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RESEARCH ARTICLE

VULNERABILITY ASSESSMENT: EVIDENCE FROM A RURAL COMMUNITY-BASED MULTIDIMENSIONAL SURVEY IN JHARKHAND, INDIA

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ABSTRACT

BACKGROUND:

Understanding the health of residents in a given community may not be a new concept but exploring and deriving social factors that determine the health dimensions and its outcomes are very complex. Household vulnerability in rural India is shaped by intersecting residential, social, occupational, and health-related factors. Panchayat-level evidence on multidimensional vulnerability remains limited despite its need for local health planning and primary care delivery. This study assessed the vulnerability status of households across rural communities of Jharkhand.

METHODS:

A community-based cross-sectional survey was conducted among all 1,605 households in one panchayat of Community Health Centre (CHC), Devipur Block, Deoghar District, Jharkhand, India. Sociodemographic information and vulnerability indicators were collected using the NHM vulnerability assessment tool, supported by social maps for systematic field navigation.

RESULTS:

Among the 1,605 households surveyed, 22.1% were categorized as most vulnerable, 40.4% as highly vulnerable, and 37.5% as vulnerable. Multivariable binary logistic regression showed significantly higher odds of severe vulnerability among male-headed households (AOR: 2.40; 95% CI: 1.07–5.35), lower-income households (AOR: 12.09; 95% CI: 5.36–27.26), and scheduled tribes (AOR: 5.52; 95% CI: 3.30–9.23). Whereas Muslim households had lower adjusted odds of severe vulnerability than Hindu households (AOR: 0.46; 95% CI: 0.35–0.62). Marked inter-village variation in household vulnerability was observed across the study villages.

CONCLUSION:

The findings highlight the need for localized, equity-focused strategies that address housing, sanitation, livelihood security, and access to health services, and emphasize the importance of periodic vulnerability assessment to monitor and guide community health action.

KEYWORDS

Assessment, household vulnerability, multidimensional survey, NHM tool, primary health care, panchayat mapping, rural communities, social determinants.

BACKGROUND

Vulnerability is an ever-changing concept. Depending on the interplay of societal, environmental, and personal factors—which can be acquired or innate—people may be more or less at risk of being in a vulnerable circumstance. These factors may provide or deprive individuals from certain types of resources. From a biosocial perspective, social scientists have claimed that vulnerability and poor health have an intricate relationship with historical, cultural, infrastructural, economic, and political environment.[1] Vulnerability assessment in the context of NHM means assessing the level of vulnerability of a slum or household towards ill-health. What factors place a household at a greater risk of illness? Labelling a group as vulnerable is insufficient; we also need to understand the mechanisms that make them susceptible and the individuals who become vulnerable as a result of these processes. Although large-scale assessments of vulnerability contribution to field, vulnerability assessments should also to be conducted at a local level, among groups of people in a more or less limited geographical area.[2]

In developing countries like in India, certain population groups are considered vulnerable. This may be either by nature or because of the deep-rooted factors of culture, beliefs and customs. However, when it comes to health perspective, women, children below 5 years, disabled, elderly, migrant workers, people from low socio-economic groups, individuals with long-term illnesses, sex workers, elderly poor, people with mental illness etc. are considered as vulnerable groups.[3] Describing any one factor of vulnerability towards health/illness in isolation is more intricate because numerous similar factors may directly or indirectly overlap with each other. The community in which people facing the problems of lack of water supply, poor drainage facilities, poor ventilation and housing, inadequate nutrition and poor sanitation, are more prone for diseases. Systematic understanding and documentation of all these issues gives baseline data for effective planning of family health care services. [4,5] Vulnerability assessment is not a onetime activity and should be conducted periodically. The study findings give the baseline and comprehend data about vulnerability status of selected community, which further helps to revise and plan for the appropriate health care services. In Primary Health Care (PHC), the understanding of the individual, family, and community context allows an approximation with the social determinants of health (SDH). [6] Periodic vulnerability assessment at the panchayat level is particularly relevant for strengthening primary health care planning, enabling targeted, equity-oriented interventions aligned with the principles of primary health care and the social determinants of health.

