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RESEARCH ARTICLE

Rural-urban disparities in the diagnosis and treatment of hypertension and diabetes among aging Indians

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Abstract

INTRODUCTION: Hypertension and diabetes are modifiable risk factors for dementia. We aimed to assess rural-urban disparities in the diagnosis and treatment of these conditions among aging Indians.

METHODS: Participants ($n = 6316$) were from two parallel, prospective aging cohorts in rural and urban India. Using self-report and clinical/biochemical assessments, we subdivided participants with diabetes and hypertension into undiagnosed and untreated groups. Logistic regression and Fairlie decomposition analysis were the statistical methods utilized.

RESULTS: There was a significant rural-urban disparity in undiagnosed hypertension (25.14%), untreated hypertension (11.75%), undiagnosed diabetes (16.94%), and untreated diabetes (11.62%). Further, sociodemographic and lifestyle factors, such as age and tobacco use were the common contributors to the disparities in both undiagnosed hypertension and undiagnosed diabetes, whereas education and body mass index (BMI) were significant contributors to the disparity in untreated hypertension.

DISCUSSION: Rural Indians face significant healthcare disadvantages as compared to their urban counterparts, which prompts the urgent need for strategies for equitable healthcare.

KEYWORDS
diabetes, health disparity, hypertension, India, rural-urban

1 | BACKGROUND

With an increase in the older population worldwide, the accompanying increase in the prevalence of dementia poses a substantial public health concern. The Global Burden of Disease study (2019) estimated that the number of people with dementia will increase from 57.4 million cases in 2019 to 152.8 million cases in 2050 across the world.[1] Interestingly, much of this increase will occur in low- and middle-income countries (LMICs), and by 2050, 71% of dementia patients will reside in LMICs.[2] However, there could be considerable heterogeneity in the prevalence of dementia, which the diverse risk factors across distinct populations could explain.

India is now the most populous nation in the world, with a current population of over 1.4 billion people, and tremendous diversity with respect to sociodemographic characteristics, language, culture, geographical region, rural-urban residence status, and so forth, which, in turn, could play a significant role in altering the risk and prevalence of dementia. A recent nationwide study that there were substantial inter-state and rural-urban differences and that sociodemographic factors, such as age, sex, and education, significantly accounted for these disparities.[3]

In addition to the above sociodemographic risk factors, lifestyle-related factors could also impact dementia risk, either directly or indirectly, by influencing the well-known cardiovascular risk factors for dementia. This is particularly relevant in the Indian scenario, wherein the burden of cardiovascular morbidity is accumulating at a disturbing rate. A recent study reported that there was at least a two-fold increase in the number of cases of cardiovascular disease from 1990 (22.7 million) until 2016 (54.5 million), possibly due to rapid urbanization and its associated lifestyle changes.[4]

In the Indian population, the role of cardiovascular risk factors, such as diabetes and hypertension, in dementia has gained prominent attention in the past few decades. This is partly due to the recent rapid escalation of their prevalence among Indians. As per the International Diabetes Federation (IDF) Atlas, India now has the second highest burden of diabetes in the world, with 72.9 million persons with diabetes.[5] The prevalence of hypertension in India is also increasing dramatically, according to the latest National Family Health Survey (NFHS-5).[6] In resource-limited settings like India, targeting such modifiable cardiovascular risk factors could be a vital community-level strategy to reduce the rising burden of dementia.

It is essential to note that there is substantial variation in the prevalence of the above-mentioned cardiovascular risk factors within India, particularly concerning rural/urban status. According to recent literature, the prevalence of diabetes and hypertension among Indian adults was significantly larger in urban (diabetes: 14.3%, hypertension: 18.3%) compared to rural (diabetes: 6.9%; hypertension: 15.5%) settings.[7] However, the literature on the factors contributing to such rural-urban disparity is minimal in India.

Despite evidence from high-income countries on rural-urban disparities in these conditions and their associated factors, extrapolating this information to the Indian scenario would not be appropriate.[8] Further, the factors contributing to these differences among Western populations could differ greatly from those that are relevant to the Indian population.[9] Understanding these factors is crucial in formulating population-specific intervention strategies and informing public health policies to ensure equitable healthcare for all individuals.

