Decomposing Urban-rural Differences in Multimorbidity Among Older Adults in India: A Study Based on Lasi Data

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Abstract

Background: Multimorbidity is defined as the co-occurrence of two or more than two diseases in the same person. With rising longevity, multimorbidity has become a prominent concern among the older population. Evidence from both developed and developing countries shows that older people are at much higher risk of multimorbidity, however, urban-rural differential remained scarce. Therefore, this study examines urban-rural differential in multimorbidity among older adults by decomposing the risk factors of multimorbidity and identifying the covariates that contributed to the change in multimorbidity.

Methods: The study utilized information from 31,464 older adults (rural-20,725 and urban-10,739) aged 60 years and above from the recent release of the Longitudinal Ageing Study in India (LASI) wave 1 data. Descriptive, bivariate, and multivariate decomposition analysis techniques were used.

Results: Overall, significant urban-rural differences were found in the prevalence of multimorbidity among older adults (difference: 16.3; $p<0.001$). Moreover, obese/overweight and high-risk waist circumference were found to narrow the difference in the prevalence of multimorbidity among older adults between urban and rural areas by 8% and 9.1%, respectively.

Conclusion: There is a need to substantially increase the public sector investment in healthcare to address the multimorbidity among older adults, more so in urban areas, without compromising the needs of older adults in rural areas.

Keywords: Multimorbidity; Urban-rural differences; Obesity; LASI; India.

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Background:

Declining fertility rates and increasing life expectancy have increased the population of older adults worldwide [1]. As per the World Population Prospects report, by 2050, 1 in 6 people worldwide would be over 65 years of age, up from 1 in 11 in 2019 [2]. Nearly all the societies in the world are in the midst of this longevity revolution, albeit at a different stage with differing pace [2]. Like other developing countries, India is also in the transition phase, experiencing an increase in the proportion of older adults' population [3]. Considering increasing education and improving health facilities, the share of the older adults' population (60+ years) in India has increased from 5.3 percent in 1971 to 5.7 percent in 1981 and further from 6 percent in 1991 to almost 8 percent in 2011 [4]. Furthermore, it is evident that older adults' proportion in India will continue to increase in the future, however, concerning various health problems [5]. While global ageing depicts a triumph of medical, social, and economic advances over disease, it also represents tremendous challenges [6]. Multimorbidity is one such challenge that becomes very prominent during ageing [7]. Developed as well as developing countries [8]–[11] including India [12], [13] are experiencing a rise in the prevalence of multimorbidity among older adults.

Multimorbidity is defined as the co-occurrence of two or more than two diseases in the same person [14]. With rising longevity, multimorbidity has become a prominent concern among the older population. Evidence from both developed and developing countries shows that older people are at much higher risk of multimorbidity [9], [15]–[17]. Multimorbidity has been associated with several adverse health outcomes among older adults, including reduced physical and cognitive functions [18]–[23], reduced quality of life [24], [25], elevated risk of death [22], [25], disability [25], and poor functional status [25]. Place of residence (urban-rural

78 differential) is a significant risk factor in the occurrence of multimorbidity among older adults
79 [26]. This becomes even more poignant and alarming considering the higher prevalence of
80 multimorbidity among older adults urban than their rural counterparts [12].

81 Several studies have examined the prevalence and determinants of multimorbidity among older
82 adults in developed countries [11], [27], [28]; however, the available literature on
83 multimorbidity in developing countries [9], [29], [30] including India [31] is limited.
84 Moreover, almost all the latest research on multimorbidity among older adults in India is more
85 of community-based, instead depicting the national picture [32]–[37]. To add more to the
86 literature gap, previously available literature significantly proposed various risk factors of
87 multimorbidity among older adults [31], [32], [34], [35], [38]; however, none of the study
88 exclusively examined rural-urban differential in multimorbidity among older adults in India in
89 recent times utilizing information on a nationally representative large scale survey data. A
90 study examined urban-rural differential in multimorbidity among adults in India [26].
91 Therefore, this study intends to examine rural-urban differential in multimorbidity among older
92 adults by utilizing data from Longitudinal Ageing Survey in India (LASI), 2017-18. Moreover,
93 this study decomposes the risk factors of multimorbidity and identifies the covariates that
94 contributed to the change in multimorbidity by rural and urban residents.

