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Assessing the Intermediate Pathways Linking Place of Residence to Health in India

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Assessing the Intermediate Pathways Linking Place of Residence to Health in India

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Abstract

Housing is a WHO-recognised social determinant of health, yet its role in linking household socioeconomic status (SES) and disease burden remains unexplored across Indian's diverse residential settings. This study examines whether housing amenities mediate the relationship between household SES and prevalence of ailments in India, and whether this pathway varies between rural, urban and slum areas. Using the NSSO's 76th round survey data on housing, sanitation, and hygiene (2018; N = 106,838 households: 63,736 rural, 40,444 urban, 2,658 slum). Structural equation modelling employed to estimate latent construct of SES, housing amenities, and disease burden represented by separate models for each resident type. Urban households recorded the highest housing amenity scores, followed by slums, with rural households having the lowest. SES is highly positively associated with housing amenities across place of residence (path coefficients: rural= 0.83, urban= 0.75, slum= 0.68), and inversely associated, with disease burden (rural= -0.21, urban = -0.20, slum= -0.14). The SES was inversely associated with disease burden through housing was weakest in slums, indicating that overcrowding and inadequate environmental comfort limit the health returns to increase in socio-economic status in the slum areas. Good Model fit was found across all places of residence (CFI= 0.92-0.97; RMSEA= 0.04-0.06). These findings highlight housing as a critical pathway through which socioeconomic inequalities influence health. Policies addressing income and education should therefore be complemented by improvements in housing quality, sanitation, clean water supply, environmental management, and shelter comfort particularly in rural and slum areas.

Keywords: Housing amenities, socioeconomic status, ailments, Structural equation modelling, Rural-urban-slum disparities, India

Abbreviation:

MPCE- Monthly Per Capita Household Consumption Expenditure
HIS-Housing Structure Index
SI-Sanitation Index
HEI-Household Environment Index
HCI-Household Comfort Index
SES-Socioeconomic Status
SEM-Structural equation modelling
RMSEA-Root Mean Square Error of Approximation
SRMR-Standardized Root Mean Square Residual
CFI-Comparative Fit Index
TLI-Tucker-Lewis Index

HH-Household Head

Introduction

Housing is far more than a physical structure that provides shelter, but it encompasses basic services, indoor and outdoor environmental quality, affordability, security, and usability (1). Increasingly, this multi-layered feature housing is documented as a key social factor of health because it lies at the intersection of biological, environmental, social and economic process that shapes health outcomes across the life course of its dwellers (2). The impact of housing on the increased burden of disease reflects the socio-structural inequalities that shape access to safe, healthy living conditions. In this context, Mehdipanah & Weinstein (2023) emphasised that housing is a by-product of the community and public policy system, which translates socio-economic status (SES) related to housing into health inequalities.

Housing either positively or negatively impacts health. Good housing supports individuals' physical and psychological well-being, whereas poor housing conditions are associated with unhygienic living conditions and environmental hazards that increase the burden of disease (2,4–6). Poor housing conditions, such as dampness, overcrowding, unsafe drinking water, and unclean cooking fuels. These poor living conditions often occur together and can contribute to intra-household disease spread and increased psychological strain (6). As a consequence, housing-related illness often clusters, leading to a cumulative health burden that primarily affects vulnerable populations (7).

Individuals' socio-economic status (SES) influences health not only through access to healthcare and material resources, but also through the quality of living conditions. Individuals with high socio-economic status live in healthy housing and environments and experience a lower burden of disease, whereas those with low socio-economic status experience a higher burden of disease. Thus, housing plays an intermediary role in the inverse relationship between socio-economic status and health (2). So, inequalities in the distribution of housing conditions reflect broader socioeconomic disparities and adversely affect public health. Empirical studies also provide evidence of this relationship, showing that individuals with low income, low education, and lower-paid jobs experience a greater health burden than their counterparts (8).

Empirical evidence from India supports this pathway. Studies have consistently shown that housing conditions and access to basic amenities are closely associated with disease risk. Shortfalls in water, sanitation, and cooking fuel infrastructure contribute significantly to vulnerability to infectious diseases in urban India (9). Similarly, household income and indoor air pollution as important factors of respiratory illness among women and children (10). Further, studies on urban informal settlements show that formal access to infrastructure does not necessarily translate into adequate service provision. City-level studies in India have found that, despite high coverage of public housing and sanitation schemes, households have irregularities in access to

safe drinking water, sanitation facilities, and a large exposure to environmental health hazards (11–13). Evidence from slum communities in Udupi also suggests that child morbidity is affected by the combined effects of factors such as income, housing quality, access to safe water, and sanitation conditions, rather than by any single factor (14). Recent national-level studies further highlight the social factors influencing exposure to environmental and housing-related health hazards. Research using the National Family Health Survey reveals that exposure to PM2.5 is unequally distributed across caste, poverty, and residential groups, with distinct patterns in rural and urban areas (15). These findings emphasise the view that the interaction of socioeconomic disadvantage, poor housing and environmental conditions not only poses health risks but elevate it too.

The policy relevance of these relationships is especially important in the Indian context. India's population exceeded 1.47 billion in 2026 (16), accompanied by rapid urbanisation (approximately 35% urban population) and the continued expansion of informal/squatter settlements (17). Government of India initiatives continue to try to improve housing conditions and access to essential amenities. Consequently, national-level estimates indicate substantial reductions in multidimensional poverty, driven in part by expanded access to sanitation, housing, drinking water, and clean cooking fuels (18). However, improvements in coverage may underestimate persistent disparities in quality service delivery and utilisation across different places of residence. Many studies discuss housing deprivation without explicitly examining the mechanisms through which socioeconomic disadvantage influences health. There is sporadic research regarding the pathways linking socio-economic inequality, housing conditions, and health. Against this backdrop, the present study aims to examine the linkage among household socioeconomic status, housing amenities, and disease burden in rural, urban, and urban slum areas in India.

Materials and Methods

Data Source

The National Sample Survey Organisation's (NSSO) 76th round survey data on drinking water, sanitation, hygiene, and housing conditions, conducted by the Ministry of Statistics and Programme Implementation from July 2018 to December 2018, has been utilised in this study. The analysis is based on a total sample of 106,838 households across the country, including 40,444 urban households, 2,658 urban slum households, and 63,736 rural households.

Methods

Structural equation modelling

As per the study context, Structural equation modelling (SEM) offers a useful approach to addressing existing study limitations by enabling the simultaneous examination of direct and indirect relationships among multiple determinants. While SEM has been applied to investigate housing quality and its determinants in other settings (19). Its

application to housing-health pathways in India remains limited. Emerging evidence suggests that the health effects of housing conditions differ substantially across residential contexts, particularly between slum and non-slum populations (20). It underscores the need for more refined analysis.

The measurement and the structural model are the two essential components of SEM (21). In the present study, measurement models were used to estimate the latent variables of the domains of overall housing amenities, socioeconomic status, and prevalence of ailments.

Equations (1), (2), and (3) are the measurement models of our structural equation model. In these equations, Confirmatory Factor Analysis (CFA) is performed. CFA is utilised to determine overall housing amenities, socioeconomic status, and ailments through their factor loadings, which represent the regression weights or strength of the relationship between the latent construct and its observed measures

$$oha_i = \Delta_{oha} OHA_i + \varepsilon_i^{oha} \quad (1)$$

$$ses_{it} = \Delta_{SES} SES_i + \varepsilon_i^{ses} \quad (2)$$

$$p_{it} = \Delta_p P_i + \varepsilon_i^{p} \quad (3)$$

Equation (1) is for overall housing amenities (latent variable). The observed variables, domains (HIS, SI, HEI, and HCI) of overall housing amenities, as explained in the first part of the methods, are utilised to create the overall housing amenities index (latent variable), denoted by oha_i for household i, whereas OHA_i represents the latent factor. The observed score (oha_i) is a function of factor loadings (Δ_{oha}) times the underlying latent variable of overall household amenities (OHA_i). Positive, high scores indicate the presence of good-quality housing amenities.