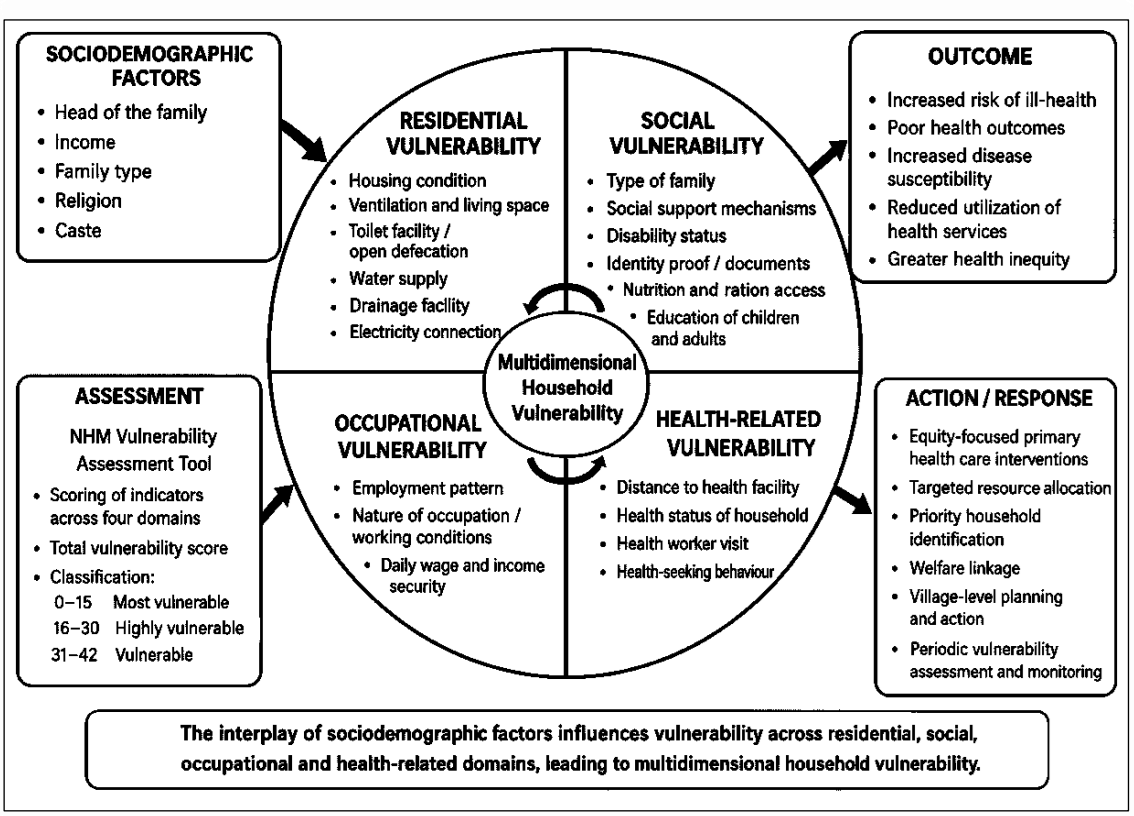
Although multidimensional poverty in rural India declined from 32.59% in 2015–16 to 19.28% in 2019–21, substantial deprivation persisted in nutrition, sanitation, drinking water, and housing across India, highlighting continuing challenges in household living conditions. [7] Vulnerability is closely linked to inequities in access to resources, opportunities, and health services, which differentially affect population groups and influence health outcomes. From a public health perspective, understanding vulnerability is essential for advancing equity and strengthening progress towards universal health coverage.[8] Apart from assessment of vulnerability, regarding the availability and utilization of medical services, the common picture seen in rural community people from low socio-economic groups, they use more emergency services and less of preventive services like immunization and screening. This may be because they perceive health as major crisis [9] rather than as something to be maintained. Vulnerability assessment about health care services of household gives an idea for health care providers to distinguish between provision and use of health care services. [10–12] The nature and dynamics of vulnerability are not adequately captured by checklists of vulnerable groups, despite their importance.[13] Previous studies on vulnerability assessments have often focused on specific vulnerable groups or individual determinants, with limited attention to their combined effects at the household and village levels. [2, 13] The present study addresses this gap by applying multidimensional approach at the household and village levels within a panchayat. It integrates residential, social, occupational, and health-related dimensions using the NHM vulnerability assessment framework, with contextual adaptation to rural settings, while traditional social maps used in community health nursing practice facilitated systematic identification and location of households. The vulnerability assessment findings will facilitate the community health care practitioners in identifying priority households and areas, strengthening micro planning, and guiding ASHA and ANM home visits, screening and follow-up, linkage with welfare schemes, and appropriate allocation of local health

and community resources. Thus, the study extends vulnerability assessment beyond description by generating household- and village-level information that can inform prioritization and planning within primary health care services.

CONCEPTUALIZATION OF VULNERABILITY

In the context of the National Health Mission (NHM), vulnerability refers to the increased susceptibility of certain households or population groups to ill-health due to overlapping social, economic, residential, and occupational disadvantages. Vulnerability extends beyond poverty and includes factors such as inadequate housing, lack of sanitation and safe drinking water, insecure living conditions, hazardous occupations, migration, social discrimination, disability, age-related dependency, and limited access to essential services.[14] Such multidimensional vulnerability contributes to a higher risk of ill-health, poor health-seeking behaviour, increased disease burden, and reduced access to preventive and curative health services. Based on the NHM vulnerability assessment framework, the present study conceptualized vulnerability as a multidimensional condition resulting from the combined effects of residential, social, occupational and health related disadvantages that reduce the capacity of households to maintain health and well-being. The assessment is intended to generate evidence for identifying high-risk households and priority areas, thereby supporting targeted resource allocation and evidence-informed micro-level planning within primary health care services. The conceptual framework depicting the interrelationship between sociodemographic factors, multidimensional vulnerability domains, and vulnerability (Figure 1)

FIGURE 1: CONCEPTUAL FRAMEWORK OF HOUSEHOLD VULNERABILITY

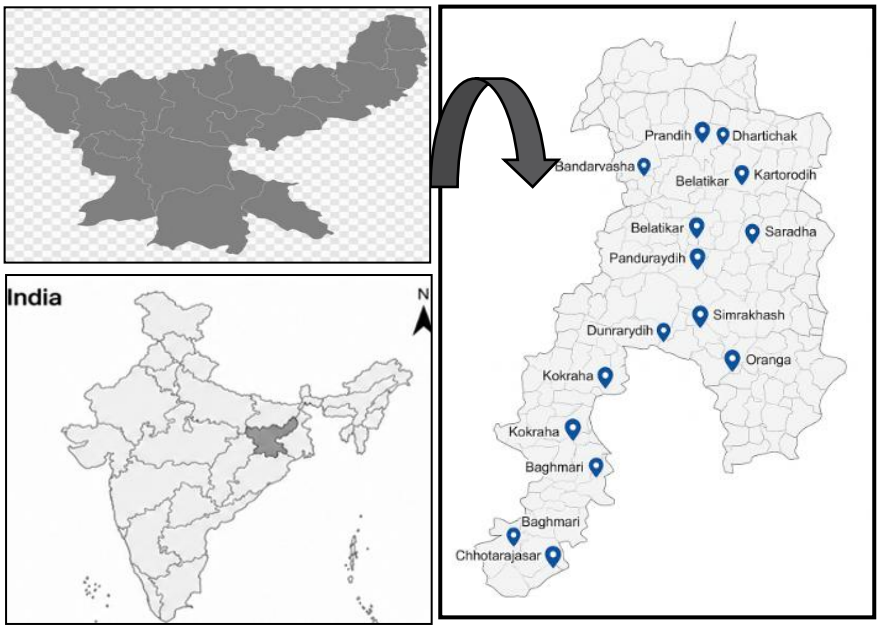


In this context, the present study aims to assess the more prominent and specific factors of multidimensional household vulnerability in selected rural communities of Deoghar district, Jharkhand. The specific objectives were to assess household vulnerability across residential, social, occupational, and health-related domains; to classify households based on overall vulnerability scores; to identify factors associated with severe vulnerability using logistic regression analysis; and to map village-wise variations in vulnerability.

