

Socio-Economic and Health Vulnerability among Vulnerable Populations during the COVID-19 Pandemic in Delhi, India

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Abstract

The COVID-19 pandemic exposed and intensified existing socio-economic and health inequalities across urban populations, particularly among socially and economically marginalized groups. In densely populated metropolitan regions such as Delhi, pre-existing disparities in income, housing, education, healthcare accessibility, and social protection significantly influenced the ability of vulnerable populations to cope with pandemic-related disruptions. This study examines the socio-economic and health dimensions of vulnerability among vulnerable populations in Delhi during the COVID-19 pandemic. The study is based on primary survey data collected from 800 respondents across the eleven districts of the National Capital Territory (NCT) of Delhi. Data were analyzed using frequency analysis, descriptive statistics, Weighted Mean Score (WMS), Chi-square tests, Analysis of Variance (ANOVA), and logistic regression models to assess patterns of socio-economic and health vulnerability. The findings reveal that income insecurity, job instability, inadequate housing conditions, and educational disruption constituted the principal dimensions of socio-economic vulnerability. Educational disruption emerged as the most severe socio-economic challenge among children, recording the highest weighted mean score (WMS = 3.54). Health-related vulnerabilities were characterized by limited healthcare accessibility, low health insurance coverage, chronic illness burdens, and significant mental health challenges. The results further indicate that socio-economic and health vulnerabilities were closely interconnected, with economically disadvantaged households experiencing greater difficulties in accessing healthcare services and maintaining overall wellbeing during the pandemic. The study highlights that by strengthening social protection systems, improving healthcare accessibility, expanding insurance coverage, and addressing educational and mental health disparities are essential for enhancing urban resilience and reducing vulnerability among marginalized populations in future crises.

Keywords: COVID-19; Urban Vulnerability; Health Vulnerability; Socio-Economic Inequality; Delhi

INTRODUCTION

The COVID-19 pandemic emerged as one of the most severe global public health crises of the twenty-first century, causing unprecedented disruptions to healthcare systems, economic activities, educational institutions, and social life across the world (Bambra et al., 2020; Patel et al., 2020). Beyond its immediate health consequences, the pandemic exposed and intensified existing social and economic inequalities, particularly within urban areas where high population densities, socio-spatial disparities, and unequal access to public services increased the vulnerability of marginalized populations (Sharifi & Khavarian-Garmsir, 2020; UN-Habitat, 2021). The unequal impacts of COVID-19 demonstrated that public health emergencies do not affect all populations uniformly; rather, their consequences are shaped by underlying socio-economic conditions, demographic characteristics, and institutional capacities that influence the ability of individuals and communities to anticipate, cope

with, and recover from crises (Adger, 2006; Cutter et al., 2003).

The concept of vulnerability has become central to geography, disaster studies, and public health research as a framework for understanding differential exposure and sensitivity to hazards. Vulnerability is commonly defined as the propensity or predisposition of individuals, households, or communities to suffer harm when exposed to external stresses or shocks (Adger, 2006). Contemporary vulnerability frameworks emphasize that vulnerability is produced through the interaction of social, economic, environmental, and institutional processes that influence adaptive capacity and resilience (Turner et al., 2003; Cutter et al., 2008). Closely associated with vulnerability is the concept of resilience, which refers to the capacity of individuals, communities, and institutions to absorb disturbances, adapt to changing conditions, and recover from adverse events (Folke, 2006; Moya & Goenechea, 2022). Together, vulnerability and resilience provide an important analytical lens for understanding the uneven impacts of the COVID-19 pandemic across different social groups and urban environments.

Urban areas emerged as major epicenters of the COVID-19 pandemic due to high population densities, extensive mobility networks, intense social interactions, and pronounced socio-economic inequalities (Sharifi & Khavarian-Garmsir, 2020). While cities often offer greater economic opportunities and healthcare infrastructure, they also concentrate poverty, informal employment, overcrowded housing, environmental risks, and inadequate access to essential services (Corburn et al., 2020; UN-Habitat, 2021). Research conducted across different countries has demonstrated that socio-economic deprivation, insecure housing conditions, limited healthcare accessibility, and dependence on informal livelihoods significantly increased both infection risks and the severity of pandemic-related impacts (Patel et al., 2020; Rocha et al., 2021). So, understanding the impacts of COVID-19 requires an integrated assessment of both socio-economic and health vulnerabilities within urban contexts.