Equation (2) is for the latent variable - socioeconomic status. SES_i denotes the socioeconomic status index for household i, whereas ses_{it} denotes the scores of the observed variables. Δ_{ses} are the factor loadings, ε_i^{ses} denotes the error term. The latent variable for socioeconomic status is created using the household head's completed education level and the MPCE quintile. Each variable has five categories. Higher positive scores indicate higher socioeconomic status.

Equation (3) is the measurement model for the latent variable, prevalence of ailments. The observed variables are used to create the latent variable for the overall ailments index, denoted by P_i for individual i, whereas p_{it} denotes the latent factor variables, i.e., the observed variables. The latent variable representing the overall prevalence of household ailments is created from the observed variables obtained across the five ailment types. These ailments include diarrhoea/dysentery, malaria/dengue, skin diseases, jaundice, and other diseases. The variables for these ailments are coded as 0 ("No") and 1 ("Yes") to indicate whether the household has the specific ailment. Thus, the latent variable for the prevalence of overall ailments is estimated from five observable variables. High, positive values indicate a high prevalence of ailments.

Structural equations are analysed simultaneously with the measurement model by employing the maximum likelihood method. Equations of the structural model are given below:

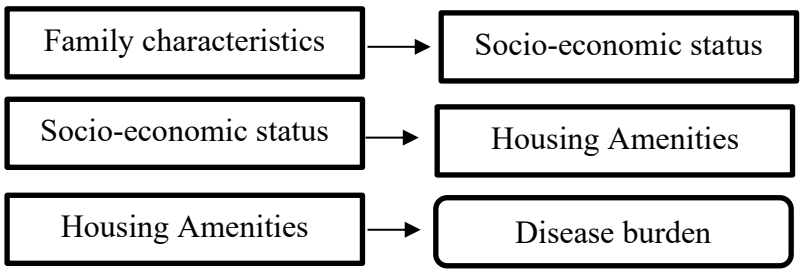
$$OHA_i = \beta_{OHA} SES_i + \varepsilon_i^{OHA} \quad (4)$$

$$P_i = \beta_P OHA_i + (\beta_{OHA} \times \beta_P) SES_i + \varepsilon_i^P \quad (5)$$

Equation (4) presents the model that investigates the effect of the socioeconomic status index on overall housing amenities. Equation (5) shows the direct effect of overall housing amenities plus the indirect effect of SES on the overall prevalence of ailments. β_P in equation 5 is the coefficient vector indicates the direct effect of latent dimensions on the prevalence of the overall ailments index. ε_i^P denotes the error term.

In the final step, the structural equation model's performance is assessed using a variety of fit metrics. Measures like RMSEA (Root Mean Square Error of Approximation), SRMR (Standardized Root Mean Square Residual), CFI (Comparative Fit Index), and TLI (Tucker-Lewis Index) are examples of these indices. A good fit is indicated by an RMSEA value of less than 0.05, and values between 0.05 and 0.08 indicate an adequate fit. A good fit is indicated when the standardised root mean square residual (SRMR) is between 0 and 0.05. TLI and CFI range from 0 to 1. A good match is indicated by CFI and TLI values that are close to 1.

Structural paths of SEM



Study Variables

Independent variables

Socio-economic status

Socio-economic variables included educational level and monthly per capita household consumption expenditure (MPCE). Household-level education was estimated using the maximum years of schooling recorded for the household head. This variable is categorical, divided into five categories based on completed years of schooling: Illiterate/without formal education, below secondary, secondary, and Graduate & above. The MPCE variable is divided into five graded categories. Higher positive scores indicate higher socioeconomic status (SES).

Dependant variables

Domains of Housing Amenities

In this study, several domains of overall housing amenities, including structure, environment, sanitation, and comfort, have been incorporated to develop a latent variable of overall shelter amenities separately for rural, urban, and urban slum areas. For each domain of overall household amenities, sub-indices have been constructed, including the Housing Structure Index (HSI), Sanitation Index (SI), Household Environment Index (HEI), and Household Comfort Index (HCI). The four aforesaid sub-indices are developed using factor analysis, with Cronbach's Alpha, a measure of internal scale consistency, assessed. A higher value for these sub-indices signifies higher quality. Only items loading 0.5 or more have been considered in constructing the housing amenities sub-indices.

Housing Structure Index (HSI)

This index evaluates three aspects of housing structure quality: floors, walls, and roofs. Each aspect is evaluated based on the material type and structural condition (poor, satisfactory, or good). The scoring system assigns each dimension a value of 1, 2, or 3. Score 1: houses with transient or readily deteriorated materials (e.g., canvas walls, mud floors in poor condition, grass/straw roofs). Score 2: houses with stronger materials that might be in average condition (such as metal sheets, satisfactorily maintained charred brick walls, and well-maintained wood or plank floors). Score 3: for houses constructed with long-lasting, premium materials and in good structural shape (e.g., pukka roofs, good condition brick/stone/mosaic/tiles flooring, good condition cement, brick walls, etc.).

Sanitation Index (SI)

The index is based on five indicators, detailing their categories and coding as: Source of Water (Drinking) - Coded from 1 (Unprotected Pond/spring/well) to 4 (Piped to dwelling or bottled); Source of Water (Non-Drinking) - Same categories and coding as drinking water; Bathroom Facility - Coded from 1 (No facility) to 4 (Attached to the dwelling). Latrine Facility: Coded from 1 (No facility) to 5 (Flushed latrine); Cooking Fuel - Coded as 1 (Others) or 2 (LPG/Solar/Electric).

Household Environment Index (HEI)

HEI is composed of the following indicators: i) drainage system: coded as - No drainage '1', Open kutcha '2', Open pukka '3', Covered pukka '4', Underground '5'; ii) Garbage collection system: coded as - No arrangement '1', Resident/group of residents '2', panchayat/municipality/corporation '3'; iii) Any effort to control mosquito problem was made by the Local Bodies/State Govt.: coded as No '1', yes '2'; iv) Frequency of garbage collection: coded as - no collection '1', not even once in a week '2', at least once in a week '3', Daily '4'; v) Poultry farming near the house: coded as - Yes '1', Yes but not near the house '2', No '3'; vi) Road to house: coded as - No direct opening to road '1', Motor able road without street light '2', Motor able road with street light '3'.

Household Comfort Index (HCI)

The index comprises: Electricity in the house - coded, No as ‘1’, Temporary as ‘2’, Fixed to the wall as ‘3’, Conduit wiring as ‘4’; Distance to the source of Drinking water coded ‘1’ as more than 0.5km far, ‘2’ as between 0.2 to 0.5km, ‘3’ as less than 0.2km, 4 as within premise, ‘5’ as inside dwelling; distance to bathroom coded ‘1’ as More than 0.2 km, ‘2’ as less than 0.2km, ‘3’ as within premise, ‘4’ as inside dwelling; Bathroom and Latrine in the premise - coded ‘1’ as No and ‘2’ as Yes; type of kitchen in household - coded 1 as No separate kitchen, 2 as Separate kitchen: without water tap=2, and 3 as Separate kitchen: with water tap; Ventilation - coded 1 as Poor, 2 as Satisfactory, and 3 as Good.

Results

Table 1 presents summary statistics for indicators used to construct housing indices across different dimensions, with higher scores indicating greater amenities.

Structural Quality: Urban households have highly durable housing, predominantly featuring pukka roofs (average score: 2.93/3), walls (2.91/3), and floors (2.91/3). Rural households score significantly lower in these structural categories.

Water and Sanitation: Safe water coverage remains unmet across all areas. Households in urban areas have the highest proportion of access to safe drinking water (3.22/5) and non-drinking water (3.07/5). Slum households score slightly better than rural households, but both rely heavily on poorer sources such as wells and ponds. Urban areas also lead in the use of improved toilet facilities and clean cooking fuels (LPG and electricity).

Environmental Amenities: Urban shelters are typically characterised by covered, pukka drains, regular garbage collection, and the absence of nearby poultry farming. Slum areas have better environmental facilities than rural areas, but lack formal garbage collection and adequate household environmental amenities.