MATERIALS AND METHODS

A community-based descriptive cross-sectional survey was conducted in 17 rural communities belonging to one panchayat (rural local government area) located in Devipur Block, Deoghar District, Jharkhand, India. (Figure 2) The study population comprised all households present in the selected communities during the data collection period. Complete enumeration of the study area identified 1,643 households. However, 38 households could not be included in the study, of which 31 were found locked and 7 had migrated to other places at the time of data collection. Thus, 1,605 households were successfully surveyed and constituted the final sample for analysis, yielding a response rate of 97.7%. The head of the household or an adult representative (≥18 years) was interviewed for each household. Homes locked after two repeated visits were excluded.

FIGURE 2: LOCATION OF THE STUDY AREA WITHIN THE CHC BLOCK, DEOGHAR, JHARKHAND (THE MAP IS NOT IN THE SCALE)



The data collection tool comprised two parts. Part I dealt with the sociodemographic information of households. Part II dealt with vulnerability assessment tool, which was developed by the National Health Mission (NHM), Government of India. Based on the earlier field observations and internal expert review, limited contextual modifications were made to selected items. Specifically, location of the household and occupational conditions, to improve their applicability to the rural socio-environmental setting, while retaining the original domains, items, and scoring framework (Supplementary File 1). The modified tool was reviewed and validated by experts in the field of community medicine and community health nursing. The NHM tool comprises 4 different sections for assessing vulnerability: Residential, Social, Occupational and Health related. The total vulnerability score ranged from 0 to 42 and was computed by summing all domain components. Based on cumulative scoring, households were categorized into three categories: 0–15 as most vulnerable, 16–30 as highly vulnerable, and 31–42 as vulnerable. Lower cumulative scores indicated greater vulnerability.

Data were collected by two trained ANMs, with assistance from eight ASHAs for household identification and field coordination. The investigators trained and oriented the field team on study objectives, administration of the modified NHM vulnerability assessment tool, interviewing, and scoring procedures. Data quality was maintained through investigator supervision and review of completed schedules. Each household was surveyed, visited physically, and face-to-face interviews was conducted with the head of household. Data collection was carried out in two phases from November 2024 to February 2025 and from May 2025 to August 2025, considering the geographical spread of the study communities, manpower availability and feasibility of systematic household coverage. Although the data collection periods differed seasonally, the occupation- and income-related indicators reflected the usual circumstances of permanent household residents, thereby reducing the potential influence of seasonal variation. Prior to data collection, community social maps were prepared with support from, local leaders, residents, and nursing students. These maps

displayed settlement patterns, household clusters, sanitation points, and key resources. They were used as field-guided navigational tools to ensure systematic coverage of all households and to validate the significant indicators during observation.

DATA ANALYSIS

The data thus generated were entered into and analyzed using the SPSS (version 25) software. Descriptive data was presented as frequencies and valid percentages. For inferential analysis, total vulnerability was dichotomized into two categories by combining "most vulnerable" and "highly vulnerable" as severe vulnerability, and comparing it with the "vulnerable" category. To determine the factors associated with total vulnerability, bivariable binary logistic regression was performed by entering each variable separately to estimate crude odds ratio (COR) with 95% confidence intervals (CI). Subsequently, all explanatory variables were entered simultaneously into a multivariable binary logistic regression model using the enter method to obtain adjusted odds ratios (AOR) with 95% CI. All tests were two tailed and p value <0.05 was considered statistically significant. The multivariable logistic regression model yielded Cox–Snell and Nagelkerke pseudo-R^2 values of 0.252 and 0.345, respectively. The Hosmer–Lemeshow goodness-of-fit test was non-significant (chi^2=6.125), df= 8, (p=0.623)), indicating the model is adequately fit. Variance inflation factor (VIF) and tolerance statistics were computed to evaluate multicollinearity among independent variables. All predictor variables showed VIF values close to 1 (range: 1.003–1.037) and tolerance values above 0.96, indicating no evidence of multicollinearity.

ETHICAL CONSIDERATION

Ethical approval was obtained from the Institutional Ethics Committee (IEC) of AIIMS, Deoghar (IEC Code: 2023-109-IND-03). Further permission was sought from the community leaders in the study area and the local authorities. Written informed consent was obtained from all the participants. To ensure confidentiality, unique identification codes were assigned to each village and household, and the data were maintained securely without using personal identifiers.