Socio-economic vulnerability during the pandemic was manifested through widespread employment losses, income insecurity, inflationary pressures, food insecurity, disruptions in education, and restricted access to essential services (Bambra et al., 2020; Donnelly & Patrinos, 2021). Vulnerable populations, including women, children, elderly individuals, migrants, and residents of informal settlements, experienced disproportionately greater impacts because of their dependence on informal livelihoods, inadequate social protection, and limited access to resources (Corburn et al., 2020; Patel et al., 2020). The pandemic further revealed the structural inequalities embedded within urban labour markets, housing systems, and welfare institutions, which constrained the ability of marginalized groups to withstand and recover from economic shocks.

At the same time, health vulnerabilities were intensified by unequal access to healthcare facilities, chronic disease burdens, inadequate health insurance coverage, and significant mental health challenges (Bambra et al., 2020; Bosmans et al., 2023). The disruption of routine healthcare services during lockdown periods adversely affected individuals with chronic illnesses and increased barriers to healthcare utilization, particularly among economically disadvantaged populations (Pfefferbaum & North, 2020). Moreover, prolonged social isolation, uncertainty, fear of infection, and financial insecurity contributed to increased levels of anxiety, depression, loneliness, and psychological distress across different age groups (Banerjee & Rai, 2020; Vindegaard & Benros, 2020; Xiong et al., 2020). These findings suggest that socio-economic and health vulnerabilities are closely interconnected and often reinforce one another during periods of crisis.

The impacts of the pandemic were particularly evident among children and elderly populations. Educational disruption emerged as a major concern for children due to school closures, unequal access to digital technologies, and interruptions to learning continuity (Engzell et al., 2021; UNESCO, 2021; UNICEF, 2021). Studies have shown that children from economically disadvantaged households experienced greater learning losses because of limited access to internet connectivity, digital devices, and supportive learning environments (Donnelly & Patrinos, 2021; Tso et al., 2022). Similarly, elderly

populations experienced heightened vulnerability because of age-related health risks, chronic illnesses, reduced mobility, and social isolation (Armitage & Nellums, 2020; Sepúlveda-Loyola et al., 2020). The pandemic therefore revealed significant disparities in vulnerability across demographic groups and highlighted the importance of adopting inclusive approaches to resilience building.

A growing body of literature has examined vulnerability and resilience during COVID-19. Studies have demonstrated that socio-economic status, gender, housing conditions, and access to healthcare significantly influenced pandemic experiences and recovery capacities (Bambra et al., 2020; Bosmans et al., 2023; Rocha et al., 2021). Research has also highlighted the importance of institutional preparedness, community support networks, and adaptive capacity in shaping resilience outcomes (Folke, 2006; Moya & Goenechea, 2022). Furthermore, investigations conducted in urban informal settlements have shown that overcrowding, poor sanitation, inadequate housing, and limited access to public services significantly increase vulnerability during public health emergencies (Corburn et al., 2020). Mental health challenges and social isolation have similarly been identified as critical yet often overlooked dimensions of vulnerability (Banerjee & Rai, 2020; Holmes et al., 2020).

Despite these advances, several important gaps remain in the existing literature. First, much of the COVID-19 research has focused on national or regional assessments, while comparatively fewer studies have examined vulnerability among specific vulnerable population groups within individual metropolitan regions. Second, socio-economic and health vulnerabilities are frequently examined separately despite growing evidence that these dimensions are deeply interconnected and mutually reinforcing. Third, there remains limited empirical research focusing simultaneously on children, women, elderly individuals, and slum dwellers within a unified vulnerability framework. Finally, although Delhi represents one of the largest and most socio-economically diverse metropolitan regions in South Asia, comprehensive assessments of socio-economic and health vulnerability among vulnerable population groups remain limited.

Delhi provides a particularly important context for examining urban vulnerability. As the National Capital Territory of India, Delhi is characterized by rapid urbanization, high population density, extensive migration, socio-economic disparities, and considerable variation in infrastructure and service accessibility (Government of NCT Delhi, 2023). The city contains affluent residential neighbourhoods alongside densely populated informal settlements, creating substantial inequalities in housing quality, healthcare accessibility, employment opportunities, and social protection. These structural disparities became increasingly visible during the COVID-19 pandemic, when vulnerable groups experienced varying levels of exposure, risk, and recovery capacity.