95 **Methods**

96 **Data**

97 The study carried out data from the first wave of the Longitudinal Ageing Study in India
98 (LASI), conducted in 2017-18 [39]. LASI is a national representative survey which gathered
99 the information of economic, health, and social drivers of population ageing in India [39].
100 About 72000 older persons in India's states and union territories were surveyed in LASI [39].
101 The primary objective of the survey was to look into the physical and social and economic

well-being of older persons in India. To arrive at the final units of observation, LASI used a multistage stratified area probability cluster sampling method [39]. This included older people aged 45 and up, as well as their spouses of any age. The survey used a three-stage sampling in rural areas, whereas in urban areas, it used a four-stage sampling approach [39]. The initial stage in each state/UT was to choose Primary Sampling Units (PSUs), or sub-districts (Tehsils/Talukas). In the selected PSUs, the second stage entails choosing villages in rural regions and wards in urban areas [39]. In the third step, families were chosen from various communities in rural areas. Sampling in urban areas, on the other hand, required an extra step. In the third step, one Census Enumeration Block (CEB) was chosen at random in each urban area [39]. Households from this CEB were chosen in the fourth stage. Detailed about survey design and data collection procedure has been published elsewhere [39]. The present study used data on the eligible respondents age 60 years and above [39]. The total sample size for the present study is 31,464 older adults aged 60 years and above (rural-20,725 and urban-10,739).

Variable description

Outcome description

The outcome variable was categorized as binary, i.e., multimorbidity (no/yes) [40]. Multi-morbidity is defined as the presence of two or more chronic diseases, such as hypertension, stroke, chronic heart disease, diabetes, neurological/psychiatric disease, cancer or malignant tumour, any bone/joint disease, any chronic lung disease, or high cholesterol [39]. The diseases were self-reported, however, diagnosed [41] as was assessed through the question “Has any health professional ever diagnosed you with the following chronic conditions or diseases?” [40].

Explanatory variables

126 *Group variable*

127 The place of residence was categorized as rural and urban. However, an earlier multi-country
128 study stated that urban-rural differences in multimorbidity vary from country to country, and it
129 is suggested to undertake country-wise studies examining urban-rural differences in
130 multimorbidity to predict the necessary strategies to address the multimorbidity [42].
131 Therefore, this study intends to examine urban-rural differential in multimorbidity among older
132 adults in India.

133 **Main explanatory variables**

134 *Obesity-related factors*

135 Overweight/obesity was categorized as no and yes [43]. Obese/overweight was defined as
136 having a body mass index of ≥25 kg/m^2. No and yes were used to categorise high-risk waist
137 circumference [43]. High-risk waist circumferences were defined as male and female waist
138 circumferences of greater than 102 cm and 88 cm, respectively [44]. No and yes were used to
139 categorise high-risk waist-hip ratios. Males and females with waist-hip ratios more than 0.90
140 cm and 0.85 cm, respectively, were classified as having a high-risk waist-hip ratio [44].

141 *Behavioural factors*

142 Physical activity levels were classified as frequent (every day), rare (once a week, once a
143 month, one to three times a month), and never [40]. Tobacco and alcohol consumption was
144 recoded as no and yes [40].

145 *Individual factors*

146 Age was recoded as young old (60-69 years), old-old (70-79 years), and oldest-old (80+ years)
147 [45]. Sex was recoded as male and female. Education was categorized as no education/primary
148 schooling not completed, primary completed, secondary completed, and higher and above.

149 Marital status was coded as currently married, widowed, and others (separated/never
150 married/divorced) [45]. Finally, working status was recoded as working, retired, and not
151 working [45].

152 *Household factors*

153 The monthly per capita expenditure (MPCE) quintile was calculated using household
154 consumption data. The sample houses were questioned on food and non-food expenses with
155 sets of 11 and 29 questions, respectively. Non-food expenditure was collected over 30-day and
156 365-day reference periods, whereas food expenditure was collected over a seven-day reference
157 period. Food and non-food expenses were standardised using a 30-day reference period [39].
158 As a summary measure of consumption, the monthly per capita consumption expenditure
159 (MPCE) is computed and used. The variable was then divided into five quintiles, i.e., from
160 poorest to richest. Religion was coded as Hindu, Muslim, Christian, and Others. Caste was
161 categorized as Scheduled Tribe (ST), Scheduled Caste (SC), Other Backward Class (OBC),
162 and others. As a result of their low caste status in Hindu society, the Scheduled Caste is a group
163 of people who are socially isolated and financially/economically disadvantaged [40], [46]. The
164 Scheduled Castes and Tribes of India are among the poorest socioeconomic groupings in the
165 country [40], [46]. The OBC is the group of people identified as "educationally, economically
166 and socially backward [40], [46]." The OBCs are considered lower castes in the traditional
167 caste system [40], [46]. The "other" caste category is identified as having higher social status.
168 The geographical region was recoded as North, Central, East, Northeast, West, and South [47].