To study these rural-urban disparities systematically, large-scale, community-based studies conducted parallelly in rural and urban areas in India, with harmonized study protocols, are required. In the context of understanding the diverse patterns of aging in rural and urban Indians and, thereby, identifying differential risk factors for dementia, there are two parallelly running longitudinal aging studies in southern India. The rural study is the Srinivaspura Aging Neuro Senescence and COGnition (SANSCOG) study,[10] and its urban counterpart is the Tata Longitudinal Study of Aging (TLSA). In the present study, we have utilized the clinical data collected in these two aging cohorts and aimed to assess rural-urban disparities in the diagnosis and treatment of diabetes and hypertension along with their associated sociodemographic and lifestyle factors.

RESEARCH IN CONTEXT

1. **Systematic review**: We reviewed the relevant literature using PubMed and found that prior studies have shown significant health disparities in the prevalence of diabetes and hypertension, especially high-income countries. However, studies examining such disparities in India is scarce. As India has a stark rural-urban divide, there is considerable need to understand health disparities in the diagnosis and treatment of hypertension and diabetes between rural and urban older Indians.
2. **Interpretations**: This is one of the few large (n = 6316), community-based studies examining rural-urban disparities in an aging Indian population and brings to light the significantly higher odds of undiagnosed hypertension and undiagnosed diabetes among rural as compared to urban participants. We have also decomposed the rural-urban disparity in the prevalence of undiagnosed hypertension and demonstrated that sociodemographic and lifestyle factors, such as age, tobacco smoking, alcohol usage, body mass index (BMI), and the number of comorbidities significantly explained nearly 40% of this disparity.
3. **Future directions**: This study underscores the urgent need for improving awareness about the importance of the timely diagnosis and prompt treatment of hypertension and diabetes, particularly in the aging rural Indian population. Further, public health strategies should include devising community level screening programs and strengthen the primary healthcare infrastructure in rural India.

2 | METHODS

2.1 | Study design

The present study employed a cross-sectional design, wherein baseline clinical assessment data from the SANSCOG (rural) and TLSA (urban) cohorts were analyzed.

2.2 | Study setting

The SANSCOG study is conducted in a rural community in the villages of Srinivaspura taluk (subdistrict) of Kolar district in Karnataka, India. TLSA is based in an urban community setting in Bangalore in Karnataka, India.

2.3 | Recruitment

SANSCOG study participants are recruited through an area sampling method, whereas TLSA participants are recruited through convenience sampling. Further details of the recruitment strategies have been published elsewhere.[10,11]

2.4 | Study participants

A total of 6316 participants (4913 rural and 1403 urban) were included in the present study. These participants were recruited into the SANSCOG and TLSA cohorts from the time of inception of these studies (January 2018 and October 2015, respectively) until the time the data from both the cohorts were frozen for analysis in this study (October 2022). The rural cohort is from a typical rural community setting in India, where the participants belong to a predominantly agrarian community with very low migration rates. They are from a lower socioeconomic status, have low levels of formal education, and limited access to modern healthcare and technology. On the other hand, our urban sample from the city of Bangalore, comprises of individuals who have settled in city, having migrated from different parts of India. They represent the typical urban middle class population of India, who predominately are well educated and hold white collar jobs. Therefore, our rural and urban samples could well reflect the prominent rural-urban divide existing in India.

2.5 | Inclusion criteria

(i) Aged 45 years and above, (ii) resident of Srinivaspura and enrolled in the SANSCOG cohort or resident of Bangalore city and enrolled in the TLSA cohort, and (iii) baseline assessments were conducted, and complete data on clinical, sociodemographic, and lifestyle-related parameters used in this study were available.

2.6 | Exclusion criteria

(i) Individuals with dementia – screening and exclusion were done pre-recruitment at the community level by trained field data collectors (further, any participants with a clinical diagnosis of dementia during the detailed clinical assessments were excluded), (ii) diagnosis of psychosis, bipolar disorder, or substance dependence (except nicotine), (iii) severe medical illness likely to interfere with study participation (e.g., cancer, renal failure, etc.), and (iv) significant hearing or vision or locomotor impairment limiting the study evaluations.