Housing comfort: Rural and slum areas lag far behind urban areas. Slum housing conditions are particularly concerning, scoring 1.99 out of 3, indicating that they are normally not satisfactorily ventilated, and on average, no separate kitchen spaces are found in both rural and urban slum houses.

Table 1: Variable definitions and summary statistics of variables included in different indices of shelter amenities

Variables	Coding	Rural		Slum		Urban	
		Mean	SD	Mean	SD	Mean	SD
Housing Structure Index							
Roof type	Kuccha=1, Semi-Pucca=2, and Pucca=3	2.74	0.58	2.68	0.57	2.93	0.28
Wall type	Kuccha=1, Semi-Pucca=2, and Pucca=4	2.61	0.68	2.64	0.62	2.91	0.33
Floor type	Kuccha=1, Semi-Pucca=2, and Pucca=5	2.45	0.69	2.64	0.61	2.91	0.34
Sanitation Index							
Source of Drinking Water	Unprotected pond/spring/well=1, Protected Pond/spring/well=2, piped water to/from yard/neighbour=3, piped to dwelling or bottled=4	2.36	0.81	2.96	0.85	3.22	0.94
Source of Non-drinking Water	Unprotected pond/spring/well=1, Protected Pond/spring/well=2, piped water to/from yard/neighbour=3, piped to dwelling or bottled=5	2.27	0.85	2.92	0.90	3.07	1.00
Bathroom facility	No facility=1, Common Use=2, In the household campus=3, Attached to the dwelling=4	2.32	1.27	2.78	1.26	3.33	1.01
Latrine Facility	No facility=1, Common Use=2, Pit latrine with cover=3, Septic tank=4, Flushed latrine=5	2.65	1.25	3.01	1.36	3.76	1.18
Cooking Fuel	Others=1, LPG/Solar/Electric=2	1.48	0.50	1.81	0.39	1.87	0.33
Household Environment Index							
Drainage	No drainage=1, Open kutcha=2, Open pukka=3, Covered pukka=4, Underground=5	2.36	1.39	3.54	1.46	4.07	1.24
Garbage collection system	No arrangement=1, Resident/group of residents=2, panchayet/municipality/corporation=3	1.29	0.66	2.52	0.84	2.54	0.81
Any effort to control the mosquito problem was made by the Local Bodies/State Government.	No=1, yes=2	1.18	0.38	1.61	0.49	1.50	0.50

Frequency of garbage collection	No collection=1, Not even once in a week=2, At least once in a week=3, Daily=4	1.56	0.93	2.79	1.25	2.64	1.32
Poultry near the house	Yes=1, Yes but not near the house=2, No=3	2.33	0.74	2.88	0.38	2.91	0.35
Road to the house	No direct opening to road=1, Motorable road without street light=2, Motorable road with street light=3	2.16	0.63	2.42	0.74	2.73	0.52
Shelter Comfort Index							
Electricity in the house	No=1, Temporary=2, Fixed to the wall=3, Conduit wiring=4	2.74	0.91	3.14	0.85	3.55	0.67
Distance to the source of Drinking water	More than 0.5km far=1, Between 0.2 to 0.5km=2, Less than 0.2km=3, Within premise=4, Inside dwelling=5	2.74	0.91	3.14	0.85	3.55	0.67
Distance to bathroom	More than 0.2 km=1, Less than 0.2km=2, Within premise=3, Inside dwelling=4	3.21	0.78	3.44	0.72	3.71	0.51
Bathroom and Latrine on the premises	No=1, Yes=2	1.48	0.50	1.59	0.49	1.88	0.32
Kitchen	No separate kitchen=1, Separate kitchen: without water tap=2, Separate kitchen: with water tap=3	1.63	0.67	1.66	0.79	2.33	0.82
Ventilation	Poor=1, Satisfactory=2, Good=3	2.19	0.68	1.99	0.76	2.49	0.62

Note: Authors' calculation

Table 2 presents summary statistics for four indices measuring housing structure, sanitation, household environment, and shelter comfort, and the overall housing index, and their correlation coefficients and scale reliability test values. All four housing amenity indices show strong reliability among the indicators included in each index (Cronbach's alpha > 0.70) and are positively correlated, indicating that improvements in one housing dimension are associated with better qualities in other dimensions as well, thereby increasing overall housing quality. However, all housing-condition domains fall significantly short of desired standards. Sanitation and shelter comfort are highly correlated to the overall index, with coefficients of 0.90 and 0.88, respectively.

Index-wise, the Housing Structure Index (HSI) scores range from 2.4 to 7.22 (average = 6.5, SD = 1.25) (Table 2). This falls below the maximum possible score of 9.0, indicating that most houses do not meet the highest structural quality standards. The household sanitation index falls well below the maximum possible score of 20, with an average of only 8.8 (range: 2.7-13.16; SD = 2.66). This highlights the lack of quality sanitation facilities across the country. The environment and comfort dimension of households scored just over half of the maximum expected values, indicating widespread inadequacies in household living conditions.

Table 2: Correlation coefficients among Indices of Household Structure, Sanitary, Environment, Comfort, and Overall housing amenities and Cronbach's alpha values

Indices	HSI	SI	HEI	HCI	OHA	Cronbach's Alpha	Mean	SD	Min	Max
HSI	1					0.86	6.51	1.3	2.41	7.22
SI	0.45	1				0.79	8.80	2.7	3.39	13.16
HEI	0.35	0.58	1			0.71	7.40	2.1	4.05	11.68
HCI	0.57	0.76	0.53	1		0.75	9.50	1.9	3.61	12.34
OHA	0.65	0.90	0.78	0.88	1	0.89	32.21	6.5	13.8	44.41

Note: Authors' calculation

In addition, analysis of housing amenities by place of residence (Table 3) shows unequal distributions across all domains. Urban areas have the highest overall housing amenity (OHA) score (36.7), followed by urban slums, which lag by just 2.5 points. By contrast, rural areas fall significantly behind both urban and slum areas, scoring 7.5 points lower than urban areas and 5 points lower than slum areas. This pattern of disparity holds across all other indices.

Table 3: Mean values of different indices of housing amenities by place of residence

Place of Residence	HSI	SI	HEI	HCI	Overall housing amenities
Rural	6.24	7.77	6.29	8.81	29.11
Urban slums	6.45	9.48	9.04	9.23	34.19
Urban non-slums	6.94	10.39	9.04	10.60	36.97

Note: Authors' calculation

Burden of disease by place of residence

Table 4 presents the prevalence of diseases and the distribution of households by the number of diseases in rural, slum, and urban areas. Aside from infectious diseases listed in the table, other diseases show a higher prevalence - around 31% in rural areas, 19% in slums, and 23% in urban areas. Diarrhoea/ dysentery accounts for a prevalence rate of 16 percent, followed by malaria or dengue at 11 percent, skin diseases at 7.5 percent, and jaundice at 2.9 percent in rural regions. The same pattern is found in slums and urban areas, though with lower prevalence rates. Additionally, the percentage of households with one or more ailments is higher in rural areas; nearly one-half of rural households have at least one disease, compared with approximately one-third of households in both urban slums and urban areas, indicating a greater disease burden in rural areas. Therefore, bivariate analyses highlight that rural households tend to have fewer housing amenities and face higher disease burdens, highlighting the importance of empirically examining the link between housing amenities and disease prevalence.

Table 4: Prevalence of diseases (per 100) by place of residence

Ailments	Rural	Urban Slums	Urban non-slums
Diarrhoea/dysentery	15.64	10.01	8.63
Malaria/dengue	11.19	8.43	7.87
Skin diseases	7.51	3.74	4.46
Jaundice	2.87	3.25	1.67
Other ailments	31.18	18.72	22.72
All Ailments	48.25	33.19	34.74
Percentage distribution of households by Number of reported ailments			
No ailments	51.75	66.81	65.26
One ailment	32.14	24.88	26.16
Two ailments	12.72	6.45	6.89
Three or more ailments	3.39	1.87	1.69
Total households	**63736**	**2658**	**40444**

Note: Authors' calculation

Housing amenities and the burden of disease

Figure 1 demonstrates an inverse relationship between housing amenities and the disease burden (prevalence of ailments) across rural and urban regions; higher amenity scores are consistently associated with reduced disease rates. Both rural and urban areas show a similar pattern: as household amenities improve, the prevalence of ailments declines, indicating a negative correlation. In slum areas, however, a very high disease burden is associated with very low housing amenities. While moderate levels of amenities are associated with a significantly lower disease burden, higher levels are associated with a slightly higher disease prevalence exceeding levels observed in rural and urban areas, indicating a nonlinear association between housing amenities and disease burden in urban slums of India.

