

Regional Disparities in the Prevalence of Hypertension and Diabetes Mellitus According to the Degree of Urbanization (DegUrba): A Cross-Sectional Study Using the 2020 Korean Community Health Survey

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Abstract

Background

Despite South Korea's achievement of Universal Health Coverage (UHC), regional health inequities persist as a significant public health challenge. Traditional urban-rural classifications often fail to capture the nuanced spatial dynamics of modern settlement patterns. This study aimed to evaluate the prevalence of hypertension (HTN) and diabetes mellitus (DM) across the urbanization gradient—Cities, Towns, and Rural areas—using the UN-recommended Degree of Urbanization (DegUrba) classification.

Methods

We conducted a cross-sectional analysis of 154,829 adults residing in Gyeonggi-do, utilizing the 2020 Korean Community Health Survey (KCHS) data. Regions were categorized into Cities (Urban Centers), Towns and Semi-dense Areas (Urbanized), and Rural Areas based on 1km² population grid cells. Prevalence and subgroup interactions were analyzed using complex sampling weights to ensure regional representativeness.

Results

A distinct geographic disparity was observed: rural areas exhibited the highest prevalence of HTN (36.31%) and DM (14.65%), significantly exceeding those in Cities (HTN: 23.04%, DM: 10.01%) and Urbanized Towns (HTN: 20.24%, DM: 9.31%). Urbanized Towns showed the lowest prevalence for both conditions. Subgroup analysis demonstrated that the prevalence gap between rural areas and urbanized towns was most pronounced among elderly females and individuals with lower educational attainment.

Conclusion

Regional disparities in chronic disease prevalence remain pronounced despite the UHC system, with rurality serving as a strong independent determinant. These findings suggest that healthcare equity cannot be achieved by financial coverage alone. There is an urgent need for density-aware, targeted community-based interventions focusing on socioeconomically vulnerable rural populations to mitigate the cardiovascular burden.

1. Introduction

Hypertension (HTN) and diabetes mellitus (DM) represent the leading global risk factors for cardiovascular disease (CVD), contributing significantly to premature mortality and escalating healthcare costs [1, 2]. Globally, the epidemiological landscape of these cardiometabolic diseases has shifted; while historically associated with high-income urban centers, recent large-scale evidence—notably from the

PURE study—indicates that the burden is rapidly increasing in rural areas of middle-income and high-income nations [3, 4]. In South Korea, the rapid demographic shift toward an ultra-aged society has intensified the socioeconomic burden of these diseases, making effective community-level management a critical priority for national healthcare sustainability [5, 6].

South Korea's healthcare system is characterized by a robust Universal Health Coverage (UHC) framework, which, in principle, provides equitable medical access to all citizens [7]. However, evidence from various developed nations suggests that geographical location remains a significant barrier to health equity even under unified insurance systems [8, 9]. Most existing literature in Korea has relied on administrative boundaries (e.g., Dong vs. Eup/Myeon) to define regionality. This binary classification is increasingly criticized for its inability to reflect actual population density and functional settlement patterns, often masking the heterogeneity of rapidly developing "semi-dense" areas. Similar limitations have been observed in other regions; for instance, studies in China and Brazil have demonstrated that traditional administrative labels often obscure the health profiles of "peri-urban" zones where urbanization is actively transitioning [10, 11].

To address this gap, international organizations including the United Nations (UN) and the European Commission developed the "Degree of Urbanization" (DegUrba) framework [12]. Unlike traditional administrative divisions, DegUrba utilizes high-resolution population grids (1km x 1km) to categorize regions based on actual settlement density and contiguity. By moving beyond a simple urban-rural dichotomy and adopting the concept of an "urbanization gradient," this framework allows for a more granular and sophisticated analysis of regional disparities. By applying this standardized metric to Gyeonggi-do, we can more precisely evaluate whether the "urban-rural gap" is driven by residential density or underlying social determinants, thereby identifying subtle health variations that were previously obscured. Gyeonggi-do was selected as the target region because it represents the most populous and rapidly developing area in South Korea. According to the 2020 Population and Housing Census conducted by Statistics Korea, Gyeonggi-do houses approximately 13.4 million residents, accounting for 25.9% of the entire national population (51.8 million), despite occupying only about 10.1% of the country's land area. This region features a unique mix of highly developed urban centers, large-scale new towns, and rural communities, making it an ideal setting to investigate the health impacts of rapid urbanization.