2.7 | Ethics and privacy

SANSCOG and TLSA studies have obtained ethical clearance from the Institutional Human Ethics Committee of the Centre for Brain Research. All participants provided voluntary, written informed consent, including specific consent for undergoing clinical assessments.

2.8 | Study assessments

The following assessment data were collected as part of this study.

2.8.1 | Sociodemographic and lifestyle assessments

Sociodemographic and lifestyle factors such as age, sex, education, marital status, socioeconomic status, body mass index (BMI), current alcohol and tobacco use, and number of medical comorbidities were considered. Education in years was categorized into illiterate (0 years), Primary/middle (1–9 years), high school/diploma (10–13 years), and graduate/postgraduate (14 and above). Marital status was categorized as living with and without a partner. Socioeconomic status was classified based on the Kuppuswamy Socioeconomic Scale[12] into lower, middle, and upper socioeconomic classes. BMI was categorized based on Asia-Pacific criteria[13] into underweight, normal, overweight, and obesity. A total of 12 medical comorbidities were considered, namely diabetes, hypertension, dyslipidemia, cardiac illness, stroke, transient ischemic attack (TIA), Parkinson's disease, thyroid disease, renal disease, cancer, arthritis, and respiratory illness; the number of comorbidities were categorized into none, one, and two or more.

2.8.2 | Clinical assessments

Hypertension

Both participant self-report and objective measurements were considered for diagnosing hypertension. Blood pressure (BP) was measured in the right upper limb with the patient in the supine position[14] using a mercurial sphygmomanometer. Per the American Heart Association criteria (17–19), a systolic BP recording of more than or equal to 140 mm Hg or a diastolic BP recording of more than or equal to 90 mm Hg were considered tabnormally high BP.

Categorization. Participants were categorized as "diagnosed hypertension" if they were aware of their diagnosis and "undiagnosed hypertension" if they were not aware of their diagnosis but had abnormally high BP. Further, among the diagnosed hypertensives, depending on whether they were taking any medical treatment for hypertension, participants were categorized into the groups "treated hypertension" and "untreated hypertension."

Diabetes

Both participant self-report and objective measurements were considered for diagnosing diabetes. Fasting, peripheral venous blood was used for glucose estimation (hexokinase method). Per the American Diabetes Association criteria, a fasting blood sugar (FBS) level of more than 126 mg/dL was used as the cutoff for diabetes.[14–16]

Categorization. Participants were categorized as "diagnosed diabetes" if they were aware of their diagnosis and "undiagnosed diabetes" if they were not aware of their diagnosis but had abnormally high FBS. Further, among those with diagnosed diabetes, depending on whether they were taking any medical treatment, participants were categorized into the groups "treated diabetes" and "untreated diabetes."

2.9 | Statistical analyses

Chi-squared tests were used to test the association between the categorical variables and the place of residence, and Student's *t*-tests were used to compare the means between the two groups. Logistic regression was used to assess the unadjusted and adjusted associations between the place of residence and undiagnosed hypertension (vs. diagnosed hypertension), untreated hypertension (vs. treated hypertension), undiagnosed diabetes (vs. diagnosed diabetes), and untreated diabetes (vs. treated diabetes). The Fairlie decomposition method was used to decompose the disparity in the prevalence of undiagnosed hypertension among total hypertensives, untreated hypertension among diagnosed hypertensives, undiagnosed diabetes among total diabetics, and untreated diabetes among total diabetics between rural and urban residents. Fairlie's decomposition technique is a nonlinear approximation of the Blinder-Oaxaca decomposition technique to logit and probit models.[17] This technique can tell how much of the difference in the prevalence of undiagnosed or untreated hypertension/diabetes between rural and urban areas could be explained by each of the variables included in the model. A positive coefficient implies a positive contribution to the rural-urban disparity (an increase in the disparity) if the inequality is positive. In contrast, a negative coefficient indicates a negative contribution (a decrease in the disparity) if the inequality is positive. All the models were estimated in Stata version 18, and the Fairlie[18] command was used for decomposition analysis with pooled estimated coefficients from both groups and 2000 decomposition replications to ensure the result's stability and randomized order of the variables. The significance of the explained disparity was assessed using Blinder-Oaxaca decomposition for nonlinear models. All models were adjusted for age, sex, marital status, education, BMI, tobacco use, alcohol use, socioeconomic status, and number of comorbidities. *p*-values < 0.05 were considered statistically significant. Missing values were handled by pairwise deletion.