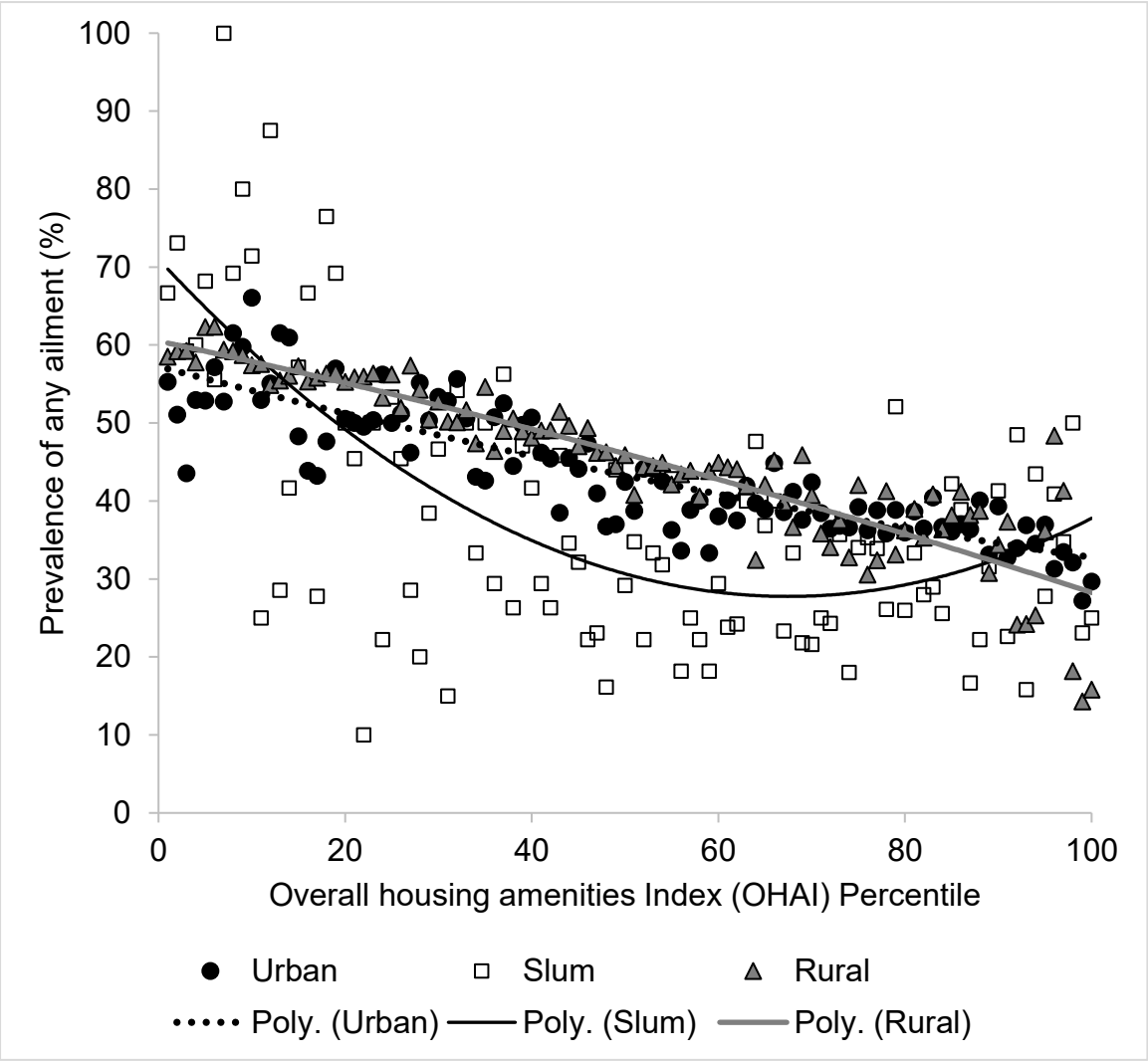


Figure 1: Relationship between housing amenities and the burden of disease (ailment prevalence)

Note: Authors' calculation

Overall Housing Amenities Index (OHAI) by State and Union Territory

While examining overall housing amenities across different states and union territories (Figure 2), Chandigarh ranks highest, with little variation in household scores. Delhi, Puducherry, Goa, and Mizoram rank second to fourth, respectively, although Mizoram shows wide variation in housing scores. Odisha has the lowest overall housing score, and Jharkhand stood second lowest score. Tripura, Manipur, and Assam in the northeast region rank in the bottom third to the fifth place; however, they show less variation in scores. Kerala and Lakshadweep have very low score variability; despite being mid-ranked, their scores are close to those of the highest-ranked states and territories. The large gap between top and bottom housing scores highlights the importance of targeted policies and planning to improve housing equity and national housing standards.