The primary objective of this study was to investigate the prevalence of HTN and DM across three DegUrba categories (Cities, Towns, and Rural) using the 2020 KCHS data. We hypothesized that significant regional disparities would persist despite the UHC system and that rural areas would bear the highest burden of cardiometabolic diseases, following patterns observed in other rapidly aging developed nations.

2. Methods

2.1 Data Source and Sampling Design

This study utilized data from the 2020 Korean Community Health Survey (KCHS). The KCHS is a nationwide, community-based cross-sectional survey conducted annually since 2008 by the Korea Disease Control and Prevention Agency (KDCA) [13]. The survey employs a multi-stage stratified cluster sampling design. Within Gyeonggi-do, sampling points were selected through probability proportion-to-size (PPS) systematic sampling, ensuring regional representativeness. Data collection was performed by trained interviewers using a Computer-Assisted Personal Interviewing (CAPI) system. After excluding participants with incomplete data, the final study population consisted of 154,829 adults.

2.2 Regional Classification: The DegUrba Framework

Regional classification was based on the DegUrba methodology [12]. Cities (Urban Centers) are areas where at least 50% of the population resides in high-density clusters (density > 1,500 inhabitants/ 1km²; minimum population 50,000). Towns and Semi-dense Areas (Urbanized) are areas where less than 50% live in an urban center but at least 50% reside in an urban cluster (density > 300 inhabitants/1km²; minimum population 5,000). Rural Areas encompass regions where most of the population lives in rural grid cells outside both urban centers and urban clusters. In accordance with this classification, we categorized the regions within Gyeonggi-do into these three groups—Cities, Towns, and Rural Areas—for our analysis in this study.

2.3 Definition of Outcomes and Covariates

The primary outcomes were the point prevalence rates of HTN and DM as of 2020, determined via self-reported physician diagnosis using the standardized Korean Community Health Survey (KCHS) questionnaire. Participants were asked whether they had ever been diagnosed with hypertension or diabetes by a physician. Covariates included age, sex, and socioeconomic indicators such as education level and marital status. Sex was defined as sex assigned at birth based on the survey questionnaire. Lifestyle factors including current smoking and alcohol consumption were also recorded to describe the study population.

2.4 Statistical Analysis

All statistical analyses were performed using R software, version 4.3.2 (R Foundation for Statistical Computing, Vienna, Austria). Categorical variables are presented as numbers and percentages. To compare the prevalence of hypertension and diabetes mellitus among the three groups (Urban, Urbanized, and Rural), the Chi-square test was performed. When the overall difference among groups was statistically significant, post-hoc pairwise comparisons were conducted using the Bonferroni correction to adjust for multiple comparisons. A two-sided P-value of < 0.05 was considered statistically significant.

3. Results

3.1 Regional Prevalence of Hypertension and Diabetes Mellitus

In 2020, significant geographic disparities were observed in the prevalence of chronic diseases (Table 1, Figure 1). The crude prevalence of hypertension was highest in rural areas (36.3%), followed by urban centers (23.0%) and urbanized towns (20.2%) ($p < 0.001$). Pairwise comparisons confirmed that rural areas had a significantly higher prevalence compared to both urban and urbanized areas ($p < 0.001$ for both). Notably, urbanized towns showed a significantly lower prevalence of hypertension than urban centers ($p < 0.001$).

For diabetes mellitus, a similar gradient was observed: prevalence was highest in rural areas (14.7%), followed by urban centers (10.0%) and urbanized towns (9.3%) ($p < 0.001$). While rural areas exhibited a significantly higher burden of diabetes compared to other regions ($p < 0.001$), the difference between urban centers and urbanized towns was marginally significant ($p = 0.054$).