3 | RESULTS

Of the total of 6316 participants in this study, 4913 lived in a rural setting, and 1403 were urban residents. The overall prevalence of hypertension was 39.84%, and that of diabetes was 22.77%. Among those individuals with hypertension and diabetes, the proportions who were undiagnosed were 52.10% and 21.45%, respectively. Among those individuals who were diagnosed with hypertension and diabetes, the proportions who were untreated were 15.36% and 18.53%, respectively.

The missing data for marital status was 746 (rural) and 341 (urban); education was 262 (rural) and 314 (urban); BMI was 82 (rural) and 124 (urban); tobacco use was 2 (rural) and 17 (urban); alcohol usage was 0 (rural) and 21 (urban); and socioeconomic status was 147 (rural) and 26 (urban).

We observed that the rural cohort had a significantly lesser overall prevalence of hypertension (33.06% vs. 63.58%; $p < 0.001$) and diabetes (19.26% vs. 35.07%; $p < 0.001$) than the urban cohort. On the other hand, the rural cohort had a significantly greater proportion of undiagnosed hypertensives among the total hypertensives (62.60% vs. 32.08%; $p < 0.001$) and a significantly greater proportion of undiagnosed diabetics among the total diabetics (26.74% vs. 10.92%; $p < 0.001$) as compared to the urban cohort (Figure 1). Similarly, the rural cohort had a significantly greater proportion of untreated hypertensives among the diagnosed hypertensives (26.78% vs. 3.04%; $p < 0.001$) and a significantly greater proportion of untreated diabetics among the diagnosed diabetics (22.94% vs. 11.32%; $p < 0.001$) as compared to the urban cohort (Figure 1). Demographic analysis of the study participants showed that rural individuals had a significantly higher proportion of illiteracy and lower socioeconomic status than urban individuals. Further details of the participant characteristics are presented in Table 1.

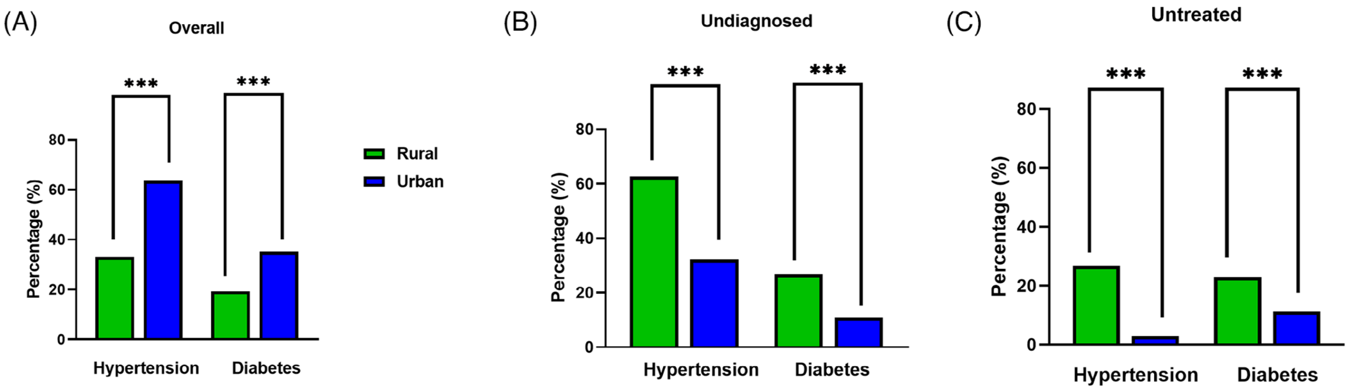

FIGURE 1 This figure depicts the (A) overall prevalence of hypertension and diabetes according to the place of residence, (B) proportion of undiagnosed hypertensives among the total hypertensives and undiagnosed diabetics among the total diabetics according to the place of residence, and (C) proportion of untreated hypertensives among the diagnosed hypertensives and untreated diabetics among the diagnosed diabetics according to the place of residence. ***$p < 0.001$.