RESULTS

TABLE 1: DISTRIBUTION OF HOUSEHOLDS ACCORDING TO SOCIODEMOGRAPHIC VARIABLES (N=1605)

Variables	Category	Frequency (f)	Percentage (%)
Head of the family	Male	1573	98
	Female	32	2
Income	Upper	59	3.7
	Upper middle	343	21.3
	Middle	494	30.8
	Lower middle	430	26.8
	Lower	279	17.4
Type of family	Nuclear family	857	53.4
	Extended /Joint family	435	27.1
	Living alone/ Others	313	19.5
Religion	Hindu	1291	80.4
	Muslim	314	19.6
Caste	General	106	6.6
	SC	670	41.8
	ST	326	20.3
	OBC	503	31.3

The sociodemographic profile showed a predominance of Hindus (80.4%), while Muslims accounted for 19.6%. Distribution of caste showed a higher representation of SC (41.8%), followed by OBC (31.3%) and ST (20.3%), while only a small proportion (6.6%) belonged to the general category. A highly patriarchal structure was evident, with 98% of households

headed by men. Most households belonged predominantly to the middle (30.8%) and lower-middle (26.8%) income groups, indicating a largely lower to middle socioeconomic profile. In terms of family composition, most households belong to nuclear families. [Table 1]

Across the surveyed households, the majority (96.9%) lacked drainage facilities and 87.5% lacked piped water supply or they use community taps, while the majority practiced open defecation (81.3%). A substantial proportion lived in kutcha houses (44.5%), and the majority depended on a single earning family member (87.1%) and low-paid daily wage employment (61.6%). Nearly half of the households (47.9%) were located more than 10 km from a health facility, while 52.1% were within 10 km, Furthermore, 80.6% relied on local practitioners, informal providers, medical stores, or no treatment, whereas only 19.4% sought care from government facilities or registered private doctors. These findings highlight economic instability, poor sanitation, and inadequate access to healthcare as key contributors to vulnerability. [Supplementary Table 2]

TABLE 3: FREQUENCY AND PERCENTAGE DISTRIBUTION OF HOUSEHOLDS ACCORDING TO VULNERABILITY CATEGORIES BASED ON DOMAIN AND OVERALL SCORES (N = 1605)

Domain of vulnerability	Most vulnerable n (%)	Highly vulnerable n (%)	Vulnerable n (%)
Residential Vulnerability	0 (0.0)	282 (17.6)	1323 (82.4)
Social Vulnerability	0 (0.0)	136 2 (84.9)	243 (15.1)
Occupational Vulnerability	354 (22.0)	1104 (68.8)	147 (9.2)
Health related Vulnerability	0 (0.0)	291 (18.1)	1314 (81.9)
Total Vulnerability	354 (22.1)	649 (40.4)	602 (37.5)

Across all domains, occupational vulnerability showed the highest level of vulnerability, with 22% of households categorized as most vulnerable and 68.8% as highly vulnerable. Social vulnerability was predominantly high (84.9%), while residential (82.4%) and health-related (81.9%) vulnerabilities were mainly within the vulnerable category. Overall, 22.1% of households were categorized as most vulnerable, 40.4% highly vulnerable, and 37.5% vulnerable, indicating a substantial burden of multidimensional vulnerability within the community. [Table 3]

TABLE 4: BIVARIABLE AND MULTIVARIABLE BINARY LOGISTIC REGRESSION ANALYSIS OF FACTORS ASSOCIATED WITH HOUSEHOLD VULNERABILITY (N= 1605)

Variable	Severely vulnerable (N=1003) n (%^)	Vulnerable (N=602) n (%^)	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	VIF
Head of the family							1.003
Male	991 (63)	582 (37)	2.83 (1.37-5.84)	0.005*	2.40 (1.07-5.35)	0.032*	
Female	12 (37.5)	20 (62.5)	Reference	---	---	---	
Income (BG Prasad scale)							1.031

Upper	9 (15.3)	50 (84.7)	Reference	---	---	---	
Upper middle	190 (55.4)	153 (44.6)	6.88 (3.28-14.47)	<0.001*	5.63 (2.56-12.40)	<0.001*	
Middle	307 (62.1)	187 (37.9)	9.12 (4.38-18.97)	<0.001*	5.86 (2.68-12.79)	<0.001*	
Lower middle	276 (64.2)	154 (35.8)	9.95 (4.76-20.79)	<0.001*	8.86 (3.96-18.97)	<0.001*	
Lower	221 (79.2)	58 (20.8)	21.16 (9.83-45.55)	<0.001*	12.09 (5.36-27.26)	<0.001*	
Type of family							
Nuclear family	558 (65.1)	299 (34.9)	Reference	---	---	---	1.005
Extended /Joint family	213 (49)	222 (51)	0.51 (0.41-0.65)	<0.001*	0.44 (0.34-0.58)	<0.001*	
Living alone/ Others	232 (74.1)	81 (25.9)	1.53 (1.14-2.05)	0.004*	1.22 (0.88-1.67)	0.220	
Religion							
Hindu	862 (66.8)	429 (33.2)	Reference	---	---	---	1.011
Muslim	141 (44.9)	173 (55.1)	0.40 (0.31-0.52)	<0.001*	0.46 (0.35-0.62)	<0.001*	
Caste							
General	52 (49.1)	54 (50.9)	Reference	---	---	---	1.037
SC	323 (48.2)	347 (51.8)	0.96 (0.64-1.45)	0.870	1.15 (0.74-1.79)	0.508	
ST	276 (84.7)	50 (15.3)	5.70 (3.52-9.31)	<0.001*	5.52 (3.30-9.23)	<0.001*	
OBC	352 (70)	151 (30)	2.42 (1.58-3.70)	<0.001*	2.44 (1.56-3.83)	<0.001*	