3.2 Subgroup Analysis by Age and Sex

The prevalence of hypertension increased with age across all regions (Table 2). Interestingly, in the young adult group (19–39 years), there was no statistically significant difference in hypertension prevalence among regions ($p = 0.589$). However, disparities emerged and widened from middle age onwards. In the 40–59 age group, rural residents had a prevalence of 19.5% compared to 16.9% in urbanized towns ($p < 0.001$). This gap persisted in the elderly population (≥ 80 years), where rural areas reached a prevalence of 61.3%, significantly higher than in urban (57.8%) and urbanized areas (57.2%).

Regarding sex, rural areas showed the highest prevalence of hypertension for both males (33.2%) and females (38.8%). Notably, females in urbanized towns exhibited the lowest hypertension prevalence (18.7%) among all groups.

For diabetes mellitus, rural dominance in prevalence was consistent across most age groups. However, in the elderly population over ≥ 80 years, urban centers showed a higher prevalence (23.6%) compared to rural areas (17.9%) ($p < 0.001$).

3.3 Impact of Socioeconomic Status and Lifestyle Factors

Consistently higher prevalence rates were observed in rural areas across all subgroups stratified by lifestyle factors and socioeconomic status (Tables 3 and 4). Regarding lifestyle habits, among non-smokers, the prevalence of hypertension was markedly higher in rural areas (38.4%) compared to urban (23.6%) and urbanized areas (20.6%) ($p < 0.001$). A similar pattern was observed for alcohol consumption; non-drinkers in rural areas had a hypertension prevalence of 43.3%, significantly exceeding that of their urban counterparts (31.3%) ($p < 0.001$).

Socioeconomic analysis revealed that lower education and single marital status (divorced/widowed/separated) were associated with higher disease burden, with the impact being most significant in rural area. For instance, among individuals with a middle school education or less, hypertension prevalence reached 50.6% in rural areas ($p < 0.001$). Similarly, the

divorced/widowed/separated group in rural areas exhibited the highest hypertension prevalence of 50.6%, compared to 40.2% in cities and 35.8% in urbanized towns ($p < 0.001$).

3.4 Longitudinal Trends (2008–2023)

Longitudinal analysis from 2008 to 2023 demonstrated a consistent upward trend in the prevalence of both conditions across all regions (Figure 2). For hypertension, the prevalence in rural areas increased from 23.9% in 2008 to 40.5% in 2023 (P for trend < 0.001). Although urban and urbanized areas also showed increases (reaching 26.2% and 24.7% in 2023, respectively), the gap between rural and non-rural areas remained substantial throughout the 15-year period.

A similar trajectory was observed for diabetes mellitus. The prevalence in rural areas nearly doubled, rising from 8.4% in 2008 to 17.0% in 2023. This increase was steeper than that observed in urban centers (5.9% to 11.8%) and urbanized towns (6.3% to 11.1%), reinforcing the persistence of the rural penalty over time.

4. Discussion

The findings of this study provide comprehensive evidence that substantial regional disparities in the prevalence of hypertension and diabetes persist in Gyeonggi-do, even within a highly integrated Universal Health Coverage (UHC) system. Our analysis revealed a clear "rural penalty," with rural residents experiencing a 36.31% prevalence for HTN and 14.65% for DM—figures approximately 1.5 times higher than those observed in more urbanized settings. A notable finding of this study is the non-linear relationship between urbanization and chronic disease, wherein "urbanized towns" (semi-dense areas) exhibited the lowest prevalence for both conditions (HTN: 20.24%, DM: 9.31%), even lower than high-density cities. Furthermore, subgroup analyses highlighted that these geographical gaps were most pronounced among the elderly (≥ 80 years), females, and individuals with lower socioeconomic status, while longitudinal data from 2008 to 2023 confirmed that this rural-urban divide is a stable, structural inequality rather than a transient fluctuation.

4.1 Drivers of Health Advantage in Moderate Urbanicity: The Benefits of Balanced Density

Our results reveal that Towns and Semi-dense Areas showed the lowest prevalence of cardiometabolic diseases, suggesting that moderate urbanicity provides a health-optimizing structural environment. Several key mechanisms explain why this specific degree of urbanization is particularly advantageous for managing chronic diseases.