TABLE 1 Comparison of sample characteristics between rural and urban participants

Characteristics	Rural n = 4913 (%)	Urban n = 1403 (%)	p-Value
Sex			0.031
Female	2573 (52.37)	689 (49.11)	
Male	2340 (47.63)	714 (50.89)	
Age, mean (SD)	58.74 (9.88)	62.82 (9.55)	<0.001
Marital status[a]			<0.001
Not living with a partner	816 (19.58)	124 (11.68)	
Living with a partner	3351 (80.42)	938 (88.32)	
Education[a]			<0.001
Illiterate	1961 (42.16)	32 (2.94)	
Primary/middle school	1684 (36.21)	29 (2.66)	
High school/diploma	809 (17.39)	176 (16.16)	
Graduate/post graduate	197 (4.24)	852 (78.24)	
BMI[a]			<0.001
Underweight	586 (12.13)	6 (0.47)	
Normal	1832 (37.92)	204 (15.95)	
Overweight	1510 (31.26)	854 (66.77)	
Obesity	903 (18.69)	215 (16.81)	
Tobacco use[a]			<0.001
No	3227 (65.71)	1327 (95.74)	
Yes	1684 (34.29)	59 (4.26)	
Alcohol use[a]			<0.001
No	4604 (93.71)	1136 (82.20)	
Yes	309 (6.29)	246 (17.80)	
Socioeconomic status[a]			<0.001
Lower	1520 (31.89)	13 (0.94)	
Middle	3211 (67.37)	852 (61.87)	
Upper	35 (0.73)	512 (37.18)	
No. of comorbidities (for individuals with diabetes)			<0.001
None	1043 (21.23)	74 (5.27)	
One	2543 (51.76)	424 (30.22)	
Two or more	1327 (27.01)	905 (64.50)	
No. of comorbidities (for individuals with hypertension)			<0.001
None	1321 (26.89)	114 (8.13)	
One	2602 (52.96)	640 (45.62)	
Two or more	990 (20.15)	649 (46.26)	

Abbreviation: BMI, body mass index; SD, standard deviation.
[a]Cases may not be equal due to missing values.

3.1 | Factors associated with undiagnosed hypertension (vs. diagnosed hypertension), untreated hypertension (vs. treated hypertension), undiagnosed diabetes (vs. diagnosed diabetes), and untreated diabetes (vs. treated diabetes)

The unadjusted logistic regression model showed that people in rural places of residence were 3.54 times more likely to have undiagnosed hypertension when compared to urban people (odds ratio [OR]: 3.54, 95% confidence interval [CI]: 2.97–4.22). Similarly, rural residents were 11.68 times more likely to have untreated hypertension than their urban counterparts (OR:11.68, 95% CI: 6.98–19.55). Rural individuals were 2.98 times more likely to have undiagnosed diabetes when compared to urban (OR: 2.98, 95% CI: 2.16–4.11) and 2.33 times more likely to have untreated diabetes than urban individuals (OR: 2.33, 95% CI: 1.65–3.31).

After adjusting for potential confounders; rural participants were 2.30 times more likely to have undiagnosed diabetes than urban participants (adjusted OR [AOR]: 2.30, 95% CI: 1.19–4.45). There was no significant association between the place of residence and undiagnosed hypertension, untreated hypertension, and untreated diabetes. Increasing age was negatively associated with undiagnosed diabetes (AOR: 0.97,95% CI: 0.95–0.99). Underweight individuals were 2.42 times more likely to have undiagnosed diabetes compared to those with normal BMI (AOR: 2.42, 95% CI: 1.06–5.50). Participants currently using tobacco had 1.57 times higher odds of having undiagnosed diabetes compared to those with no current tobacco usage (AOR: 1.57, 95% CI: 1.07–2.30, Table 2, Figure 2).