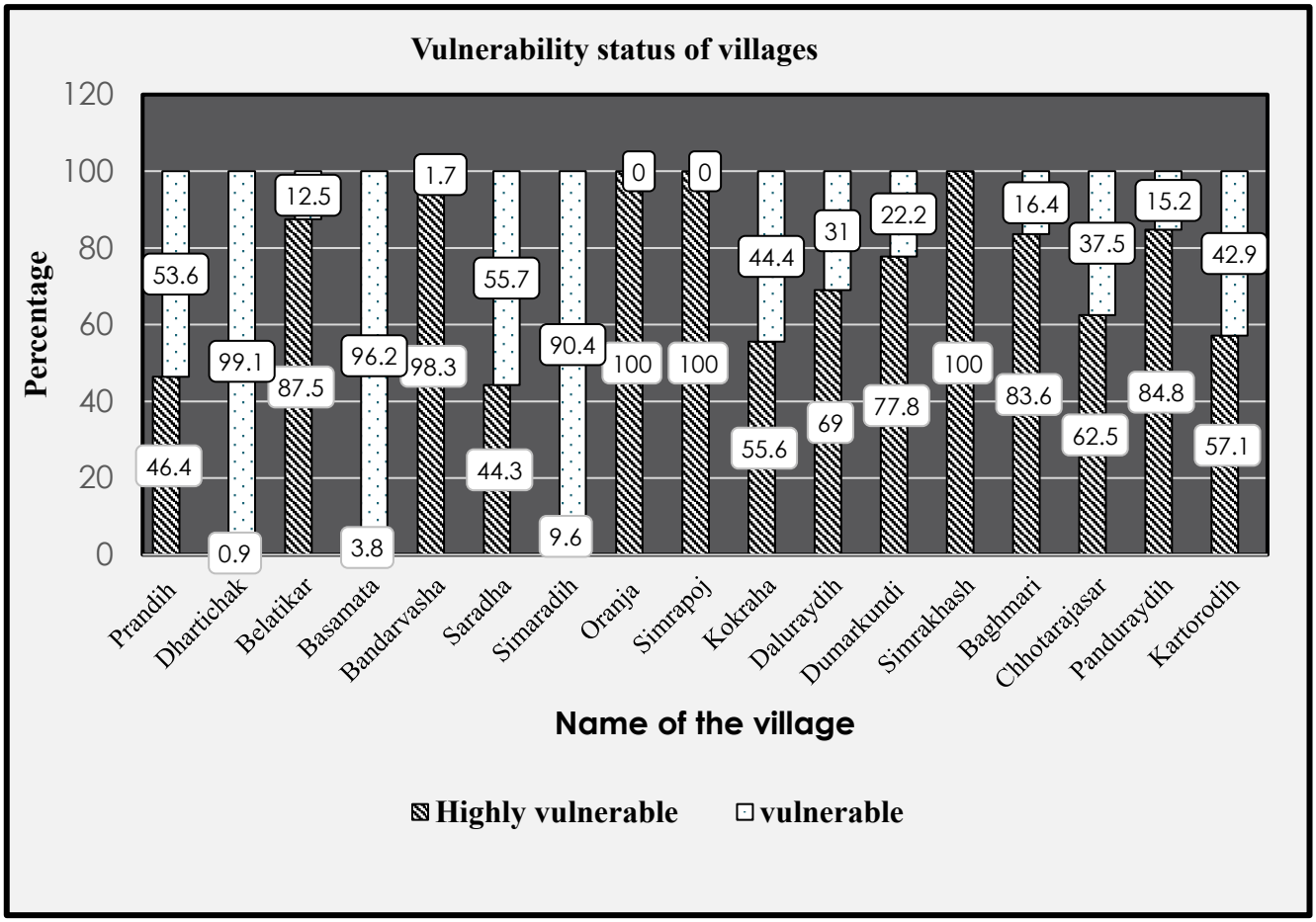
Note: ^ row percentage, OR- Odds Ratio, CI-Confidence Interval, * Statistically significant (<0.05). SC-Scheduled Caste, ST-Scheduled Tribes, OBC-Other Backward Classes, VIF = variance inflation factor

Bivariable logistic regression analysis of 1,605 households showed that 991 (63.0%) male-headed households and 12 (37.5%) female-headed households were severely vulnerable. Male-headed households had 2.83 times higher odds of severe vulnerability than female-headed households (95% CI: 1.37–5.84). Household economic status was classified using the modified B. G. Prasad socioeconomic scale (2024 update) and categorised into five classes: upper, upper-middle, middle, lower-middle, and lower. In the current study lower-income households had the highest proportion of severe vulnerability, with 221 (79.2%) households affected. In the crude analysis, lower-income households had 21.16 times higher odds of severe vulnerability compared to upper-income households (95% CI: 9.83–45.55; p < 0.001). Lower-middle (OR: 9.95; 95% CI: 4.76–20.79), middle (OR: 9.12; 95% CI: 4.38–18.97), and upper-middle income groups (OR: 6.88; 95% CI: 3.28–14.47) also showed significantly higher odds. Households living alone had the highest proportion of severe vulnerability, with 232 (74.1%) categorized as severely vulnerable, and had 1.53 times higher odds compared to nuclear families (95% CI: 1.14–2.05). Compared to Hindu households, Muslim households had 0.4 times lower odds of severe vulnerability (95% CI: 0.31-0.52). Among caste groups, 276 (84.7%) ST households were severely vulnerable. ST households had 5.70 times higher odds of severe vulnerability (95% CI: 3.52–9.31), while OBC households had 2.42 times higher odds (95% CI: 1.58–3.70) compared to the general category. Although 323 (48.2%) SC households were severely vulnerable, the association was not statistically significant.