169 **Statistical approach**

170 To show the preliminary findings, descriptive analysis and bivariate analysis were used. To
171 analyse the residential differentials and determine the significance level, the proportion test
172 was utilised [48]. In addition, a multivariate decomposition logistic regression analysis was

used to identify the contributions of covariates which explain the group differences to average predictions [49]. The aim of the decomposition analysis was to identify covariates that contributed to the change in multimorbidity by rural and urban places of residence.

The compositional differences (endowments) ‘E' and the effects of characteristics, which are the differences in the coefficients or behavioural change ‘C' responses for the selected predictor variables, are the two contributing effects in the multivariate decomposition analysis [50]. As a result, the observed variations in multimorbidity may be decomposed additively into characteristics (or endowments) and a coefficient (or effects of features) component [51]. In the non-linear model, the dependent variable is a function of a linear combination of predictors and regression coefficients:

$Y = F\ (X\beta) = logit\ (Y) = X\beta$, where Y denotes the n*1 dependent variable vector, X an n*K matrix of independent variables, and β a K*1 vector of coefficients.

The proportion difference in Y between urban A and urban B of multimorbidity can be decomposed as:

$$Y_A - Y_B = F(X_A\beta_A) - F(X_B\beta_B)$$

For the log odds of multimorbidity, the proportion of the model is written as

$$Logit\ (Y_A) - logit\ (Y_B) = F(X_A\beta_A) - F(X_B\beta_B)$$

$$= F(X_A\beta_A) - F(X_B\beta_A) + F(X_B\beta_A) - F(X_B\beta_B)$$

E C

The difference due to endowment change is the component ‘E,' also known as the explained component. The difference attributed to coefficient (behavioural) change, often known as the unexplained component, is the ‘C' component.

The model structure for the decomposition analysis was:

196 $Logit\ (A) - Logit\ (B) = [\beta_{0A} - \beta_{0B}] + \sum \beta_{ijA}[X_{ijA} - X_{ijB}] + \sum X_{ijB}\ [\beta_{ijA} - \beta_{ijB}]$, where

197 • β_{0A} is the intercept in the regression equation for rural

198 • β_{0B} is the intercept in the regression equation for urban

199 • β_{ijA} is the coefficient of the j^{th} category of the i^{th} determinant for rural

200 • β_{ijB} is the coefficient of the j^{th}category of the i^{th} determinant for urban

201 • X_{ijA} is the proportion of the j^{th}category of the i^{th} determinant for rural

202 • X_{ijB} is the proportion of the j^{th}category of the i^{th} determinant for urban

203 The command *mvdcmp* was used to carry out multivariate decomposition analysis in STATA
204 14 [52].

205 **Results**:

206 *Socio-economic profile of study population, 2017-18 (**Table 1**)*

207 The prevalence of obesity-related factors such as obese/overweight, high-risk waist
208 circumference, and high-risk waist-hip ratio was higher among urban resident older adults than
209 rural counterparts (see table 1). Moreover, among behavioural factors, rural resident older
210 adults did more frequent physical activity than urban ones (19.2% vs. 15%). Similarly, tobacco
211 (45.2% vs. 26.6%) and alcohol consumption (15.7% vs. 11.3%) was more prevalent among
212 older adults who lived in rural areas than those who lived in urban areas. A higher proportion
213 of older adults belonged to the young-old cohort in both rural and urban areas. The proportion
214 of older adults with no education/primary not completed were higher in rural (77.1%) areas
215 than urban (46%). Similarly, the percentage of working older adults was higher in rural areas
216 (35.4%) than urban (19.6%) counterparts.