3.2 | Decomposition analysis of rural-urban disparities

3.2.1 | Undiagnosed hypertension (vs. diagnosed hypertension)

The rural-urban disparity in the prevalence of undiagnosed hypertension was 25.14%. The decomposition model results suggested that 77.69% of the disparity in the prevalence of undiagnosed hypertension was significantly explained by the exposure variables included in our analysis (Table 3). The variables that significantly explained the disparity in the prevalence of undiagnosed hypertension in the model were age, tobacco use, alcohol usage, BMI, and number of comorbidities (Table 3).

3.2.2 | Untreated hypertension (vs. treated hypertension)

There was an 11.75% rural-urban disparity in the prevalence of untreated hypertension of which 58.01% was significantly explained by education and BMI.

TABLE 2 Association between the place of residence and undiagnosed diabetes (vs. diagnosed diabetes)

	Undiagnosed diabetes	
Characteristics	**COR (95% CI)**	**AOR (95% CI)**
Residence		
Urban (reference)		
Rural	2.98 (2.16,4.11)*	2.30 (1.19,4.45)*
Sex		
Female (reference)		
Male	0.83 (0.65,1.08)	1.05 (0.70,1.57)
Age	0.96 (0.95,0.98)*	0.97 (0.95,0.99)*
Marital status		
Living with a partner (reference)		
Not living with a partner	1.13 (0.77,1.65)	1.13 (0.69,1.85)
Education		
Graduate/postgraduate (reference)		
Illiterate	2.48 (1.66,3.70)*	1.59 (0.76,3.31)
Primary/middle school	2.15 (1.45,3.18)*	1.12 (0.58,2.19)
High school/diploma	1.88 (1.24,2.84)*	1.24 (0.65,2.34)
Body mass index (BMI)		
Normal (reference)		
Underweight	2.32 (1.17,4.60)*	2.42 (1.06,5.50)*
Overweight	0.93 (0.68,1.28)	0.78 (0.49,1.26)
Obesity	0.77 (0.52,1.15)	1.09 (0.73,1.63)
Tobacco use		
No (Reference)		
Yes	1.98 (1.46,2.69)*	1.57 (1.07,2.30)*
Alcohol use		
No (reference)		
Yes	0.64 (0.41,0.99)*	1.03 (0.59,1.80)
Socioeconomic status		
Upper (reference)		
Lower	2.87 (1.66,4.97)*	0.81 (0.31,2.09)
Middle	2.05 (1.25,3.34)*	0.80 (0.34,1.87)
No. of comorbidities		
None (reference)		
One	1.63 (1.00,2.67)	1.48 (0.83,2.65)
Two or more	0.88 (0.54,1.43)	1.11 (0.61,2.03)

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; COR, crude odds ratio.
*p-Value < 0.05.

3.2.3 | Undiagnosed diabetes (vs. diagnosed diabetes)

The rural-urban disparity in the prevalence of undiagnosed diabetes was 16.94%, of which 41.98% was significantly explained by age and tobacco use.

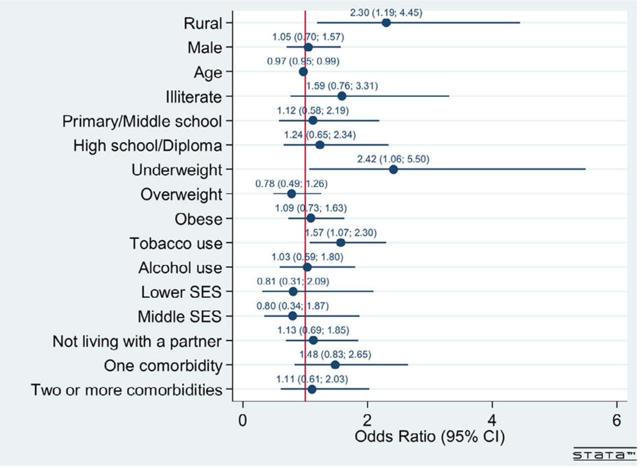

FIGURE 2 This figure is forest plot of odds ratios for the factors associated with undiagnosed diabetes (vs. diagnosed diabetes). Urban was the reference category for the place of residence. Female was the reference category for sex. Living with a partner was the reference category for marital status. Graduate or Postgraduate was the reference category for education. Normal Body Mass Index (BMI) was the reference for BMI. No current use was the reference for both tobacco and alcohol use. Upper socioeconomic status was the reference for socioeconomic status (SES). No comorbidity was the reference for the number of comorbidities.