In the multivariable binary logistic regression analysis, male-headed households remained significantly associated with severe vulnerability (AOR: 2.40; 95% CI: 1.07–5.35; p = 0.032). However, the female-headed reference group contains only 32 households, of which 12 were severely vulnerable. Compared with upper income households, lower-income

households had 12.09 times higher odds of severe vulnerability (95% CI: 5.36–27.26; p < 0.001), while lower-middle (AOR: 8.86; 95% CI: 3.96–18.97), middle (AOR: 5.86; 95% CI: 2.68–12.79), and upper-middle income groups (AOR: 5.63; 95% CI: 2.56–12.40) also showed significantly higher odds. Extended/joint families had lower odds of severe vulnerability than nuclear families (AOR: 0.44; 95% CI: 0.34–0.58; p < 0.001). Muslim households had shown lower odds of severe vulnerability than Hindu households (AOR: 0.46; 0.35-0.62). In caste groups, ST households (AOR: 5.52; 95% CI: 3.30–9.23), and OBC households (AOR: 2.44; 95% CI: 1.56–3.83) had higher adjusted odds than general-category households (both p < 0.001), whereas SC households and households living alone were not significant after adjustment [Table 4]. Given the high prevalence of severe vulnerability (62.5%), the odds ratios may overestimate the corresponding prevalence ratios and should not be interpreted as relative risks.

FIGURE 3: VILLAGE-WISE DISTRIBUTION OF HOUSEHOLD VULNERABILITY LEVELS IN THE STUDY AREA (N = 17)



In the current study, substantial variation in vulnerability was observed across the 17 villages, with several villages including Oranja, Simrapoj, Simrakash exhibiting 100% highly vulnerable households, indicating severe multidimensional deprivation. In contrast, villages like Dharthicak, Basmata, Simradih, show very low levels of high vulnerability, with most households falling in the vulnerable category. Moderate patterns are observed in villages such as Prandih, Saradha, Koraha, Daluraydih, Chotarajasar, reflecting mixed levels of Vulnerability. [Figure 3] Regarding proximity to designated public healthcare facilities, all households in Prandih, Belatikar, Saradha, Simradih, Daluraydih, Kartorodih, Dumarkundi and Baghmari were located more than 10 km away from a health facility. Rest of the villages were located within 10 km. Of these villages, Belatikar, Daluraydih, and Baghmari are tribal communities. Such distance may pose an accessibility challenge for households requiring healthcare.

DISCUSSION

The present study provides a comprehensive assessment of multidimensional household vulnerability, revealing a substantial proportion of families experiencing high levels of residential, social, occupational, and health-related

disadvantages. The principal findings showed that, 22.1% of households were most vulnerable and 40.4% were highly vulnerable. Similar findings were reported by Ravish KS et al. in a study where 45.8% were highly vulnerable and 54.2% were vulnerable, highlighting the widespread burden of vulnerability across Indian communities. [15] A health vulnerability study by Mohapatra S, highlighted poor sanitation, non-functional toilets, open drains, and insufficient water supply facilities, inadequate infrastructure, and limited healthcare access as major contributors to ill-health. Consistent with these findings, our study observed that 96.9% of households lacked drainage and 87.5% lacked piped water supply or they use community taps, while 81.3% practised open defecation, reflecting inadequate sanitary conditions.[16,17] Furthermore, the high proportion of households living in kutcha houses (44.5%), dependence on a single earning member (87.1%), and reliance on daily wage occupations (61.6%) in our study indicate substantial economic insecurity and poor living conditions comparable to the aforementioned study. These findings are comparable to the NFHS-5 Jharkhand report (2019–21).[18] Banerjee et al. report that Scheduled Caste and Scheduled Tribe adults consistently exhibit lower utilization of curative healthcare services. NFHS-5 data show that SC/ST households have 15–20% higher likelihood of living without improved sanitation and 10–18% higher rates of untreated illness compared to general caste groups. These disparities are reflected in our findings where caste was significantly associated with vulnerability.[19,20] A study by Cowling et al. utilized the multidimensional Poverty Index (MPI) to provide a composite indicator of several social determinants of health.[21] The index weights ten indicators across three dimensions: health, education and standard of living. In our study, indicators such as educational deprivation were observed among 33.3% of households where either children had dropped out of school or adults had minimum literacy. Similarly, standard of living deprivation was reflected through lack of improved sanitation facilities, practising open defecation, absence of piped water supply, poor drainage, use of kutcha or semi-pucca housing by the majority of households, and lack of electricity in 9.4% households.

In our study, by domain, 84.9% of households exhibited high social vulnerability and 22.1% showed the highest occupational vulnerability, indicating severe socioeconomic fragility. These findings closely align with national estimates where over 30% of rural households depend on irregular daily wage labour, and over 50% lack secure employment, making them highly susceptible to income-related shocks as per National Health Accounts, MoHFW, 2022. [12] During the survey, it was observed that the majority of households lacked solid waste disposal systems and depended on unsafe water sources. In the current study, 87.5% of households lacked individual piped water supply and 33.3% reported school dropout or illiteracy, whereas the Itanagar study showed comparatively better conditions with 60.7% of households having individual water connections and 79.8% of children pursuing elementary education with minimum literacy among adults.[22] Awasthi et al., conducted a study in Uttarakhand reported that, the proportion of highly vulnerable households ranged from 2.8% to 21.8%, while the majority of households were categorized as vulnerable. In contrast, the present study showed a substantially greater burden of most and high vulnerability categories among households.[23] Reports by Rama Baru et al. and Gupta et al. highlighted that socioeconomic inequities in India are strongly influenced by caste, class, gender, and disparities in the availability, utilization, and affordability of health services. [24–26] These observations are consistent with the findings of the present study, where caste and income emerged as significant predictors associated with severe vulnerability. Previous studies from India has frequently documented greater socioeconomic deprivation among female-headed households, although the relationship varies by region and may be influenced by household-head education, household composition and the definition of poverty.[27–29] In the present study, male-headed households had higher adjusted odds of severe vulnerability; however, this finding should be interpreted cautiously because in our study the female-headed reference group was small. Extended/joint family households had lower adjusted odds of severe vulnerability than nuclear households, consistent with our study linking non-nuclear family structures with lower multidimensional deprivation.[30] Our study revealed Muslim households also had lower adjusted odds of severe vulnerability than Hindu households. This finding contrasts with studies reporting greater deprivation among Muslim populations.[31, 29]