First, moderate urbanicity provides an environment where local medical services are highly accessible. Unlike rural areas where a low population density makes it difficult to maintain medical facilities, towns have a sufficient population to support a stable network of neighborhood clinics and pharmacies. This leads to higher rates of regular health screenings and better long-term management of blood pressure

and glucose levels. Simultaneously, these areas avoid the "medical overcrowding" often seen in megacities, where a high volume of patients can limit the time physicians spend with each individual, potentially reducing the quality of personalized follow-up care.

Second, the physical living environment in towns is more conducive to regular exercise. While residents in high-density cities often face barriers such as a lack of green spaces, noise pollution, and heavy traffic that discourage outdoor activity, moderately urbanized areas tend to have better-integrated walking paths and local parks. This environment encourages "incidental exercise"—such as walking to a nearby market—without the stress of air pollution or overcrowded streets found in large urban centers [14]. This ease of staying active is a critical factor in preventing metabolic conditions like diabetes.

Third, moderate urbanicity promotes stronger social support and community-level monitoring. In large cities, the anonymity of urban life and the weakening of neighborhood ties are often linked to higher stress levels. In contrast, towns often maintain a level of community connection where residents are more likely to know and look out for one another. This social closeness facilitates informal health monitoring and peer support, which is essential for managing chronic diseases over the long term [15]. By using the DegUrba framework to focus on these semi-dense areas, we have highlighted that a balanced population density acts as a protective factor for heart and metabolic health.

4.2 Global Comparison and the Persistence of Rural Penalty

The higher rural prevalence in Gyeonggi-do mirrors trends in other aging high-income nations. In the United States, rural residents have a 7–10% higher prevalence of HTN than urban residents, driven by social determinants rather than just insurance status [16]. Conversely, in low-income regions of South Asia, urban areas still report higher prevalence, but the gap is narrowing rapidly [17]. Our finding that Korea's rural burden remains high even under UHC suggests that financial coverage does not negate the Social Determinants of Health (SDOH), such as lower health literacy and physical barriers to specialized care.

4.3 Limitations

However, our study has several limitations. First, the cross-sectional design of the study limits our ability to establish definitive causal relationships between the degree of urbanization and the onset of cardiometabolic diseases. Second, the reliance on self-reported physician diagnoses from the KCHS may have introduced information bias, likely leading to an underestimation of the true prevalence of hypertension and diabetes. This "hidden" disease burden may be particularly pronounced in rural areas, where reduced access to screening services could result in a higher proportion of undiagnosed cases, potentially masking an even wider rural-urban gap than reported here. Third, while Gyeonggi-do serves as a diverse proxy for the urbanization gradient, the study was restricted to a single province. This may limit the generalizability of our findings to other regions of South Korea that may exhibit different socioeconomic or geographical dynamics, such as more remote mountainous or island territories. Forth,

although we controlled for several key demographic and lifestyle variables, residual confounding from unmeasured factors—such as dietary patterns, precise levels of environmental pollutants, or detailed healthcare utilization data—cannot be entirely ruled out. Fifth, this study did not account for residential mobility, such as migration inflow and outflow. We could not control for the potential 'selective migration' of individuals with chronic diseases moving to specific areas, or the 'healthy migrant effect' where younger, healthier individuals move to urban centers for employment. These migration patterns may have influenced the observed regional disparities. Finally, regional disparities in healthcare access may have influenced diagnostic rates. The high prevalence in rural areas, despite limited access, underscores a substantial disease burden. Conversely, the lower prevalence in urban centers might reflect a 'masking effect,' where time-constrained working populations remain undiagnosed despite better physical access to care.

However, unlike prior research relying on a traditional urban-rural binary classification, we utilized the Degree of Urbanization (DegUrba) framework to explain the heterogeneity of the urbanization gradient. This approach allowed us to identify the specific health dynamics of urbanized area, a crucial insight often obscured in simple binary urban-rural analyses. The strength of this study lies in using the globally standardized DegUrba classification, providing precise evidence for resource allocation. By demonstrating that population density is a key driver of health outcomes, our research provides a framework for future spatial epidemiological modeling that can inform urban planning and proactive primary prevention strategies to mitigate the burden of cardiometabolic diseases. Consequently, a paradigm shift is needed toward density-aware health policy. While the scope of this study was restricted to hypertension and diabetes mellitus, future research is needed to expand this detailed spatial analysis to a broader spectrum of chronic diseases and wider geographical regions. These extended studies will be essential for a more comprehensive understanding of the structural determinants of health.