3.2.4 | Untreated diabetes (vs. treated diabetes)

The rural-urban disparity in the prevalence of untreated diabetes was 11.62%. However, the exposure variables included in the decomposition model did not significantly explain this disparity.

4 | DISCUSSION

Hypertension and diabetes are well-recognized modifiable risk factors for dementia.[19] The adverse impact of these conditions is much greater when they are undiagnosed or untreated.[20,21] However, proper diagnosis and treatment depend on various factors, which, in turn, could contribute to disparities between different population groups. It is essential to identify these disparities and understand the factors that contribute to them to put in practical strategies to prevent or mitigate their impact. Toward this, our study aimed to study rural-urban disparities in the diagnosis and treatment of hypertension and diabetes among aging Indians.

We found a 25.14% disparity in the prevalence of undiagnosed hypertension, 11.75% disparity in the prevalence of untreated hypertension, 16.94% disparity in the prevalence of undiagnosed diabetes, and 11.62% disparity in the prevalence of untreated diabetes. Further, sociodemographic and lifestyle factors, such as age and tobacco use, were the common contributors to the disparities in both undiagnosed hypertension and undiagnosed diabetes whereas education and BMI were significant contributors to the disparity in untreated hypertension.

TABLE 3 Decomposition of the rural-urban gap in prevalence of undiagnosed hypertension, untreated hypertension, and undiagnosed diabetes

Terms of decomposition		Undiagnosed hypertension		Untreated hypertension		Undiagnosed diabetes
Difference (Rural-Urban)		0.25138		0.11753		0.16941
Explained (%)		0.19529 (77.69)		0.06818 (58.01)		0.07112 (41.98)
Variable	**Beta Coefficient (SE)**	**Contribution (%)**	**Beta Coefficient (SE)**	**Contribution (%)**	**Beta Coefficient (SE)**	**Contribution (%)**
Age	0.02434 (0.00387)*	9.68	0.00342 (0.00291)	2.91	0.02101 (0.00664)*	12.40
Sex	0.00006 (0.00054)	0.02	0.00049 (0.00228)	0.42	0.00001 (0.00099)	0.01
Marital status	−0.00088 (0.00318)	−0.35	−0.00290 (0.00502)	−2.47	0.00159 (0.00346)	0.94
Education	0.02958 (0.03205)	11.77	0.07126 (0.03508)*	60.63	0.03140 (0.03611)	18.53
Tobacco use	0.01406 (0.00675)*	5.59	0.00577 (0.00687)	4.91	0.01721 (0.00797)*	10.16
Alcohol use	0.01138 (0.00497)*	4.53	−0.00141 (0.00792)	−1.20	−0.00059 (0.00559)	−0.35
BMI	0.03512 (0.00782)*	13.97	0.02125 (0.00880)*	18.08	−0.00222 (0.00827)	−1.31
Socioeconomic status	0.02377 (0.01507)	9.45	−0.03461 (0.03527)	−29.45	−0.00897 (0.02084))	−5.29
No. of comorbidities	0.05786 (0.00739)*	23.02	0.00494 (0.00688)	4.20	0.01173 (0.01036)	6.92

Note: Standard errors are presented in parentheses.
Abbreviations: BMI, body mass index; SE, standard error.
**p*-Value < 0.05.

Our findings on hypertension are in line with a previous study that analyzed data from 17 countries and reported that rural individuals had higher proportions of undiagnosed and untreated hypertension than urban residents.[22] Similar trends were observed in studies from populations in China,[23-25] Cameroon,[26] and Latin America.[27] However, a large study from the United States reported higher medication use among residents from rural areas as compared to most urban counties.[28] In some of these studies, sociodemographic and metabolic/lifestyle factors contributed to the rural-urban differences.