Against this background, the present study examines the socio-economic and health dimensions of vulnerability among vulnerable populations in Delhi during the COVID-19 pandemic. The study focuses on four vulnerable groups—children, women, elderly individuals, and slum dwellers—to identify major patterns of vulnerability and understand the factors contributing to differential outcomes. By integrating socio-economic and health indicators within a multidimensional vulnerability framework, the study contributes to the growing literature on urban vulnerability and resilience while providing evidence to support targeted policy interventions and inclusive public health planning. The findings are expected to assist policymakers, public health practitioners, and disaster management agencies in designing more equitable and resilient responses to future public health emergencies.

MATERIALS AND METHODS

Study Area

The present study was conducted in Delhi, officially known as the National Capital Territory (NCT) of Delhi, India. Delhi is one of the world's largest urban agglomerations and serves as the political, administrative, and economic center of the country. Delhi is situated between 28°24'17"N to 28°53'00"N latitude and 76°50'24"E to 77°20'37"E longitude, covering an area of approximately 1,483

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km². The city is strategically located in the northern part of India and is bounded by the states of Haryana and Uttar Pradesh. The Yamuna River flows through the eastern part of the city, while the Delhi Ridge, an extension of the Aravalli Range, forms an important physiographic feature influencing the local environment and urban development patterns.

Delhi experiences a semi-arid climate characterized by extremely hot summers, a monsoon season extending from June to September, and cool winters. Summer temperatures frequently exceed 45°C, while winter temperatures may fall below 5°C. The city receives an average annual rainfall of approximately 700–800 mm, most of which occurs during the southwest monsoon season. Climatic variability, combined with rapid urbanization and environmental stress, has significant implications for public health, living conditions, and the resilience of vulnerable populations.

According to the Census of India, Delhi has a population exceeding 16 million, while recent estimates place the metropolitan population above 20 million, making it one of the most densely populated urban regions in the world. The city exhibits substantial demographic diversity and attracts large-scale migration from different parts of India. Despite relatively high levels of economic development, significant socio-economic disparities persist across the city. Affluent residential and commercial areas coexist alongside extensive informal settlements and densely populated slum clusters, resulting in pronounced inequalities in housing quality, healthcare access, educational opportunities, employment security, and basic urban services.

Delhi is dominated by the tertiary sector, including government services, finance, trade, transport, information technology, education, and healthcare. However, a substantial proportion of the workforce remains engaged in informal and precarious employment, particularly among migrants, women, and low-income households. These structural inequalities became increasingly evident during the COVID-19 pandemic, when vulnerable groups faced disproportionate challenges related to livelihood disruption, food insecurity, healthcare accessibility, and social protection. Consequently, Delhi provides an appropriate and significant urban setting for examining the dimensions of socio-economic and health vulnerability during public health emergencies.

Data Sources

The present study utilized both primary and secondary data sources to examine the socio-economic and health vulnerabilities experienced by vulnerable populations during the COVID-19 pandemic in Delhi. Primary data were collected through a structured questionnaire survey conducted across all eleven administrative districts of the National Capital Territory of Delhi.

A total of 800 respondents were surveyed using a stratified sampling approach to ensure adequate representation of population groups identified as highly vulnerable during the pandemic. The sample consisted of 200 women, 200 children, 200 elderly individuals, and 200 slum dwellers. The survey was designed to capture information related to demographic characteristics, socio-economic conditions, housing circumstances, educational disruptions, health status, healthcare accessibility, and resilience mechanisms during and after the COVID-19 pandemic.

For the purpose of the present study, only variables associated with socio-economic and health vulnerability were selected from the broader survey dataset. The socio-economic domain comprised household income, job insecurity, housing conditions, and educational disruption. Household income was used to assess economic capacity, while job insecurity captured employment instability and livelihood uncertainty resulting from pandemic-related disruptions. Housing condition was evaluated through indicators related to ownership status, rental dependence, slum residence, and institutional or shelter accommodation. Educational disruption was assessed through indicators reflecting irregular school attendance, interruptions in learning activities, and barriers associated with digital access.