5. Conclusion

Our study demonstrates a significant geographic disparity in the prevalence of hypertension and diabetes mellitus within Gyeonggi-do, with rural areas bearing the heaviest disease burden despite the national Universal Health Coverage system. Consequently, achieving true health equity necessitates a paradigm shift from broad national statistics to density-aware, community-centric interventions that specifically target the structural vulnerabilities of rural populations.

Declarations

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Competing interests: The authors declare they have no conflicts of interest related to this work to disclose.

Ethics approval and consent to participate: The study protocol was approved by the Institutional Review Board of St. Vincent's Hospital (VC25ZISI0016, approved date 2025.02.06). The requirement for informed consent was waived due to the retrospective nature of the study using anonymized data. All methods were carried out in accordance with relevant guidelines and regulations, including the Declaration of Helsinki.

Availability of data and materials: The data that support the findings of this study were obtained from the Korean Community Health Survey (KCHS). These data are not publicly available due to restrictions related to data protection and privacy regulations but are available to qualified researchers upon reasonable request and with permission from the respective data providers.

Authors' contributions: SSC and JJ contributed equally to this work and share first authorship. SSC and JJ conceptualized the study, conducted the formal analysis, and wrote the main manuscript text. JHK, SYJ, and KDY contributed to the data curation and methodology. DM, SNL, and WYJ assisted in data interpretation and literature review. JHJ provided statistical support and prepared the figures and tables. SHH acquired funding, supervised the research, and critically revised the manuscript for important intellectual content. All authors reviewed and approved the final manuscript.

Consent for publication: Not applicable

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Tables

Table 1. Comparison of Prevalence Rates of Hypertension and Diabetes Mellitus by Residential Area in 2020

Group	Urban (n=79,360)	Urbanized (n=10,946)	Rural (n=64,523)	P overall	P (U vs Uz)	P (U vs R)	P (Uz vs R)
Hypertension	18,283 (23.0)	2,216 (20.2)	23,427 (36.3)	< 0.001	< 0.001	< 0.001	< 0.001
Diabetes	7,945 (10.0)	1,019 (9.3)	9,453 (14.7)	< 0.001	0.054	< 0.001	< 0.001

Values are presented as n (%). P-values for pairwise comparisons were adjusted using the Bonferroni correction. U: Urban; Uz: Urbanized; R: Rural.

Table 2. Subgroup Analysis of Prevalence by Age and Sex (2020)

Variable	Urban (n/N (%))	Urbanized (n/N (%))	Rural (n/N (%))	P-value
Hypertension				
Age				
19–39	535/22,923 (2.3)	73/3,421 (2.1)	189/7,659 (2.5)	0.589
40–59	5,030/29,216 (17.2)	782/4,640 (16.9)	3,757/19,221 (19.5)	< 0.001
60–79	10,501/23,386 (44.9)	1,131/2,483 (45.5)	14,360/29,285 (49.0)	< 0.001
≥80	2,217/3,835 (57.8)	230/402 (57.2)	5,121/8,358 (61.3)	< 0.001
Sex				
Male	8,605/35,867 (24.0)	1,123/5,107 (22.0)	9,554/28,808 (33.2)	< 0.001
Female	9,678/43,493 (22.3)	1,093/5,839 (18.7)	13,873/35,715 (38.8)	< 0.001
Diabetes Mellitus				
Age				
19–39	199/22,923 (0.9)	41/3,421 (1.2)	102/7,659 (1.3)	< 0.001
40–59	2,078/29,216 (7.1)	334/4,640 (7.2)	1,712/19,221 (8.9)	< 0.001
60–79	4,763/23,386 (20.4)	557/2,483 (22.4)	6,139/29,285 (21.0)	0.005
≥80	905/3,835 (23.6)	87/402 (21.6)	1,500/8,358 (17.9)	< 0.001
Sex				
Male	4,020/35,867 (11.2)	547/5,107 (10.7)	4,439/28,808 (15.4)	< 0.001
Female	3,925/43,493 (9.0)	472/5,839 (8.1)	5,014/35,715 (14.0)	< 0.001

Values are presented as number of cases/total number (percentage). P-values were calculated using the Chi-square test to compare the prevalence among the three groups (Urban, Urbanized, and Rural) within

each subgroup.