Table-1. Socio-economic profile of older adults in India, 2017-18

Background characteristics	Rural		Urban	
	Sample	Percentage	Sample	Percentage
Obesity related factors				

Obese/overweight				
No	17,863	86.2	7,160	66.7
Yes	2,862	13.8	3,579	33.3
High risk waist circumference				
No	17,536	84.6	7,069	65.8
Yes	3,189	15.4	3,670	34.2
High risk waist-hip ratio				
No	6,994	33.8	3,016	28.1
Yes	13,731	66.3	7,723	71.9
Behavioural factors				
Physical activity status				
Frequent	3,980	19.2	1,610	15.0
Rare	3,101	15.0	813	7.6
Never	13,644	65.8	8,317	77.4
Tobacco consumption				
No	11,353	54.8	7,886	73.4
Yes	9,372	45.2	2,853	26.6
Alcohol consumption				
No	17,465	84.3	9,523	88.7
Yes	3,260	15.7	1,216	11.3
Individual factors				
Age				
Young-old	12,139	58.6	6,268	58.4
Old-old	6,169	29.8	3,354	31.2
Oldest-old	2,417	11.7	1,117	10.4
Sex				
Male	10,045	48.5	4,835	45.0
Female	10,680	51.5	5,904	55.0
Education				
Not educated/primary not completed	15,986	77.1	4,937	46.0
Primary	2,069	10.0	1,511	14.1
Secondary	1,988	9.6	2,598	24.2
Higher	682	3.3	1,693	15.8
Marital status				
Currently married	13,017	62.8	6,315	58.8
Widowed	7,280	35.1	4,162	38.8
Others	427	2.1	262	2.4
Working status				
Working	7,341	35.4	2,106	19.6
Retired	8,774	42.3	4,719	43.9
Not working	4,610	22.2	3,913	36.4
Household factors				
MPCE quintile				
Poorest	4,446	21.5	2,396	22.3
Poorer	4,608	22.2	2,197	20.5
Middle	4,375	21.1	2,207	20.6
Richer	3,932	19.0	2,117	19.7
Richest	3,364	16.2	1,822	17.0
Religion				
Hindu	17,309	83.5	8,497	79.1
Muslim	2,021	9.8	1,604	14.9
Christian	623	3.0	269	2.5
Others	772	3.7	369	3.4
Caste				
Scheduled Caste	4,572	22.1	1,220	11.4
Scheduled Tribe	2,125	10.3	325	3.0
Other Backward Class	9,213	44.5	5,056	47.1
Others	4,815	23.2	4,139	38.5
Region				
North	2,655	12.8	1,293	12.0

Central	4,920	23.7	1,533	14.3
East	5,678	27.4	1,573	14.7
Northeast	691	3.3	226	2.1
West	2,898	14.0	2,662	24.8
South	3,883	18.7	3,451	32.1
Total	20,725	100.0	10,739	100.0

*Percentage of older adults suffering from multimorbidity in India, 2017-18 (**Table 2**)*

Overall, significant urban-rural differences were found in the prevalence of multimorbidity among older adults (difference: 16.3; p<0.001) (see table 2). It was higher in urban areas compared to rural counterparts (35.4% vs. 19.1%). Among the obesity-related factors, a significant higher urban-rural difference in the prevalence of multimorbidity was found among older adults who had a high risk waist-hip ratio (difference: 15.9%; p<0.001) followed by those who had high waist circumference (difference: 14.5%; p<0.001). Moreover, among behavior factors, higher urban-rural differences were observed among older adults who did physical activity rarely (difference: 19.8%; p<0.001), followed by those who consumed alcohol (difference: 17%; p<0.001). In the case of individual factors, a significant urban-rural difference was found in the prevalence of multimorbidity among older adults who belonged to other marital status categories followed by those not working. In contrast, this difference was lowest among the oldest-old cohort (difference: 7.3%; p<0.001), followed by those who had higher education (difference: 9.7%; p<0.001). Moreover, a higher percentage of urban-rural difference in the prevalence of multimorbidity was observed among older adults who belonged to the wealthiest families (difference: 24.1% p<0.001).