The health vulnerability domain included chronic health conditions, healthcare access, health insurance coverage, and mental health status. Chronic illness indicators reflected the presence of long-

term health conditions within households. Healthcare access was measured through frequency of healthcare utilization and the ability to obtain medical services when required. Health insurance coverage was assessed through access to government or private health protection schemes. Mental health status was evaluated through respondents' perceptions of psychological well-being and experiences of anxiety, depression, loneliness, and sleep disturbances during the pandemic period.

Secondary data were obtained from Census publications, government reports, district-level administrative records, and official statistical sources to provide contextual information on population characteristics, urban structure, and administrative boundaries.

METHODOLOGY

The study adopted a quantitative analytical framework to assess socio-economic and health vulnerabilities among vulnerable populations during the COVID-19 pandemic. Data analysis was conducted using Microsoft Office 365 and IBM SPSS Statistics Version 27. The methodological approach consisted of descriptive, comparative, and inferential statistical analyses designed to examine the magnitude and patterns of vulnerability across selected indicators.

2.3.1 Variables Used

Based on the objectives of the study and the availability of survey data, eight indicators were selected and grouped into two thematic domains.

Socio-Economic Vulnerability Indicators

1. Household income
2. Job insecurity and irregular income
3. Housing condition
4. Educational disruption

Health Vulnerability Indicators

1. Chronic health conditions
2. Healthcare access
3. Health insurance coverage
4. Mental health status

These indicators were selected because they directly reflect the economic, educational, and health-related challenges experienced by vulnerable households during the COVID-19 pandemic and were consistently reported across the surveyed population groups.

2.3.2 Statistical Tools Used

Frequency and Percentage Analysis: Frequency distributions and percentage analysis were employed to summarize the characteristics of respondents and assess the prevalence of socio-economic and health vulnerabilities. This approach facilitated the identification of dominant vulnerability patterns across different population groups and provided a descriptive overview of the magnitude of pandemic-related impacts.

Weighted Mean Score (WMS): To determine the relative severity of socio-economic and health vulnerability indicators, a WMS technique was employed. The method was applied to Likert-scale variables related to educational disruption, mental health, healthcare access, resilience strategies, inflation impact, and wellbeing changes. The weighted mean score was computed using the following formula:

$$WMS = \frac{\sum_{i=1}^n (f_i \times w_i)}{N}$$

where f_i represents the frequency of responses in the i th category, w_i denotes the weight assigned to that response category, and N represents the total number of valid responses. Higher WMS values indicate greater perceived severity and vulnerability. The resulting scores were used to rank indicators according to their relative level of vulnerability and perceived impact.

Descriptive Statistical Analysis: Descriptive statistics were computed to summarize the distributional characteristics of selected indicators. Measures included mean, median, standard deviation, variance, minimum values, maximum values, range, and confidence intervals. These statistics were used to understand variability and dispersion within the selected socio-economic and health vulnerability indicators.

Chi-Square Test of Association: The Chi-Square test was applied to examine associations between selected vulnerability indicators and demographic characteristics. This non-parametric statistical technique was used to determine whether observed differences in vulnerability outcomes were statistically significant. The test provided insights into the relationship between socio-economic and health vulnerability dimensions and respondent characteristics.

Analysis of Variance (ANOVA) : ANOVA was employed to examine differences in selected vulnerability indicators across categories of respondents. The technique enabled comparison of mean responses and assessment of whether observed differences among groups were statistically significant. ANOVA outputs included F-statistics, significance levels, and variance estimates, providing an assessment of variability across vulnerability dimensions.

Logistic Regression Analysis: To further examine the determinants of vulnerability outcomes, logistic regression models were employed. Ordinal Logistic Regression was used for ordered response variables such as educational disruption and healthcare access, while Multinomial Logistic Regression was applied to variables such as mental health status and perceived well-being. Maximum Likelihood Estimation (MLE) was used for parameter estimation, and model performance was evaluated using Wald statistics, significance levels, and pseudo R^2 values. These models were used to explore the influence of demographic characteristics on selected socio-economic and health vulnerability indicators.

The results obtained from descriptive statistics, weighted mean scores, Chi-square tests, ANOVA, and logistic regression analyses were interpreted collectively to identify the most prominent socio-economic and health vulnerabilities experienced during the COVID-19 pandemic. The integrated analytical framework enabled a comprehensive understanding of how economic insecurity, educational disruption, healthcare accessibility, chronic illness, health insurance coverage, and mental health challenges shaped vulnerability among Delhi's vulnerable populations.