Considering the Indian scenario, we compared our findings to those from the recent nationwide Longitudinal Study of Aging in India (LASI) conducted in the same age group as our cohorts (45+ years). Similar to our findings, the LASI reported a higher prevalence of overall hypertension and diabetes in urban individuals compared to rural individuals (47.1% vs. 26.9% and 26.2% vs. 9.4%, respectively). A similar trend was observed when considering only the proportion of self-reported hypertension (35.6% vs. 21.2%) as well as self-reported diabetes (19.9% vs 7.6%).[29] A recent study on the rural-urban disparities in the prevalence of undiagnosed and untreated hypertension using the LASI data revealed that education and comorbidities were the factors that accounted for a majority of the above disparities.[30] Interestingly, our findings related to disparities in undiagnosed and untreated hypertension also pointed to education being an important factor contributing to the above disparities.

Concerning diabetes, our study pointed to a rural disadvantage in the diagnosis of the condition and that individuals who were underweight and current tobacco users were more likely to have undiagnosed diabetes. Our findings align with a large study that conducted pooled data analysis of 42 LMICs on diabetes diagnosis and management, revealing that rural populations fell behind in diagnosis, treatment, and control.[31] Similarly, a large study from England observed that achievement of diabetes treatment targets was lower in rural areas than in urban general health practices.[32] Interestingly, a recent Indian study among adults aged 40 years and above reported no significant difference in the prevalence of undiagnosed diabetes between rural and urban participants. However, it is to be noted that, in this study, there were considerable state-wise differences, but the rural-urban disparities were not calculated state-wise.[33] On the other hand, findings from the Indian Council of Medical Research Diabetes Study 4 (Phase I) pointed out that rural Indians had lesser knowledge and awareness about diabetes than urban Indians.[34]

Our study has several advantages. First, the two datasets used have large sample sizes, and the harmonized study protocols between the rural and urban cohorts enabled head-to-head comparison of the variables of interest and the utilization of both self-reported and objective measurements for hypertension and diabetes. Limitations of the study include a cross-sectional design that renders it difficult to make any causal inferences. In addition to the unequal sample sizes between the rural and urban cohorts, the sampling techniques were also different, namely area sampling for SANSCOG and convenience sampling for TLSA and that this could have affected the frequency of diagnosis/treatment of the studied conditions, consequently, impacting the size of the disparities between these populations. This limitation is due to the difference in the study design when these parent cohort studies were originally conceptualized. However, the assessment protocols were subsequently harmonized, which enabled us to make these comparisons. Another limitation of our study is that BP was measured on a single occasion, whereas the current guidelines recommend using an average of ≥2 readings obtained on ≥2 occasions to correctly diagnose hypertension. Also, the study did not include other crucial related health outcomes, such as treatment details and the effectiveness of treatment in terms of adequate BP/blood sugar control. The sociodemographic and lifestyle-related factors included in our analysis only partly explained the rural-urban disparities. Other relevant factors could include migration, health awareness, self-reported health, and physical activity.

With the alarming rise of hypertension and diabetes in India and their considerable role in elevating dementia risk in this population, early identification and control of these cardiovascular risk factors would be a cost-effective and scalable strategy to reduce the dementia burden. Against this backdrop, we highlight the urgent need to improve awareness about the importance of a timely diagnosis and prompt treatment of these conditions, particularly in the aging rural Indian population. Further, public health strategies should include devising community-level screening programs and strengthening rural India's primary healthcare infrastructure. Such initiatives could involve training community workers at the grassroots level to carry out basic screening for these conditions since rural India faces a severe shortage of doctors. Formal diagnosis and treatment could then be made at an adequately equipped satellite center or using telemedicine services. Mobile health clinics could also be another way to enhance healthcare access to remote rural areas. An excellent example of an effective treatment delivery strategy for hypertension is the Indian Hypertension Control Initiative (IHCI),[35] which was recently launched by the Government of India, in collaboration with the Indian Council of Medical Research and WHO-India, which includes door-to-door drug dispensing by trained community health workers, namely ASHAs (Accredited Social Health Activist) and ANMs (Auxiliary Nurse and Midwife). Our study also emphasizes that policymakers and relevant stakeholders should consider the crucial role of sociodemographic and lifestyle factors to ensure equitable healthcare delivery to disadvantaged communities.

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CONFLICT OF INTEREST STATEMENT

All authors declare no conflicts of interest. Author disclosures are available in the supporting information.

CONSENT STATEMENT

All human subjects provided written informed consent to voluntarily participate in the study.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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