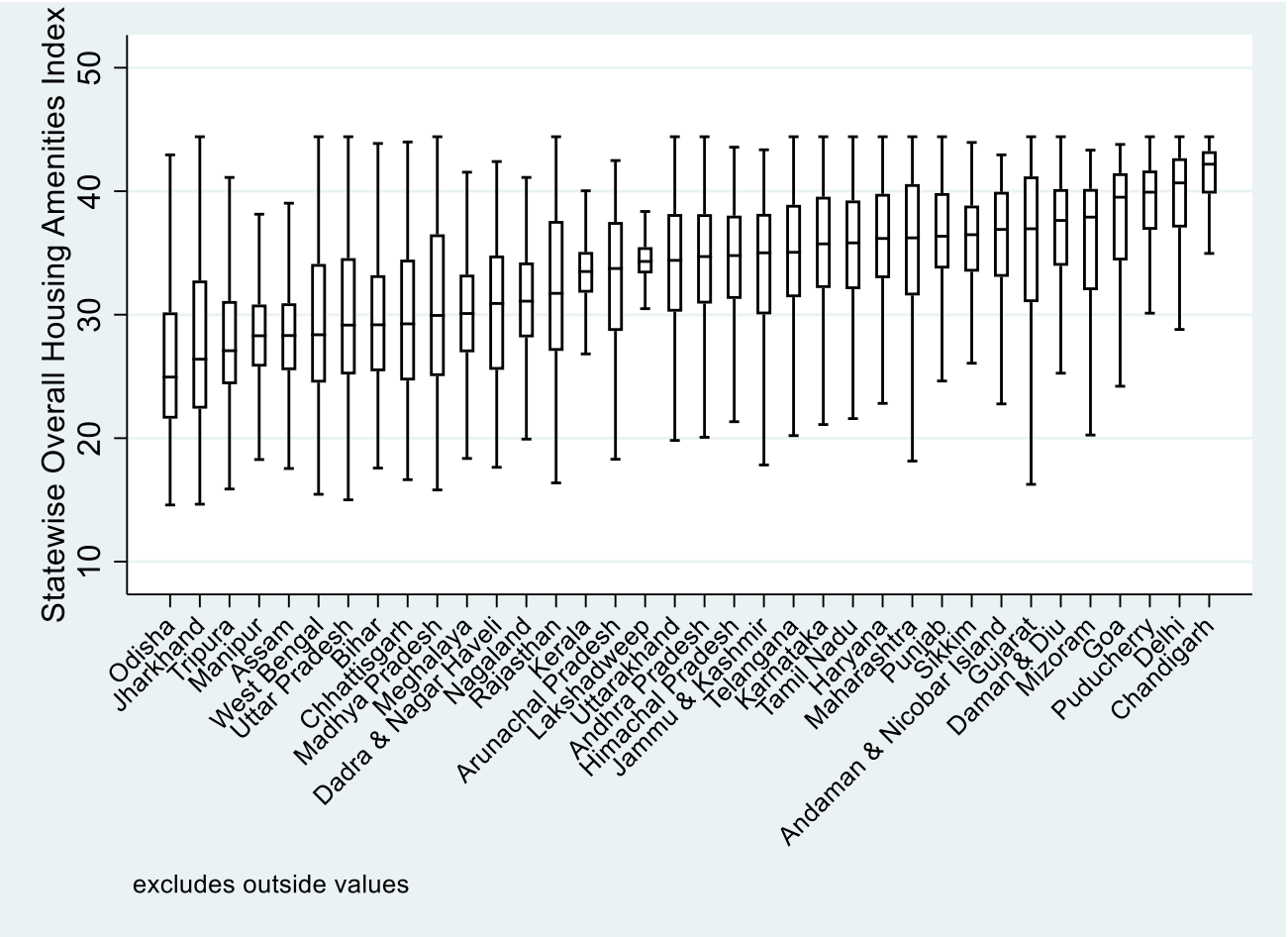


Figure 2: Box-plot of Overall Housing Amenities Index (OHAI) by State and Union Territory

Note: Authors' calculation

Distribution of Overall Housing Amenities Index (OHAI) and households by Socio-Economic status

Housing quality also varies significantly by socio-economic status (Figure 3). Across all areas, higher housing scores are associated with wealthier quintiles (measured by monthly per capita consumption expenditure) and with better-educated household heads. Over half of the population falls into the two poorest wealth quintiles, with only about 5% in the highest quintile in rural areas (Table 5). In urban areas, 5% are in the lowest wealth quintile, and two-thirds are in the top two wealth quintiles. Slum areas show a more balanced distribution across all quintiles, unlike rural and urban areas, where the urban population is concentrated in the upper quintiles and the rural population in the lower ones. We find that low housing amenities scores are associated with lower MPCCE quintiles, which in turn correlate with higher disease burden. In rural and slum areas, most household heads lack higher education, unlike in urban areas, where higher education is more common. It is thus important to test empirically how household socio-economic status influences housing amenities and, in turn, disease burden.

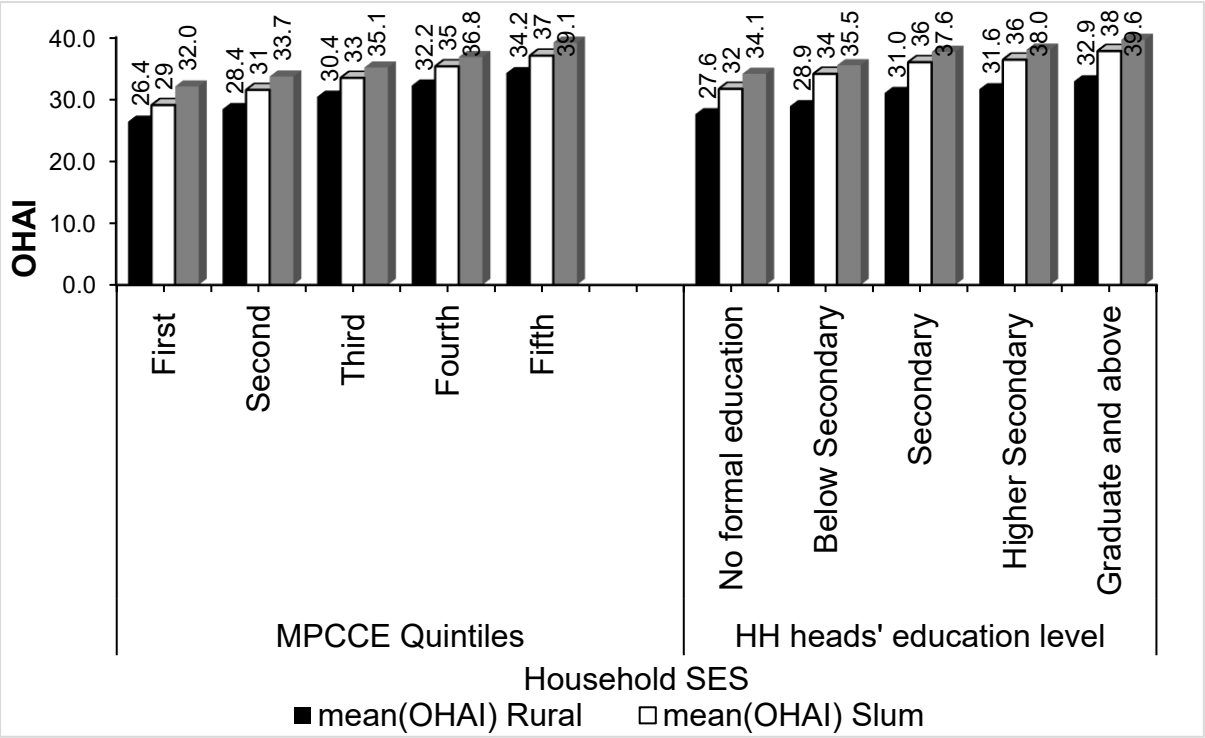


Figure 3: Overall Housing Amenities Index (OHAI) by Socio-Economic status
Note: Authors' calculation

Table 5: Percentage distribution of sample population by household socio-economic status (SES) by place of residence

		Rural	Slum	Urban
MPCCE Quintiles	First	29.6	11.6	5.4
	Second	27.5	12.7	8.7
	Third	23.2	19.9	16.9
	Fourth	14.3	28.2	26.4
	Fifth	5.3	27.6	42.6
HH heads' education level	No formal education	33.18	28.44	13.86
	Below Secondary	41.59	38.22	30.96
	Secondary	13.12	17.04	18.32
	Higher Secondary	6.92	8.84	13.96
	Graduate and above	5.19	7.45	22.91

Note: Authors' calculation

Structural Equation Modelling (SEM) analysis result

Tables 6, 7, and 8, along with Figures 4, 5, and 6, present the results of the Structural Equation Modelling analysis of measurement and fit. These findings highlight a strong connection among disease burden, housing amenities, and socio-economic status across rural, urban, and slum regions. All factor loadings and path coefficients were significant at the 1 per cent level ($P<0.01$).

Measurement Model validity: Firstly, the model's validity is assessed through standardised factor loadings, which confirm the latent reliability of most indicators (Table 6). The shelter comfort index shows the strongest loading on overall housing amenities (0.89-0.92) across various areas. It underscores the centrality of perceptions of housing quality. The ailments show moderate loadings (0.15 -0.32), with other diseases strongest at rural (0.27) and slum areas (0.29) and skin diseases (0.32) in urban areas. Socio-economic status plays a significant role in rural and urban areas, with higher status well defined by both education (0.40 in rural areas, 0.50 in slums, and 0.58 in urban areas) and the MPCCE quintile (0.58 in rural areas to 0.64 in urban areas).

Table 6: Standardized factor loadings for latent variables of burden of diseases, OHAI, and SES by place of residence

Latent Variables	Observed variables	Rural Areas		Slum Areas		Urban Areas	
		Standardised Factor loadings	SE	Standardised Factor loadings	SE	Standardised Factor loadings	SE
Ailment	Diarrhoea/ dysentery	0.53	0.01	0.59	0.04	0.57	0.01
	Malaria/ dengue	0.24	0.01	0.33	0.03	0.22	0.01
	Skin diseases	0.27	0.01	0.25	0.03	0.32	0.01
	Jaundice	0.15	0.01	0.17	0.03	0.14	0.01
	Other diseases	0.27	0.01	0.29	0.03	0.28	0.01
Overall Housing Amenities	HSI	0.57	0.00	0.62	0.01	0.53	0.00
	SI	0.78	0.00	0.81	0.01	0.75	0.00
	HEI	0.43	0.00	0.46	0.02	0.46	0.00
	SCI	0.92	0.00	0.94	0.01	0.89	0.00
SES	MPCE quintile	0.58	0.01	0.61	0.02	0.64	0.01
	Highest education completed by the HH	0.40	0.00	0.50	0.02	0.58	0.00

Note: All factor loadings were significant at the 1 per cent level (P<0.01); SE=standard error
Authors' calculation

Structural Path Insights: The direct paths indicate that socioeconomic status strongly predicts better overall housing amenities (standardised β=0.68 in slums, 0.75 in urban areas, and 0.83 in rural areas), with the strongest effect in rural areas (Table 7). It clearly shows the disparity in access to resources. Overall, housing amenities negatively affect the burden of disease (standardised β = -0.14 in slums, -0.20 in urban areas, and 0.21 in rural areas), suggesting that improved access to amenities reduces the burden of disease; rural areas show the strongest effect.

