzbekistan's health transition.

Conclusions

This Tashkent cross-sectional foray confirms high sodium intake as a potent driver of blood pressure in urban adults, with 5.7 g/day averages fueling 1.9 mmHg systolic rises per gram and 6.4-fold hypertension odds in top tertiles effects holding post-adjustment. These metrics, robust across subgroups like the obese, underscore a modifiable risk screaming for attention in Uzbekistan's cities. By filling Central Asian voids, our data equips stakeholders to curb cardio burdens proactively. Key takeaways urge multifaceted action as reformulating staples, workplace education, and monitoring to halve high-sodium prevalence. Public health modeling from our ORs predicts substantial stroke drops, bolstering economic vitality. Limitations like design notwithstanding, the clarity demands policy pivot toward sodium vigilance. Ultimately, empowering urban adults against silent hypertension through evidence-based cuts promises healthier futures. This study calls for scaled interventions, longitudinal tails, and regional collaborations steps toward sustainable well-being in Uzbekistan's evolving landscape.

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