FINDINGS

Socio-Demographic Profile of Respondents

The study surveyed 800 respondents belonging to four vulnerable population groups in Delhi, comprising children ($n = 200$), women ($n = 200$), elderly individuals ($n = 200$), and slum dwellers ($n = 200$). The demographic profile reflects substantial diversity in age, educational attainment, household characteristics, income levels, and housing conditions, highlighting the multidimensional nature of vulnerability experienced during the COVID-19 pandemic (Table 1).

Children constituted 25% of the sample and were exclusively below 18 years of age. Women respondents were predominantly in the economically active age groups of 18–45 years, whereas all elderly respondents were above 60 years. Slum dwellers were largely concentrated within the working-age population, with approximately 68.5% belonging to the 18–45-year age group. Gender distribution was relatively balanced among children, elderly individuals, and slum dwellers, while

women respondents constituted a separate category represented entirely by females.

Educational attainment varied considerably across groups. Secondary and primary education were the dominant educational levels among children, elderly individuals, and slum dwellers, while women exhibited comparatively higher educational diversity. However, a substantial proportion of slum dwellers (26.5%) and women (23.0%) reported having no formal education, indicating persistent educational disadvantages among vulnerable populations.

Household characteristics reveal that nuclear and joint family systems were the predominant family arrangements across the study population. Large household sizes were common, particularly among women and slum dwellers, where nearly half of the respondents resided in households containing more than eight members. Such household structures may increase dependency burdens and intensify vulnerability during crisis situations.

Income distribution demonstrates widespread economic insecurity. Among children, elderly individuals, and slum dwellers, the majority of households reported monthly incomes below ₹30,000, while slum dwellers exhibited the highest concentration of households earning less than ₹5,000 per month (38.0%). Women displayed comparatively greater income variation, although low- and middle-income categories remained dominant. Housing conditions also varied substantially. Children and elderly respondents primarily lived in rented or owned accommodation, whereas all slum dwellers resided in informal settlements. Women exhibited the highest levels of housing insecurity, with notable proportions residing in shelters, slums, and homeless conditions. These findings indicate that socio-economic disadvantage, housing insecurity, and limited economic resources were widespread across all vulnerable groups and likely contributed to differential experiences during the pandemic.

Table 1. Socio-Demographic Characteristics of Respondents (n = 800).

Variable	Children (n=200)	Women (n=200)	Elderly (n=200)	Slum Dwellers (n=200)
Dominant Age Group	<18 years (100%)	18–30 years (45.0%)	>60 years (100%)	18–30 years (46.5%)
Female (%)	51.0	100.0	46.0	49.0
Male (%)	48.5	0.0	54.0	50.5
No Formal Education (%)	7.0	23.0	8.5	26.5
Primary Education (%)	45.0	15.0	19.5	36.0
Secondary Education (%)	29.5	21.5	30.5	25.5
Senior Secondary (%)	18.5	21.5	27.0	8.0
Graduate and Above (%)	—	19.0	14.5	4.0
Nuclear Family (%)	44.5	54.0	33.0	52.0
Joint Family (%)	42.5	30.0	61.0	34.0
Household Size >8 Members (%)	18.5	50.0	18.5	20.5
Monthly Income <₹10,000 (%)	47.0	37.0	41.0	66.0
Monthly Income >₹50,000 (%)	8.5	20.5	6.5	5.5
Permanent Residents (%)	91.0	29.0	89.0	60.0
Migrant Workers (%)	0.0	39.5	0.0	32.5
Living in Slums (%)	13.0	18.5	12.5	100.0
Living in Shelters (%)	25.0	21.0	3.5	0.0

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Homeless (%)	0.0	22.0	5.0	0.0
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Source: Primary Survey, 2025.

Socio-Economic Vulnerability

The COVID-19 pandemic significantly exacerbated existing socio-economic inequalities among vulnerable populations in Delhi. The findings indicate that economic insecurity, employment instability, inadequate housing conditions, and educational disruption collectively reduced the adaptive capacity of households and intensified their susceptibility to pandemic-related shocks. The impacts were particularly severe among low-income households, slum dwellers, women, and children, highlighting the unequal distribution of socio-economic vulnerability across the study population.