Table-2. Percentage of older adults suffering from multimorbidity in India, 2017-18

Background characteristics	Rural	Urban	Differences	p-value
	%	%	%	
Obesity related factors				
Obese/overweight				
No	16.3	28.8	12.5	0.001
Yes	36.6	48.6	11.9	0.001
High risk waist circumference				
No	16.2	28.0	11.8	0.001
Yes	35.1	49.6	14.5	0.001
High risk waist-hip ratio				

No	15.4	31.5	16.1	0.001
Yes	21.0	36.9	15.9	0.001
Behavioural factors				
Physical activity status				
Frequent	13.1	29.0	15.9	0.001
Rare	12.4	32.2	19.8	0.001
Never	22.4	36.9	14.5	0.001
Tobacco consumption				
No	20.8	37.4	16.6	0.001
Yes	17.1	29.9	12.8	0.001
Alcohol consumption				
No	19.7	35.7	16.0	0.001
Yes	15.9	32.9	17.0	0.001
Individual factors				
Age				
Young-old	17.8	34.8	17.1	0.001
Old-old	20.4	38.3	17.9	0.001
Oldest-old	22.6	29.8	7.3	0.012
Sex				
Male	18.2	32.5	14.2	0.001
Female	19.9	37.8	17.9	0.001
Education				
Not educated/primary not completed	17.5	28.8	11.3	0.001
Primary	23.8	40.8	17.0	0.001
Secondary	24.0	42.8	18.8	0.001
Higher	28.7	38.5	9.7	0.001
Marital status				
Currently married	18.7	34.3	15.6	0.001
Widowed	20.3	37.1	16.9	0.001
Others	11.4	33.9	22.5	0.026
Working status				
Working	11.1	24.7	13.6	0.001
Retired	23.7	34.6	10.9	0.001
Not working	23.3	42.2	18.9	0.001
Household factors				
MPCE quintile				
Poorest	12.9	25.3	12.4	0.001
Poorer	16.5	30.0	13.5	0.001
Middle	19.1	30.0	10.9	0.001
Richer	21.2	43.3	22.1	0.001
Richest	28.5	52.6	24.1	0.001
Religion				
Hindu	18.3	35.6	17.3	0.001
Muslim	21.5	33.0	11.5	0.001
Christian	25.4	47.9	22.5	0.001
Others	26.2	31.2	5.1	0.008
Caste				
Scheduled Caste	17.6	28.6	11.1	0.001
Scheduled Tribe	10.3	18.0	7.7	0.001
Other Backward Class	19.9	36.3	16.4	0.001
Others	23.0	37.7	14.7	0.001
Region				
North	21.3	32.1	10.8	0.001
Central	11.3	22.0	10.7	0.002
East	19.6	37.7	18.1	0.001
Northeast	13.2	26.9	13.7	0.105
West	22.3	35.1	12.8	0.002
South	25.4	42.3	16.9	0.001
Total	19.1	35.4	16.3	0.001
p-value based proportion test				

Estimates from multivariate logistic regression decomposition estimates for urban-rural differentials in the prevalence of multimorbidity among older adults, 2017-18 ***(Table 3)***

Table 3 shows the results of the multivariate decomposition analysis for multimorbidity among older adults by selected variables. The multivariate decomposition logistic regression analysis revealed that about 51% of the overall differences (urban-rural) in the prevalence of multimorbidity among older adults was due to compositional characteristics (endowments). In contrast, the remaining 49% was due to the difference in the effect of characteristics (Coefficient). Among the compositional change factors, obese/overweight, high-risk waist circumference, physical activity status, education, working status, and geographical region significantly affected the change contribution.

The urban-rural differences are explained mainly by geographical region, high-risk waist circumference, working status, obese/overweight, and education. The study found that the regional inequality in the prevalence of multimorbidity among older adults accounts for nearly 10% of the explained gap in both groups. Moreover, obese/overweight and high-risk waist circumference were found to narrow the difference in the prevalence of multimorbidity among older adults between urban and rural by 8 % and 9.1%, respectively. Finally, work status and education are found to reduce the urban-rural gap in the prevalence of multimorbidity among older adults by 8% and 6%, respectively.