Mediation Effects: The result shows the indirect paths between socio-economic status and ailments via overall housing amenities (Table 7). Socio-economic status improves

overall housing amenities, thereby reducing ailments. Therefore, housing plays a key role in the relationship between household socio-economic status and health. The indirect effect of socio-economic status on the burden of disease is negative across all places of residence, with the strongest effect in rural (-0.17) and followed by urban (-0.15) areas, and nearly zero (-0.09) or weakly mediated in slum areas, indicating that constraints on housing and living conditions in slums outweigh socio-economic benefits.

Table 7: Direct and indirect structural coefficients from the SEM model

Dependent variables	Latent Variables	Direct Structural Coefficients Standardized		
		Rural	**Slum**	**Urban**
Ailments	Overall Housing Amenities	-0.21	-0.14	-0.20
Housing	SES	0.83	0.68	0.75
		Indirect Structural Coefficients Standardized		
Ailments	SES	-0.17	-0.09	-0.151

Note: All path coefficients were significant at the 1 per cent level (P<0.01)
Authors' calculation

Model fit Evaluation: The Comparative Fit Index (CFI) of the present study's SEM ranged from 0.94 to 0.97 across rural, urban and urban slum areas, exceeding the acceptable threshold of 0.90, and the Tucker-Lewis Index (TLI) ranged from 0.93 to 0.96, also above 0.90 (Table 8). These values indicate a good model fit. The Root Mean Square Error of Approximation (RMSEA) varied from 0.04 to 0.06, and the Standardised Root Mean Square Residual (SRMR) ranged from 0.02 to 0.05, both below the 0.08 cutoff, indicating an excellent to acceptable fit. The combination of good RMSEA and SRMR values, along with high CFI and TLI, indicates that our measurement and structural models meet standard SEM criteria.

Table 8: Structural Equation Modelling fit indices result

Indicators	Model fit result			Threshold for acceptable fit
	Rural	**Slum**	**Urban**	
RMSEA	0.04	0.06	0.05	(Excellent/Good: ≤ 0.05; Acceptable: 0.05 to 0.08; Marginal/Borderline: 0.08 to 0.10; Poor: > 0.10)
CFI	0.97	0.92	0.95	≥ 0.90 "Good Fit."
TLI	0.96	0.9	0.93	≥ 0.90 "Good Fit."
SRMR	0.02	0.05	0.03	< 0.08 "Good Fit."

Note: Authors' calculation

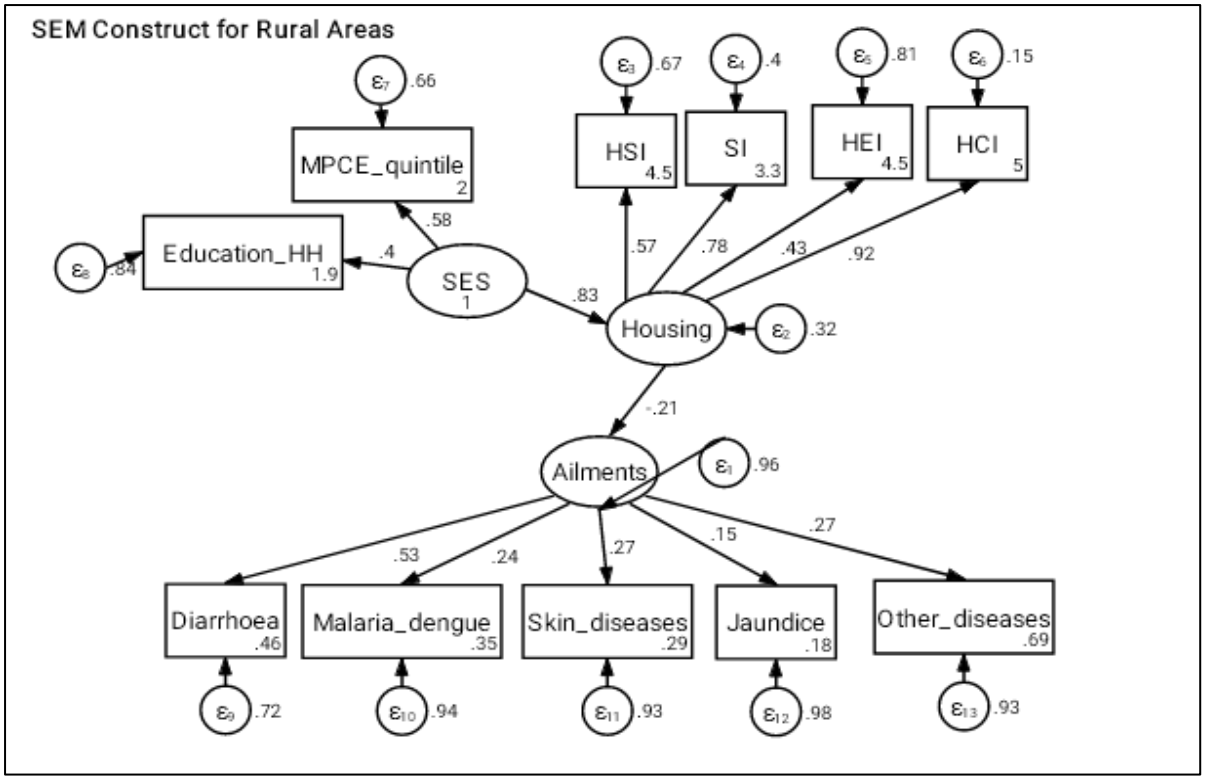


Figure 4: Structural Equation Modelling (SEM) path diagram illustrating the latent and observed predictors of disease burden in rural areas

Note: Authors' calculation

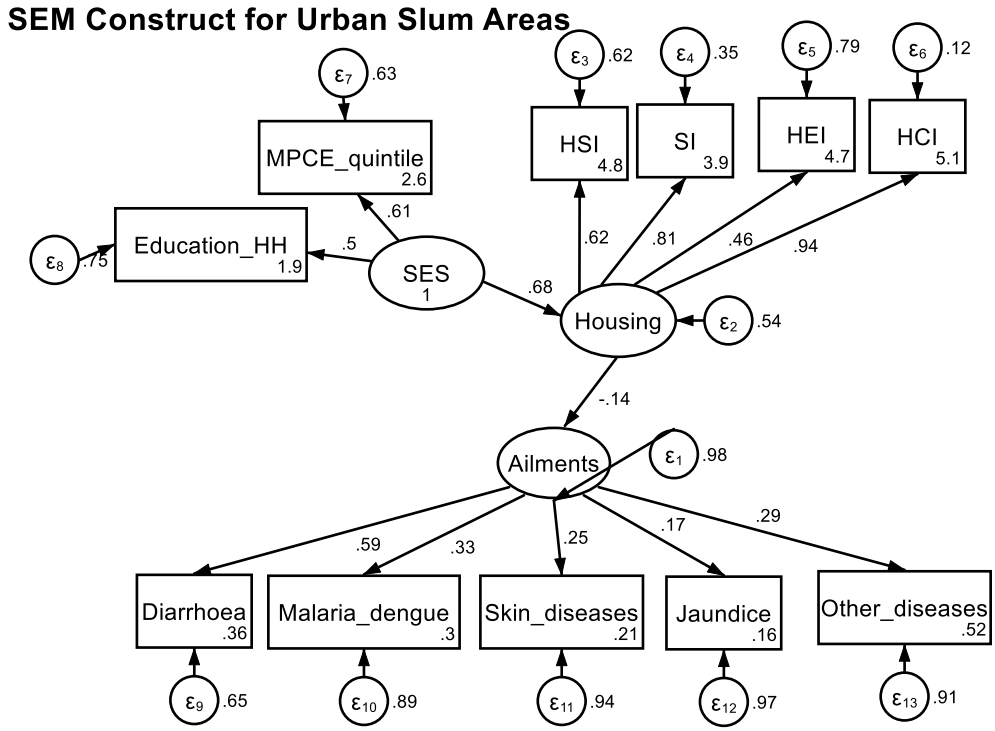


Figure 5: Structural Equation Modelling (SEM) path diagram illustrating the latent and observed predictors of disease burden in slum areas