Income Insecurity and Economic Stress

Income insecurity emerged as one of the most prominent dimensions of socio-economic vulnerability. The majority of respondents belonged to low- and middle-income households, with considerable variation across vulnerable groups. Among slum dwellers, 66.0% of households reported monthly incomes below ₹10,000, followed by children (47.0%) and elderly respondents (41.0%). In contrast, women displayed relatively greater income diversity, although over one-third (37.0%) still belonged to low-income categories (Table 2).

Table 2. Monthly Household Income Distribution among Respondent Groups (%).

Income Category (₹)	Children	Women	Elderly	Slum Dwellers
Less than 5,000	26.0	20.5	23.5	38.0
5,000–10,000	21.0	16.5	17.5	28.0
10,001–30,000	20.5	18.5	37.0	18.0
30,001–50,000	16.0	24.0	15.5	10.5
More than 50,000	8.5	20.5	6.5	5.5

The economic consequences of the pandemic were further reflected through inflation-related stress. Inflation impact emerged as the highest-ranked vulnerability indicator among elderly respondents (WMS = 4.07) and the second highest among slum dwellers (WMS = 4.05). ANOVA results confirmed statistically significant variation in inflation-related impacts among elderly respondents ($F = 3.30$, $p = 0.008$) and slum dwellers ($F = 4.00$, $p = 0.002$), indicating that the economic burden of the pandemic was not uniformly distributed across vulnerable groups. These findings demonstrate that rising living costs substantially amplified existing economic disadvantages and reduced household resilience during the crisis.

Employment Insecurity and Livelihood Disruptions

Employment insecurity emerged as a significant component of socio-economic vulnerability during the COVID-19 pandemic. Restrictions on mobility, closure of economic activities, and disruptions in informal labour markets substantially affected household livelihoods across vulnerable population groups. The impacts were particularly severe among slum dwellers, migrant populations, daily wage workers, and households dependent on informal-sector employment, where income generation opportunities were abruptly interrupted during successive lockdown phases (Table 3).

The demographic profile of respondents highlights the precarious nature of employment among vulnerable groups. Among slum dwellers, 32.5% were migrant workers, while 7.5% were temporary residents, indicating a substantial dependence on unstable labour markets. Similarly, 39.5% of women respondents were migrant workers and 31.5% were temporary residents, reflecting high levels of occupational insecurity and limited access to formal employment protections. These conditions increased susceptibility to job losses and livelihood disruptions during the pandemic.

Table 3. Employment Vulnerability Characteristics of Respondent Groups.

Indicator	Women (%)	Elderly (%)	Slum Dwellers (%)
Migrant Workers	39.5	0.0	32.5
Temporary Residents	31.5	11.0	7.5
Monthly Income < ₹10,000	37.0	41.0	66.0
Monthly Income > ₹50,000	20.5	6.5	5.5

The relationship between employment insecurity and vulnerability is further reflected through income patterns. Approximately 66.0% of slum-dweller households reported monthly incomes below ₹10,000, compared with 41.0% among elderly respondents and 37.0% among women respondents. Such income profiles indicate a strong dependence on informal and low-paying occupations that were highly susceptible to disruption during the pandemic.

Evidence of livelihood loss is particularly visible among elderly respondents. Weighted Mean Score analysis identified job loss during lockdown as a notable vulnerability indicator (WMS = 0.31), indicating that approximately 31% of elderly respondents reported losing employment or livelihood opportunities during the pandemic. Although many elderly individuals were retired or economically inactive, a significant proportion remained dependent on informal work and supplementary income sources that were adversely affected by pandemic restrictions.

To examine whether employment-related vulnerability differed significantly across respondent categories, inferential statistical analyses were conducted. ANOVA results for livelihood-related indicators among elderly respondents revealed statistically significant variation across groups, suggesting uneven experiences of economic disruption during the pandemic. Similarly, chi-square analysis demonstrated significant associations between demographic characteristics and selected socio-economic vulnerability indicators, highlighting the role of social and economic inequalities in shaping employment outcomes (Table 4).

Table 4. Statistical Validation of Employment-Related Vulnerability Indicators.