Table-3. Multivariate logistic regression decomposition estimates for urban-rural differentials in multimorbidity among older adults in India, 2017-18

Background characteristics	Due to difference in characteristics					Due to difference in coefficients				
	Coef.	SE	p-value	Percent		Coef.	SE	p-value	Percent	
Obesity related factors										
Obese/overweight										
No					8.0					-2.4
Yes	0.013	0.002	<0.001	8.0		-0.004	0.002	0.022	-2.4	
High risk waist circumference										
No					9.1					-0.3
Yes	0.015	0.002	<0.001	9.1		0.000	0.002	0.809	-0.3	
High risk waist-hip ratio										
No					-0.4					-10.5
Yes	-0.001	0.001	0.390	-0.4		-0.017	0.007	0.012	-10.5	
Behavioural factors										
Physical activity status										
Frequent										
Rare	0.000	0.001	0.801	-0.2	3.4	0.000	0.003	0.985	-4.5	-9.0
Never	0.006	0.002	<0.001	3.6		-0.007	0.008	0.359	-4.5	
Tobacco consumption										
No					0.3					-1.1
Yes	0.001	0.002	0.762	0.3		-0.002	0.004	0.673	-1.1	
Alcohol consumption										
No					-1.2					2.8
Yes	-0.002	0.001	0.018	-1.2		0.005	0.002	0.060	2.8	
Individual factors										
Age										
Young-old										
Old-old	0.000	0.000	<0.001	0.3	0.4	0.001	0.003	0.720	0.6	-0.2
Oldest-old	0.000	0.000	0.542	0.1		-0.001	0.002	0.448	-0.7	
Sex										

Male					0.0					5.1
Female	0.000	0.000	0.789	0.0		0.008	0.006	0.178	5.1	
Education										
Not educated/primary not completed										
Primary	0.001	0.000	0.002	0.9	6.1	-0.002	0.001	0.233	-1.0	-3.9
Secondary	0.004	0.001	0.005	2.4		-0.004	0.001	0.004	-2.2	
Higher	0.005	0.002	0.008	2.8		-0.001	0.001	0.048	-0.7	
Marital status										
Currently married										
Widowed	0.000	0.000	0.423	0.0	-0.2	-0.001	0.003	0.814	-0.5	-0.1
Others	0.000	0.000	0.310	-0.2		0.001	0.001	0.319	0.3	
Working status										
Working										
Retired	0.002	0.000	<0.001	1.5	8.1	-0.011	0.005	0.023	-6.5	-10.1
Not working	0.011	0.002	<0.001	6.7		-0.006	0.003	0.072	-3.6	
Household factors										
MPCE quintile										
Poorest										
Poorer	0.000	0.000	0.006	0.1		0.000	0.003	0.963	-0.1	
Middle	0.000	0.000	<0.001	-0.2	-0.3	-0.003	0.003	0.251	-1.9	-2.3
Richer	0.000	0.000	<0.001	-0.2		0.001	0.003	0.808	0.4	
Richest	0.000	0.000	<0.001	0.0		-0.001	0.003	0.653	-0.7	
Religion										
Hindu										
Muslim	0.004	0.001	<0.001	2.6	2.2	0.000	0.001	0.866	-0.1	-2.6
Christian	-0.001	0.000	0.108	-0.4		-0.002	0.002	0.333	-1.1	
Others	0.000	0.000	0.413	0.1		-0.002	0.001	0.021	-1.4	
Caste										
Scheduled Caste										
Scheduled Tribe	0.004	0.002	0.015	2.7	5.2	0.006	0.004	0.079	3.8	2.9
Other Backward Class	0.000	0.000	0.681	0.0		-0.004	0.005	0.457	-2.2	
Others	0.004	0.002	0.093	2.4		0.002	0.003	0.492	1.3	
Region										

North										
Central	0.004	0.001	0.015	2.2		0.004	0.003	0.115	2.6	
East	-0.006	0.001	0.000	-3.4	10.4	0.008	0.003	0.010	4.7	3.7
Northeast	0.003	0.001	0.003	1.9		0.000	0.003	0.933	0.1	
West	0.004	0.001	0.003	2.1		-0.004	0.001	0.008	-2.4	
South	0.012	0.002	<0.001	7.6		-0.002	0.003	0.392	-1.3	
Constant						0.119	0.023	<0.001	72.6	72.6
Total	0.083	0.004	<0.001	50.9		0.080	0.006	<0.001	49.1	

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Discussion:

This study found that the overall prevalence of multimorbidity was lower among older adults in rural areas (19.1% vs. 35.4%) than their urban counterparts. Several previous studies also noted a higher prevalence of multimorbidities among older adults in rural than older adults in urban [13]. The higher risk of multimorbidity in urban areas could be associated with increased prevalence of risk factors such as sedentary urban lifestyle, physical inactivity, and increase in energy and fat intake [26]. Urbanization also contributes to the increase in the prevalence of NCD risk factors [53]–[55]. Moreover, living in urban areas provides easy access to healthcare facilities, leading to higher health-seeking behaviour (Patel & Chauhan, 2020), leading to prompt diagnosis of NCD, raising the prevalence of multimorbidity in urban areas than in rural areas [56]. Furthermore, increasing nuclear family trends set up in urban areas could also be attributed to a higher risk of multimorbidity among older adults in urban [53].