Note: Authors' calculation

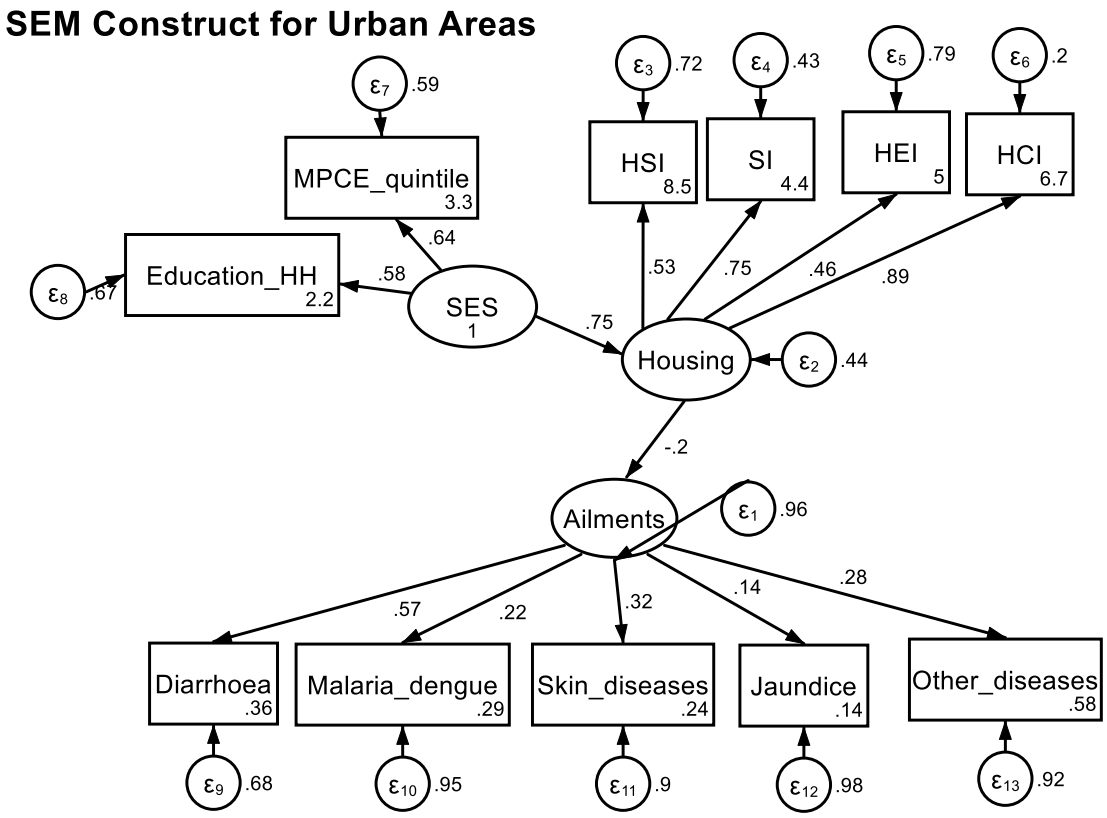


Figure 6: Structural Equation Modelling (SEM) path diagram illustrating the latent and observed predictors of disease burden in urban areas
Note: Authors' calculation

Discussion

Maintaining healthy housing is critical since people spend the majority of their time at home. Substandard housing is so widespread and creates such significant health risks that it remains a serious public health concern (22). Using Structural Equation Modelling (SEM) on nationally representative NSSO data, this study examined how housing amenities, socioeconomic status, and the burden of disease are interlinked across rural, slum, and urban non-slum households in India. The nexus of these domains cannot be understood in aggregate terms alone; hence, a study carried out a comparative analysis to reveal how household amenities and socioeconomic contexts shape illness risk in different ways. The key findings were segregated and discussed under the following domains: the graded flow of amenities, the inverse association with disease burden, the graded socioeconomic status, and the study's measurement robustness.

Our findings reveal firstly that housing amenities follow a clear and consistent 'rural-slum-urban' gradient. Urban non-slum households record the highest scores on every sub-index of housing quality (i.e., Housing Structure Index, Sanitation Index, Household Environment Index, and Shelter Comfort Index), consequently the highest

Overall Housing Amenities Index (36.97), followed by urban slums (34.19) and rural households (29.11). Though slum dwellings score higher than rural households on the composite index. However, this advantage is not uniform across indicators, as slum ventilation is poorer than in rural households, and kitchen space remains cramped and largely without a water tap in both settings. This uneven pattern suggests that slum housing is better mainly in terms of amenities linked to public infrastructure, such as piped water, latrines, and electricity, which are mainly administered by municipal bodies and have extended to notified slums. Whereas, amenities that depend on adequate living space, such as ventilation and separate kitchens, remain constrained by density and informality. These reflected disparities are consistent with international evidence that suggests unequal access to infrastructure, public services, and economic opportunity creates large gaps in housing and health outcomes, even within the same place or country (23). Further, it also reported that urbanisation normally improves housing and living conditions, but often, due to rapid rural-to-urban migration along with poor planning, pressurised and deteriorates existing infrastructure quality. Consequently, it helps to give rise to slums with substandard housing and services (24). In recent years, India has made considerable efforts to expand sanitation coverage and eliminate open defecation (25), yet housing infrastructure, sanitation, and shelter comfort remain below optimal levels nationally (26), and the quality of housing and its neighbourhood environment continue to shape dwellers' health and well-being substantially (27).

Secondly, we found that disease burden is inversely related to amenity gradient-led housing quality, but not in a strictly linear fashion. Rural households with the poorest amenities report the highest overall prevalence of ailments (48.25 per 100 persons), reaffirming that a lack of basic amenities, such as improved toilets and clean cooking fuel, raises the prevalence of waterborne and infectious diseases, including diarrhoea, malaria, and tuberculosis (28). Besides, what is less expected is that urban slums report a marginally lower overall prevalence of ailments (33.19 per 100) than urban non-slum households (34.74 per 100), despite slums scoring appreciably lower on the housing amenities index. Disease-specific figures partly explain this: diarrhoea/dysentery, the ailment most tightly linked to sanitation and drinking water, is indeed higher in slums than in non-slum urban areas (10.01 vs 8.63 per 100), consistent with the crowding-driven transmission of infectious disease documented elsewhere (29). But prevalence in the residual 'other ailments' category is markedly lower in slums, pulling the aggregate figure down. A comparable pattern was recently reported for hypertension among urban Indian women, where prevalence was lower in slums (11.6%) compared to non-slum areas (16.0%), a result attributed to the younger, migrant-dominated composition of slum populations and to tenure and compositional differences rather than to genuinely healthier physical environments (20). Lower rates of healthcare-seeking and health awareness among slum populations, and the consequent under-reporting of morbidity, are also plausible contributors, and this should temper any reading of the slum-versus-non-slum gap as evidence that slum conditions are adequate.