In a study by Wankhade K et al. [32] reported that, in slums of Coimbatore, all slums were categorized as either least vulnerable (scores 11–15) or moderately vulnerable (scores 16–20) with relatively homogeneous vulnerability patterns, In contrast, the present study demonstrated substantial variation in vulnerability across villages. Several villages reported 100% highly vulnerable households, while others had predominantly vulnerable households with very low levels of high vulnerability. These findings indicate marked heterogeneity in multidimensional vulnerability within the study area. The

village-wise variation observed in this study highlights the strong micro-geographic clustering of deprivation. This finding is consistent with evidence demonstrating substantial village-level variation in health and development indicators across India, highlighting the importance of considering local contexts in rural planning and resource allocation. [33] Current study findings collectively support the need for village-specific planning, prioritisation of high-risk clusters, and tailored health and welfare interventions informed by multidimensional vulnerability scores.

STRENGTHS AND LIMITATIONS

The use of complete enumeration minimized selection bias and ensured comprehensive coverage. The use of social maps strengthened systematic data collection. The study provides actionable, village-level evidence for equity-focused primary health care planning. The cross-sectional design limits causal interpretation, and reliance on household-level reporting may introduce reporting bias. As the study was confined to a single panchayat, the findings may have limited generalizability to other rural settings. Although the proportion of non-included households was small, the possibility of selection bias due to household non-availability or migration cannot be completely excluded. Furthermore, the study did not assess the burden of specific morbidities, limiting the interpretation of vulnerability in relation to actual health status. Although households were clustered within 17 villages, village-level clustering was not explicitly accounted for in the primary household-level regression analysis, and potential intra-village correlation may therefore have influenced the precision of the estimated associations.

CONCLUSION AND RECOMMENDATION

The findings highlight the need for targeted, village-specific interventions and routine vulnerability assessments to strengthen equity-oriented rural health planning. Routine vulnerability assessment can support evidence-based planning, prioritization of high-risk households, and equitable delivery of primary health care services. Sharing these results through public forums will facilitate planning and action for appropriate healthcare and welfare services. High-risk households should be prioritized for ASHA/ANM home visits, screening, and government welfare linkage. It is recommended that routine Panchayat-level vulnerability assessments be integrated into primary health care planning to support continuous monitoring and action. Future assessments should also incorporate measures of morbidity and health outcomes to better understand the relationship between vulnerability and ill-health.

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DECLARATION OF CONFLICTING INTERESTS

None

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SUPPLEMENTARY FILE 1

NHM VULNERABILITY ASSESSMENT TOOL

(Adapted for household vulnerability assessment in rural communities)

Administration: The tool is administered to the head of the household or an adult household representative (≥18 years). Select the response that best reflects the household's usual circumstances.

Scoring: Each of the 21 scored items is assigned a score of 0, 1, or 2. The four domain scores are summed to obtain the total vulnerability score (maximum score = 42).

Section I- Residential Vulnerability

1. House Status
   - 0 Homeless shelters/roadside/railway tracks
   - 1 Unauthorized Settlement/Land belonging to local authority/Leased Land
   - 2 Own land/authorized quarters/Registered slum
2. Migration Status
   - 0. Seasonal/Recent migration (Less than one year)
   - 1. Living in the area from last few years (1 to 5 years)
   - 2. Living in the area from more than 5 years
   - 3. Location of the Household
   - 0. Located in a hazardous area prone to flooding, waterlogging, erosion, proximity to polluted water sources/open waste disposal, or other environmental hazards.
   - 1. Household located in a congested area with poor ventilation or limited living space
   - 2. Safe environment with adequate ventilation and space
   - 4. Housing
   - 0. Kutcha house with weak structure, No separate space for cooking, minimal ventilation
   - 1. Fairly pukka but with mud/tin roof and non-cemented walls/brick walls with plastic or thatch roof; marginally better than earlier category
   - 2. Permanent structure, ventilation present, separate space for cooking
   - 5. Basic Services: Toilet
   - 0. No toilet, defecation in the open by all-men, women and children
   - 1. Use common/community toilet, do not have bath facilities
   - 2. Majority have private/defined space for bathing and toileting
   - 6. Basic Services: Water
   - 0. No piped water supply, use community taps/tankers etc., irregular supply
   - 1. Use community taps or hand pumps/ bore well with regular water supply
   - 2. Have individual water pipe
   - 7. Basic Services: Drainage

0. No drains, clogged drains with open pits
1. Open drains-kutcha or pucca
2. Underground connected drains and paved roads

8. Electricity

0. No electricity connection at all
1. Illegal electricity connection
2. Metered individual electricity connection

Section II- Social Vulnerability

9. Type of Family

0. Child Headed household/Women headed household/Single parent family/Single male
1. Nuclear Family with only one earning member with informal employment
2. Joint family with one earning member with regular income or more than one earning member with regular or irregular incomes

10. Social Support Mechanisms

0. Living far from the family, no social support available at all
1. Living alone in the area but people from your community are living nearby
2. Living with family

11. Disability Status

0. Member with chronic disability/debilitating illness like TB, AIDS, Cancer, Kidney failure
1. Household member suffering from mild impairment but functional
2. No member with disability

12. Identity Proof

0. Do not have any documents
1. Have at least one legal document (BPL Card, Ration card, voter ID, Aadhar Card etc.)
2. Have all the necessary documents

13. Episodes of harassment by any Groups in Power

0. Very often
1. Rarely
2. Not at all

14. Nutrition

0. Children are not enrolled in Anganwadi Centre (AWC) and no access to PDS ration
1. Government ration not available but children are enrolled in Anganwadi Centre
2. Children enrolled in AWC and access to PDS/Government ration