Table 3. Subgroup Analysis of Prevalence by Lifestyle Habits (Smoking and Alcohol Consumption) in 2020

Variable	Urban (n/N (%))	Urbanized (n/N (%))	Rural (n/N (%))	P-value
Hypertension				
Current Smoker				
No	15,732/66,547 (23.6)	1,842/8,940 (20.6)	21,066/54,823 (38.4)	< 0.001
Yes	2,551/12,813 (19.9)	374/2,006 (18.6)	2,361/9,700 (24.3)	< 0.001
Alcohol Consumption				
Non-drinker	9,178/29,330 (31.3)	1,004/3,775 (26.6)	14,703/33,948 (43.3)	< 0.001
Drinker	9,105/50,030 (18.2)	1,212/7,171 (16.9)	8,724/30,575 (28.5)	< 0.001
Diabetes Mellitus				
Current Smoker				
No	6,604/66,547 (9.9)	828/8,940 (9.3)	8,150/54,823 (14.9)	< 0.001
Yes	1,341/12,813 (10.5)	191/2,006 (9.5)	1,294/9,700 (13.3)	< 0.001
Alcohol Consumption				
Non-drinker	4,373/29,330 (14.9)	512/3,775 (13.6)	6,127/33,948 (18.0)	< 0.001
Drinker	3,572/50,030 (7.1)	507/7,171 (7.1)	3,326/30,575 (10.9)	< 0.001

Values are presented as number of cases/total number (percentage). P-values were calculated using the Chi-square test to compare the prevalence among the three groups (Urban, Urbanized, and Rural) within each subgroup.

Table 4. Subgroup Analysis of Prevalence by Socioeconomic Status (Education and Marital Status) in 2020

Variable	Urban (n/N (%))	Urbanized (n/N (%))	Rural (n/N (%))	P-value
Hypertension				
Education Level				
Middle school or less	8,819/18,669 (47.2)	881/1,891 (46.6)	17,375/34,340 (50.6)	< 0.001
High school	5,181/22,251 (23.3)	697/3,454 (20.2)	4,097/16,188 (25.3)	< 0.001
College or more	4,258/38,372 (11.1)	603/5,500 (11.0)	1,939/13,960 (13.9)	< 0.001
Marital Status				
Single	834/18,581 (4.5)	106/2,365 (4.5)	449/6,387 (7.0)	< 0.001
Married	12,168/47,615 (25.6)	1,534/6,970 (22.0)	14,775/41,909 (35.3)	< 0.001
Divorced/Widowed/Separated	5,266/13,107 (40.2)	571/1,593 (35.8)	8,199/16,210 (50.6)	< 0.001
Diabetes Mellitus				
Education Level				
Middle school or less	3,938/18,669 (21.1)	417/1,891 (22.1)	6,710/34,340 (19.5)	< 0.001
High school	2,283/22,251 (10.3)	350/3,454 (10.1)	1,865/16,188 (11.5)	< 0.001
College or more	1,711/38,372 (4.5)	245/5,500 (4.5)	872/13,960 (6.2)	< 0.001
Marital Status				
Single	341/18,581 (1.8)	48/2,365 (2.0)	220/6,387 (3.4)	< 0.001
Married	5,294/47,615 (11.1)	735/6,970 (10.5)	6,305/41,909 (15.0)	< 0.001
Divorced/Widowed/Separated	2,303/13,107 (17.6)	235/1,593 (14.8)	2,926/16,210 (18.1)	< 0.001

Values are presented as number of cases/total number (percentage). P-values were calculated using the Chi-square test to compare the prevalence among the three groups (Urban, Urbanized, and Rural) within each subgroup.