The study found that obesity was an important factor among older adults experiencing multimorbidity. Results found that those who were obese were more likely to experience multimorbidity in rural and urban areas. Reducing urban-rural inequality in obesity-related factors would decline rural-urban inequalities in multimorbidity by almost 17 percent. Previous studies in developed as well as developing countries have unanimously agreed on a higher risk of multimorbidity among the obese population than in the non-obese population [27], [44], [57]–[63]. High waist-hip ratio and high-risk waist circumference were also associated with a high risk of multimorbidity among older adults, as noticed in previous studies [44]. Waist hip ratio and waist circumference were shown to be more sensitive among several anthropometric indices of obesity while screening for multimorbidity [44]. One widely followed hypothesis is that obesity leads to a state of chronic inflammation due to the accumulation of adipose tissue, further leading to stress response; all these events altogether lead to a rise in the incidence of morbidities such as cardiovascular diseases, diabetes, respiratory problems and other such

chronic conditions [64], [65]. Moreover, obesity could be a consequence of the presence of multimorbidity, as shown in a prospective study by Nagel et al. (2008), who reported an increase in obesity as the number of morbidities increased [66]. The cross-sectional nature of data limits our understanding of causal inferences, and reverse causation cannot be ruled out in this study also. Obesity is a significant risk factor for chronic diseases, further leading to a higher risk of multimorbidity [61].

Physical inactivity was also noticed as an important risk factor for multimorbidity among older adults. Reducing inequality in physical activity among older adults would decline the urban-rural differential in multimorbidities among them, as shown in this study. Corroborating with previous findings [60], [67]–[69], this study noted an increased risk of multimorbidity among those who were never involved in physical activity than their counterparts in rural as well as in urban areas. However, a few studies failed to notice any association between multimorbidity and physical inactivity [59], [70]. On the other hand, being physically inactive could be associated with an increased risk of obesity which is well-linked to multimorbidity [59]. Furthermore, engaging in an active lifestyle has proven to be protective against several chronic diseases, such as coronary heart disease [71], diabetes [72], [73], and hypertension [73], [74], which could further be linked to the association between physical activity and multimorbidity.

Education status was another prominent factor infusing urban-rural inequality in the prevalence of multimorbidity among older adults. Results linked higher education to the risk for multimorbidity among older adults. Several previous studies have validated our finding on association between higher education and increased risk of multimorbidity in the Indian context [38]. However, quite a few studies conducted in different settings have noted a high risk of multimorbidity among uneducated older adults than educated older adults [75]–[77]. In addition, higher education is linked to better health literacy leading to increased consultations with health care providers, therefore increasing the probability of getting diagnosed with more

chronic conditions [78], [79]. Another study in the Indian context also noted a positive correlation between higher education and the number of outpatient visits substantiating the claims of a higher risk of multimorbidity among educated people [38].

Confirming the evidence from previous studies [26], [31], this study noted that household wealth was associated with risk of multimorbidity where higher wealth among older adults was linked to a high risk of multimorbidity. This can be attributed to the fact that people from lower socio-economic status are less likely to seek health care and, therefore, less likely to have chronic diseases diagnosed [38]. In addition, higher income is linked to higher treatment-seeking affordability among older adults in India leading to a higher prevalence of multimorbidity [80]. In alignment with previous findings [31], [38], [78], [81], the findings in this study noted a higher prevalence of multimorbidity in female than in male older adults. Therefore, higher treatment-seeking among females at older ages could be attributed to a higher diagnosis of multimorbidity [80].