Statistical Test	Indicator	Test Statistic	p-value	Interpretation
ANOVA	Job Loss During Lockdown	F = 3.89	<0.05	Significant
ANOVA	Inflation Impact	F = 3.30	0.008	Significant
Chi-Square	Employment Status × Vulnerability	$\chi^2 = 8.01$	<0.05	Significant Association
Logistic Regression	Economic Vulnerability Model	R ² = 0.04	0.020	Significant Model Fit

The findings demonstrate that employment insecurity functioned as a critical pathway through which the pandemic intensified socio-economic vulnerability. Households experiencing livelihood disruption simultaneously reported greater financial stress, reduced healthcare affordability, and increased dependence on social support systems. Consequently, job insecurity not only represented an economic challenge but also contributed to broader dimensions of vulnerability and reduced resilience among marginalized populations in Delhi.

3.2.3 Housing Vulnerability

Housing conditions represented another critical dimension of socio-economic vulnerability. Significant disparities were observed across respondent groups (Table 5). While elderly respondents

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were more likely to reside in owned accommodation (45.5%), children's households predominantly occupied rented housing (41.0%). Women exhibited the highest levels of housing insecurity, with 22.0% reporting homelessness and 21.0% residing in shelters or institutional accommodation. All respondents classified as slum dwellers resided within informal settlements characterized by overcrowding, inadequate infrastructure, and limited access to basic urban services.

Table 5. Housing Characteristics of Respondent Groups (%).

Living Situation	Children	Women	Elderly	Slum Dwellers
Own House	21.0	20.5	45.5	0.0
Rented House	41.0	18.0	33.5	0.0
Slum/Informal Settlement	13.0	18.5	12.5	100.0
Shelter/Institution	25.0	21.0	3.5	0.0
Homeless	0.0	22.0	5.0	0.0

Housing insecurity intensified vulnerability through multiple pathways. Overcrowded living environments restricted opportunities for physical distancing, increased exposure to infection risks, and limited access to educational and healthcare resources. Respondents residing in slums, shelters, and temporary accommodation reported greater challenges in accessing welfare programmes and maintaining adequate living standards during lockdown periods.

Educational Disruption

Educational disruption emerged as the most severe socio-economic vulnerability among children and represented one of the strongest findings of the study. School closures, restricted mobility, limited access to digital devices, inadequate internet connectivity, and reduced interaction with teachers significantly affected learning continuity during the pandemic (Table 6).

Weighted Mean Score analysis identified educational disruption as the highest-ranked vulnerability indicator among children (WMS = 3.54). More than half of respondents (57.5%) reported that their education was significantly affected (26.0%) or extremely affected (31.5%), while only 11.0% indicated that their education was not affected by the pandemic.

Table 6. Impact of COVID-19 on Education among Children (n = 200).

Response Category	Frequency	Percentage
Not at all affected	22	11.0
Slightly affected	26	13.0
Moderately affected	37	18.5
Significantly affected	52	26.0
Extremely affected	63	31.5

ANOVA results demonstrated statistically significant variation in educational impacts ($F = 4.012$, $p = 0.020$), indicating that educational disruption was strongly associated with underlying socio-economic inequalities. Logistic regression analysis further revealed a significant model fit ($R^2 = 0.040$), although the explanatory power remained relatively low, suggesting that educational vulnerability was influenced by multiple interacting factors beyond demographic characteristics alone.

Statistical Validation of Socio-Economic Vulnerability

To assess the relative severity of socio-economic vulnerability dimensions, weighted mean scores and inferential statistical analyses were examined. Educational disruption emerged as the most severe vulnerability among children, while inflation-related stress dominated among elderly respondents and slum dwellers. ANOVA results consistently indicated statistically significant variation in major socio-economic indicators, confirming the uneven distribution of vulnerability across the study

population (Table 7).

Table 7. Statistical Summary of Major Socio-Economic Vulnerability Indicators.

Indicator	WMS	ANOVA (F)	p-value	Findings
Educational Disruption (Children)	3.54	4.012	0.020*	Regression $R^2 = 0.040$
Inflation Impact (Elderly)	4.07	3.30	0.008*	Highest ranked indicator
Inflation Impact (Slum Dwellers)	4.05	4.00	0.002*	Severe economic stress
Wellbeing Change (Children)	3.42	Significant	<0.05	Moderate-to-high impact
Resilience Strategy Effectiveness (Children)	3.21	Significant	<0.05	Adaptive response capacity

Significant at $p < 0.05$.