Figures

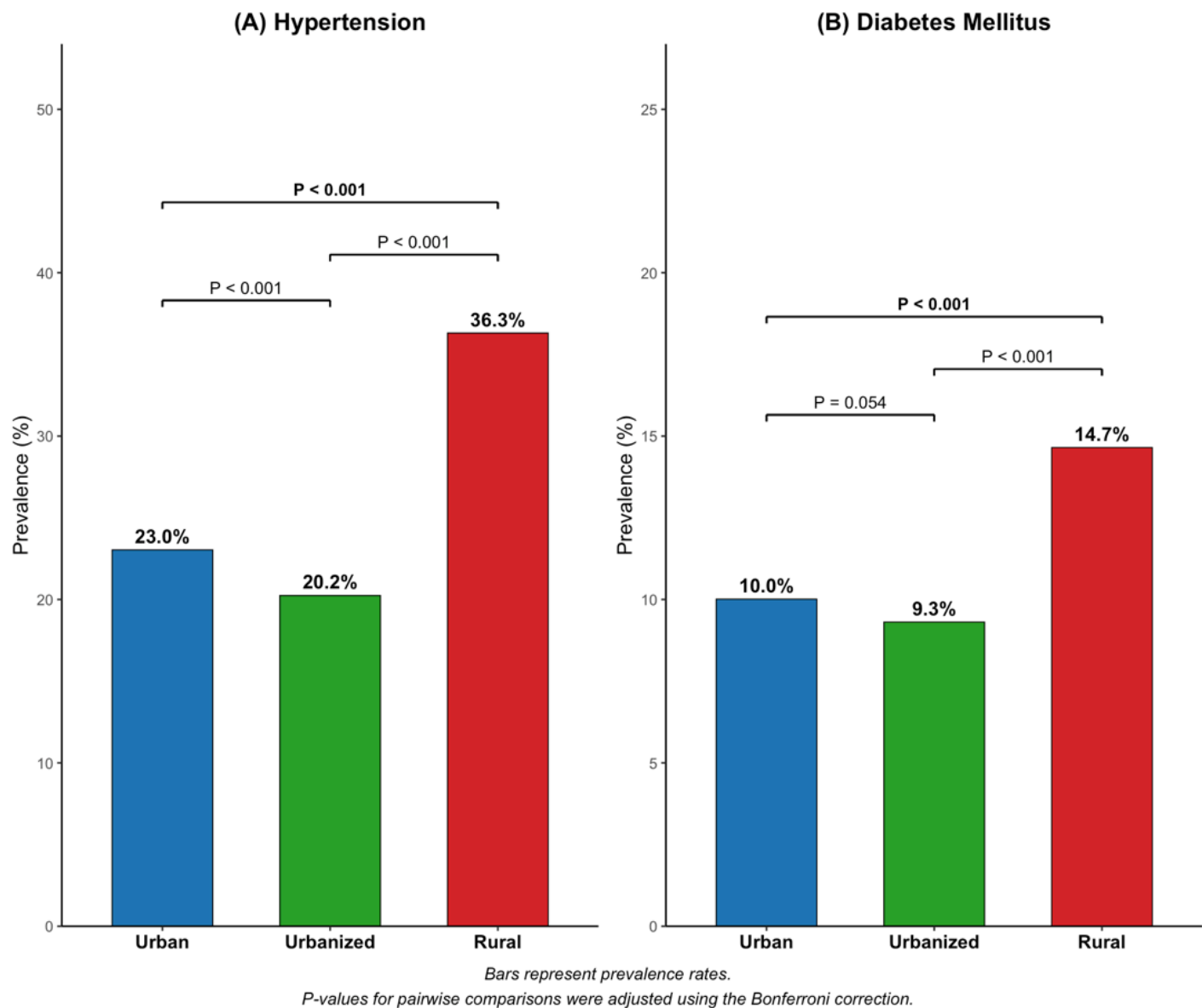


Figure 1

Prevalence of hypertension and diabetes mellitus by residential area in 2020. (A) Prevalence of hypertension. (B) Prevalence of diabetes mellitus.

P-values for pairwise comparisons were adjusted using the Bonferroni correction.