Thirdly, we found that the rural-slum-urban gradient is similar in socioeconomic status, indicating that housing and economic deprivation reinforce one another. Nearly 30 per cent of rural households fall into the lowest monthly per capita consumption expenditure (MPCE) quintile, compared with 11.6% of slum households and just 5.4% of urban households. At the same time, only 5.3% of rural households are in the top quintile, compared with 42.6% of urban households. A parallel pattern holds for education: one-third of rural household heads (33.2%) have no formal education compared to urban areas (13.8%). Urban households are more than four times as likely to have a graduate head (22.9%) as rural households (5.2%). Rural settings comprise approximately two-thirds of the country's population, and they contribute to the highest concentration of low-wealth, low-education households with the poorest housing amenities and the highest disease burden. This fact underscores the urgent need for rigorous policy planning to achieve more equitable income distribution and to improve rural living conditions (30,31). This pattern is consistent with the well-documented social gradient in health, whereby socioeconomic status structures access to material living conditions and, through them, health outcomes (32,33).

Fourthly, the SEM results confirm that socioeconomic status is a strong and statistically significant direct predictor of housing amenities across all residential settings (β= 0.83 rural, 0.68 slum, 0.75 urban). Moreover, overall housing amenities have a significant direct negative effect on the burden of disease across all dwelling areas (β= -0.21 rural, -0.14 slum, -0.20 urban). Taken together, these two paths establish housing amenities as a mediating pathway through which socioeconomic status influences health. Higher socioeconomic status does not appear to reduce disease prevalence directly, although it can improve housing conditions, which in turn may reduce disease prevalence. The indirect (mediated) effect of SES on ailments is significant across all residential settings but is distinctly weaker in slums (β = -0.09) than in rural (β= -0.17) or urban (β= -0.151) areas. This weaker mediation suggests that Community-level environmental constraints, such as overcrowding, poor drainage, trash accumulation, and high population density, reduce the health returns that slum households would otherwise obtain from increased individual socioeconomic status. A similar pattern was also documented for housing quality in urban China, where dwelling-level conditions, rather than housing assets alone, were the stronger predictor of health (34). In other words, a slum household with relatively better economic standing can remain exposed to health risks that originate outside its own dwelling. Slums, while better provisioned than rural areas on paper, continue to combine overcrowding, poor sanitation, and limited amenities in ways that entrench poverty and disease (35,36). In this context, a study on slums found that inadequate waste disposal, garbage collection, and access to clean water increased the risk of dengue, malaria, and leptospirosis (37). Government programs in slums are further limited by documentation requirements that a predominantly short-term migrant population (around 50 to over 90%) of slum residents in Indian cities fails to meet (38–40). Housing and rehabilitation schemes frequently require proof of long-term stay, thereby excluding the very people most in need (41).

Fifth, the measurement model underlying these findings is itself sound. The five housing sub-indices are positive and, in most cases, strongly correlated with one another and with the Overall Housing Amenities Index (r= 0.35 to 0.90). Likewise, each index demonstrates good-to-excellent internal consistency (Cronbach's alpha ranging from 0.71 to 0.89). Diarrhoea/dysentery is consistently the strongest indicator of the disease-burden latent construct across the rural, slum, and urban models alike (standardised loadings of 0.53 to 0.59), pointing to water and sanitation as the single most policy-actionable disease pathway. All three place-specific SEM models also achieve good-to-excellent fit (RMSEA= 0.04 - 0.06; CFI= 0.92 - 0.97; TLI= 0.90 - 0.96; SRMR= 0.02 - 0.05), comfortably within accepted thresholds (42). This provides confidence that the Overall Housing Amenities Index is a valid, reliable, and comparable construct across residential settings, and that it could be adopted as a monitoring tool to track progress on housing and health under national development frameworks.

These findings suggest that housing amenities act as an important link between socioeconomic position and health consequences. While higher socioeconomic position improves housing quality, better housing conditions also reduce disease burden. As a result, programs aimed at reducing health disparities must also address socioeconomic inequality and inadequacies in housing amenities, particularly in rural and slum areas where vulnerabilities are most acute.

Conclusion

In a nutshell, findings suggest housing amenities follow a consistent rural–slum–urban gradient, with rural households the most disadvantaged and slum households occupying an intermediate but uneven position-better served by public infrastructure yet still constrained by density-related deficits such as poor ventilation. Disease burden is broadly inversely related to residential gradients, such as rural households carrying the highest burden, followed by urban slums and urban non-slum areas. Counterintuitively, urban slums report a marginally lower overall prevalence of ailments than non-slum urban areas; this pattern likely reflects the demographic composition of slum populations as much as their physical conditions. Socioeconomic disadvantage conditions also follow a residential gradient, like the concentration of low-wealth, low-education households in rural India. The SEM analysis confirms that socioeconomic status is a strong determinant of housing quality and that housing amenities are a key mediating pathway through which socioeconomic status reduces disease burden. Although this mediating pathway is considerably weaker in slums, where community-level environmental constraints appear to offset individual-level gains. Finally, the underlying measurement model, as the housing indices and the SEM specifications perform reliably and fit the data well across all three residential settings, lending confidence to these substantive conclusions.

Policy Implications

The study findings point out towards broad areas for policy attention, corresponding to the results discussed above.

1. Increase investment in rural housing and infrastructure such as piped water, improved sanitation, drainage, and clean cooking fuel. Since, two-thirds of the population resides here increase amenities should be a priority.
2. Slum interventions need to look beyond individual dwelling upgrades to address community-level infrastructure particularly density-linked deficits such as ventilation and kitchen space. Since it is precisely linked to shared living environmental factors that appear to weaken the health returns to individual housing and socioeconomic improvement in slums.
3. Slum-specific governance reforms led by simplification of required documentation related to identity and residence. Further, redesign rehabilitation schemes so that proof of long-term residence is not a precondition for assistance. It is needed to ensure that existing sanitation and housing schemes actually reach their intended beneficiaries.

Limitations of the study

1. Survey design: Used data is Cross-sectional designed that collect information at a single point in time. Hence, observed associations, including the mediation pathways identified through SEM, should be interpreted statistical relationships rather than evidence based on long-term causal trends.
2. Reporting errors: Reported disease burden is based on participants' self-reports that is subject to recall bias and misreporting, and it may vary systematically with awareness and healthcare-seeking behaviour particularly in case of slum-versus-non-slum urban comparison.
3. SEM limitations: SEM is used to explore how housing amenities mediate the relationship between socioeconomic status and disease burden. But cross-sectional data does not establish causal relationships among the variables.
4. Incomplete housing data: The analysis relies on the housing, sanitation, and drinking-water variables available in the NSSO 78th round. But some dimensions of housing quality (for example, structural safety or indoor air pollution from cooking) are not captured, which may affect the comprehensiveness of the housing amenities index.
5. Compositional confounding: The study does not control for the demographic composition of slum, rural, and urban populations (age structure, migration status, length of residence), which may partly explain some of the counter-intuitive patterns observed, such as the lower aggregate disease burden reported in slums relative to non-slum urban areas.

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Author Contribution
The project was conceived by **SN**, who also carried out the statistical analysis and wrote the report. **VY** helped with the manuscript's critical revisions, literature review, and data interpretation. **AKY** examined the statistical analysis, oversaw the analysis, and offered methodological advice. **NSD** saw the final manuscript and review the project. The final manuscript was read and approved by all writers.

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Data availability
The data used in this study are derived from the National Sample Survey Organization (NSSO), operates under the Ministry of Statistics and Programme Implementation (MoSPI), New Delhi, India. These data are publicly available upon request from the NSSO website.

Declarations

Ethics approval
This study is based on secondary analysis of publicly available, de-identified data from the National Sample Survey Organization (NSSO), operates under the Ministry of Statistics and Programme Implementation (MoSPI), New Delhi, India. As the study utilizes pre-existing, de-identified secondary data with no direct involvement of human participants, formal institutional ethical review and clearance were exempt/not required.

Consent to participate
Informed consent was obtained from all participants by the NSSO implementing agencies prior to data collection. The authors had no direct contact with survey participants.

Consent to publish
Not applicable, as the data is publicly available and does not include any identifiable individual data.

Competing interests
The authors declare no competing interests.

Clinical trial number: Not applicable.

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