15. Education: Children and Adults

0. Children in the household do not attend school and adults are illiterate
1. Young children going to school but drop out in other children, adults with minimum/functional literacy
2. All children pursuing elementary education and adults also have minimum elementary condition

Section III- Occupational Vulnerability

16. Employment Pattern

0. Daily wage earner with irregular pattern, daily wages below Rs 150
1. Daily wage earner with regular employment, daily wages up to 150-500
2. Regular employment or irregular employment with daily wages more than Rs 500

17. Occupational Conditions

0. Hazardous working conditions like agricultural work involving high-risk exposure, sex trade, mining/quarrying, recycling waste collectors, construction workers, brick-kiln work, engaged in bidi making, matchbox making, or other hazardous manual work.
1. Engaged in unskilled and semi-skilled jobs like street vendors, casual laborer, domestic workers
2. Private or government regular job with monthly wages

Section IV- Health Related Vulnerability

18. Proximity to the Health Facility

0. more than 10 kilometers
1. within the range of 5-10 km
2. Less than 5 km

19. Status of Health and Health Services

0. Reported history of maternal death/child death/death due to TB, Malaria or other infectious diseases in last five years
1. Poor health status of the family/individual e.g., Reported cases of diarrhea, TB or any other disease
2. No case of illness at the time of survey

20. ANM Visit

0. Never
1. Once in 3 months
2. Monthly

21. Health Seeking

0. Do not take treatment in case of illness
1. Go to local practitioners/quacks/stores
2. Go to government facilities/registered private doctor

Adaptation note: The tool was adapted from the NHM Vulnerability Assessment Tool with minimal contextual modifications for rural household assessment, particularly for household location and occupational conditions. The original four-domain structure, 21 scored items and 0–2 scoring framework were retained.

SUPPLEMENTARY TABLE 2

TABLE 2: FREQUENCY AND PERCENTAGE DISTRIBUTION OF HOUSEHOLDS ACCORDING TO SIGNIFICANT FACTORS ACROSS THE DOMAIN OF VULNERABILITY (N=1605)

Vulnerability	Category	Frequency (n)
Residential		
Location of the Household	Household located in a congested area with poor ventilation or limited living space	221 (13.8)
	Adequate ventilation and space	1384 (86.2)
Housing	Kutcha house with weak structure, No separate space for cooking, minimal ventilation	715 (44.5)
	Fairly pukka but with mud/tin roof and non-cemented walls/brick walls	757 (47.2)
	Permanent structure, ventilation present, separate space for cooking	133 (8.3)
Basic Services: (a)Toilet	No toilet, defecation in the open by all-men, women and children	1305 (81.3)
	Majority have private/defined space for bathing and toileting	300 (18.7)
(b)Water	No piped water supply/ use community taps/tankers/ Irregular supply.	1404 (87.5)
	Have individual water pipe	201 (12.5)
(c) Drainage	No drains with open pits /Open drains-kutcha or pucca	1555 (96.9)
	Underground connected drains and paved roads	50 (3.1)
(d) Electricity	No electricity/ Illegal electricity connection	151 (9.4)
	Individual electricity connection	1454 (90.6)
Social	**Category**	
Type of Family	Women headed household /Child Headed household/ Single parent family/Single male	73 (4.6)
	Nuclear Family with only one earning member	1398 (87.1)
	Joint family with one or more than one earning member with regular/ Irregular income.	134 (8.3)
Social Support Mechanisms	No social support available at all	334 (20.8)
	Living with family /Alone in the area but people from the community are living nearby	1271 (79.2)
Disability Status	Member with chronic disability/debilitating illness	121 (7.5)
	Household member suffering from mild impairment but functional	378 (23.5)
	No member with disability	1106(68.9)
Identity Proof	Have at-least one legal document (BPL Card, Ration card, voter ID, Aadhar Card etc.)	852 (53.1)
	Have all the necessary documents	753 (46.9)
Nutrition	Children are not enrolled in Anganwadi Centre (AWC) /Not availing ration	694 (43.2)
	Children enrolled in AWC and access to PDS/Government ration	911 (56.8)
Education: Children and Adults	Children do not attend school/drop out and adults are illiterate/ Minimum literacy	536 (33.3)

	All children pursuing elementary education and adults also have minimum elementary condition	1070 (66.7)
Occupational		
Employment Pattern	Daily wage earner with irregular pattern, daily wages below Rs 150	415 (25.9)
	Daily wage earner with regular employment, daily wages up to 150-500	989 (61.6)
	Regular employment or irregular employment with daily wages more than Rs 500	201 (12.5)
Occupational Conditions	Hazardous working conditions like agricultural work involving high-risk exposure, sex trade, mining/quarrying, recycling waste collectors, construction workers, brick-kiln work, engaged in bidi making, matchbox making, or other hazardous manual work.	381 (23.8)
	Engaged in unskilled and semi-skilled jobs	760 (47.3)
	Private or government regular job with monthly wages	464 (28.9)
Health related		
Proximity to the Health Facility	More than 10 kilometres	768 (47.9)
	Within the range of 0-10 km	837 (52.1)
Status of Health and Health Services	Reported history of maternal death/child death/death due to TB, Malaria or other infectious diseases in last five years	73 (4.5)
	Poor health status of the family/individual e.g., Reported cases of diarrhea, TB or any other disease	624 (38.9)
	No case of illness at the time of survey	908 (56.6)
Health care worker visit	No visit/Once in 3 months	230 (14.3)
	Monthly	1375 (85.7)
Health Seeking	In case of illness Go to local practitioners/quacks/stores/ Do not take treatment	1293 (80.6)
	Go to government facilities/registered private doctor	312 (19.4)