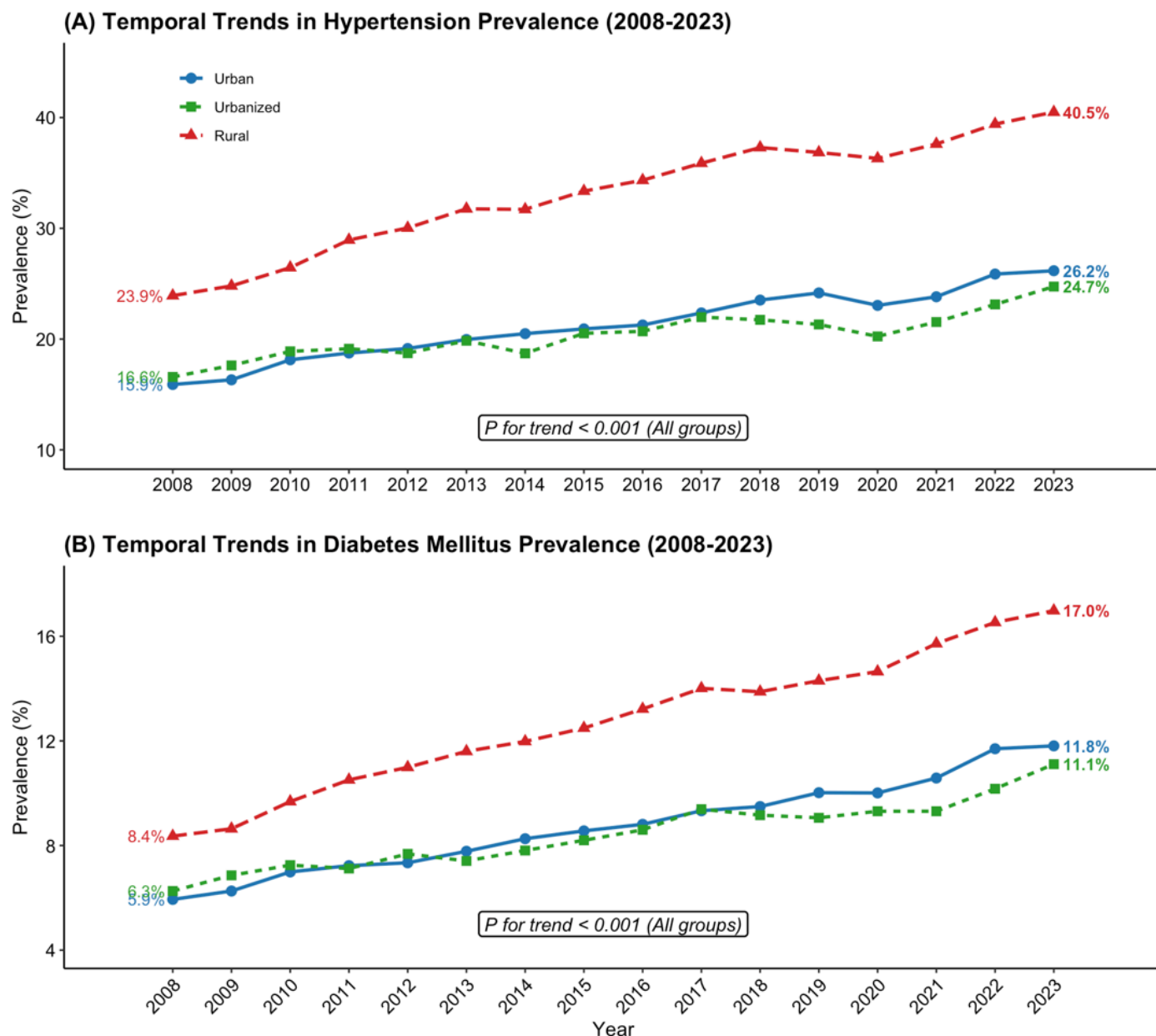


Figure 2

Temporal trends in the prevalence of hypertension (A) and diabetes mellitus (B) by residential area from 2008 to 2023.

From 2008 to 2023, the prevalence of hypertension steadily increased in all residential areas (Figure 2). In rural areas, the prevalence rose significantly from 23.9% in 2008 to 40.5% in 2023 (P for trend < 0.001), maintaining a consistently higher rate compared to urban areas (15.9% to 26.2%). Similarly, the prevalence of diabetes mellitus showed an increasing trend. Notably, the prevalence in rural areas nearly doubled over the 16-year period (from 8.4% to 17.0%)