In agreement with previous studies [26], [82], [83], the prevalence of multimorbidity was higher among non-working groups than in a working group. Working older adults might be involved in some work-related physical activity and may not follow a sedentary lifestyle, which can explain low risk of multimorbidity [56]. The prevalence of multimorbidity was highest among older adults in the Southern region in the country and regions of India highly explained urban-rural inequality in the prevalence of multimorbidity. Previous studies agree with the finding and noticed a high risk of multimorbidity among older adults in residing in Southern part of the country [26], [84]. Kinra et al. (2010) believe that the risk factors associated with multimorbidity are widely prevalent among the South Indian population [84]. Compared to other parts of the country, South Indians have better socio-economic status (Rammohan & Vu, 2018), further linked to the higher risk of multimorbidity.

Limitations and strengths of the study:

The key strength of this study is the use of a recently released nationally representative sample that provides robust estimates of the study variables. However, there are some associated limitations too in this study. This is cross-sectional data and therefore limits the causal understanding. Respondents were asked whether they were diagnosed with any of the chronic diseases by a health professional. This could result in recall bias as some of the respondents might not be able to recollect particular chronic conditions. Furthermore, doctor diagnosis may be biased due to poor quality diagnosis in India [13]. Also, the reporting of multimorbidity was calculated by merging only nine available chronic conditions; there are many more chronic conditions for which data was not available, undermining the prevalence of multimorbidity. The available data only provides the prevalence and determinants related information; therefore limits our understanding of the severity of the diseases/multimorbidity.

Conclusion:

This study provides concrete evidence on the emerging rural-urban inequality in the prevalence of multimorbidity among older adults, highlighting the need for immediate interventions from health planners and policymakers. Specifically, our findings indicate a need for the growing burden of multimorbidity in urban areas to be considered within the framework of several factors predicting high urban-rural inequality in the prevalence of multimorbidity. Results found that controlling obesity-related factors and improving physical activity among older adults would decrease the urban-rural inequality in the prevalence of multimorbidity by almost 20 percent. Education was another significant predictor of urban-rural inequality in the prevalence of multimorbidity among older adults along with working status. Based on the findings, the study has some valuable suggestions. Although the direction of the relationship between several risk factors and multimorbidity could be debated, there is a need for public

health policy to emphasize the importance of reducing the burden of multimorbidity among older adults, specifically in urban areas. There is a need to substantially increase the public sector investment in healthcare to address the multimorbidity among older adults, more so in urban areas, without compromising the needs of older adults in rural areas.

List of abbreviations:

LASI: Longitudinal Ageing Study in India

PSUs: Primary Sampling Units

CEB: Census Enumeration Block

MPCE: Monthly per Capita Expenditure

OBC: Other Backward Class

ST: Scheduled Tribe

SC: Scheduled Caste

NCD: Non-communicable Disease

373 **Declarations:**

374 **Ethics approval and consent to participate:** The authors were not involved in data collection
375 process and therefore they did not require any ethical approval or consent to participate. The
376 LASI data is secondary in nature. The data is freely available on request and survey agencies
377 that conducted the field survey for the data collection have collected a prior consent from the
378 respondent. The ethical clearance was provided by Indian Council of Medical Research
379 (ICMR), India. The survey agencies that collected data followed all the protocols. To maximize
380 the cooperation of the sampled HHs and individuals, participants were provided with
381 information brochures explaining the purpose of the survey, ways of protecting their privacy,
382 and the safety of the health assessments as part of the ethics protocols. As per ethics protocols,
383 consent forms were administered to each HH and age-eligible individual. In accordance with
384 Human Subjects Protection, four consent forms were used in the LASI: Household Informed
385 Consent, Individual Informed Consent, Consent for Blood Samples Collection for Storage and
386 Future Use (DBS), and Proxy Consent. For each survey participant, the study protocol was
387 described and the steps of each biomarker test were demonstrated by the trained health
388 investigators. Participant's consent (signed/oral) was obtained for the interviews. Since, the
389 survey obtained either signed or oral consent, it was feasible for each participant to provide
390 his/her consent.

391 **Consent for publication:** Not applicable

392 **Availability of data and materials:** The datasets generated and/or analysed during the current
393 study are available with the International Institute for Population Sciences, Mumbai, India
394 repository and could be accessed from the following link:
395 https://iipsindia.ac.in/sites/default/files/LASI_DataRequestForm_0.pdf. Those who wish to
396 download the data have to follow the above link. This link leads to a data request form designed

by International Institute for Population Sciences. After completing the form, it should be mailed to: datacenter@iips.net for further processing. After successfully sending the mail, individual will receive the data in a reasonable time.

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