Overall, the findings demonstrate that socio-economic vulnerability during the COVID-19 pandemic was multidimensional and characterized by strong interactions between income insecurity, livelihood disruptions, housing precarity, and educational inequality. These vulnerabilities collectively reduced household resilience and contributed to uneven experiences of the pandemic among vulnerable populations in Delhi.

Health Vulnerability

The COVID-19 pandemic exposed substantial health-related vulnerabilities among the surveyed populations in Delhi. The findings indicate that pre-existing chronic health conditions, limited healthcare accessibility, inadequate health insurance coverage, and deteriorating mental health collectively increased susceptibility to adverse health outcomes during the pandemic. These vulnerabilities were closely intertwined with socio-economic disadvantages, creating multiple layers of risk among vulnerable populations. The results further demonstrate that health vulnerability extended beyond infection risk and encompassed broader concerns related to healthcare utilization, financial protection, psychological wellbeing, and long-term health resilience.

Chronic Illness and Health Risks

The presence of chronic illnesses emerged as an important determinant of health vulnerability during the COVID-19 pandemic. Pre-existing health conditions increased susceptibility to severe disease outcomes, intensified healthcare needs, and reduced the ability of vulnerable populations to cope with pandemic-related disruptions. Elderly respondents reported the highest burden of chronic illness, reflecting greater exposure to age-related health complications including diabetes, cardiovascular diseases, hypertension, respiratory disorders, and other long-term medical conditions.

Respondents suffering from chronic illnesses reported greater concerns regarding continuity of treatment, medication availability, routine medical consultations, and increased risk of severe COVID-19 outcomes. These challenges were further amplified by movement restrictions, healthcare system overload, and financial constraints during the pandemic period. Consequently, households affected by chronic diseases experienced both increased healthcare dependency and heightened economic pressure.

The survey findings indicate that approximately 30.5% of children belonged to households reporting one or more chronic health conditions, while 69.5% reported no chronic illness. Although the prevalence among children was lower than among elderly respondents, the existence of chronic illness increased vulnerability through higher healthcare needs and greater dependence on already constrained health systems during the pandemic (Table 8).

Table 8. Chronic Health Conditions among Children (n = 200).

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Chronic Health Condition	Frequency	Percentage
No	139	69.5
Yes	61	30.5
Total	200	100.0

Source: Primary Survey Data.

To assess variation in chronic illness across demographic groups, ANOVA and Chi-square analyses were conducted (Table 9).

Table 9. Statistical Validation of Chronic Health Conditions.

Statistical Test	Test Statistic	p-value	Interpretation
ANOVA (Gender)	F = 4.57	0.180	Not Significant
ANOVA (Condition)	F = 2.86	0.233	Not Significant
Pearson Chi-Square	$\chi^2 = 4.286$	0.232	Not Significant
Logistic Regression	Wald $\chi^2 = 0.343$	0.558	Not Significant

Source: Computed from survey data.

The statistical results suggest that although chronic illness constituted an important health vulnerability, significant differences across gender categories were not observed. The logistic regression model similarly indicated that gender was not a statistically significant predictor of chronic health conditions (Wald $\chi^2 = 0.343$, $p = 0.558$). These findings imply that chronic illness was widely distributed across the study population and represented a persistent structural health burden rather than a vulnerability confined to specific demographic categories.

Overall, the findings demonstrate that chronic illness amplified health vulnerability during the COVID-19 pandemic by increasing healthcare dependency, treatment requirements, and exposure to adverse health outcomes. The interaction between chronic disease burdens and socio-economic disadvantages further intensified vulnerability among already marginalized populations in Delhi.

Healthcare Access and Utilization

Access to healthcare services was significantly disrupted during the pandemic. Respondents reported difficulties in obtaining timely medical consultations, accessing healthcare facilities, arranging transportation during lockdown periods, and affording healthcare expenditures. Financial constraints, mobility restrictions, service interruptions, and concerns regarding infection exposure emerged as major barriers to healthcare utilization.

WMS analysis revealed notable disparities in healthcare access across vulnerable groups. Among children, healthcare access recorded a relatively low WMS value of 1.63, indicating restricted utilization of healthcare services during the pandemic. In contrast, elderly respondents recorded a substantially higher WMS score of 3.19, reflecting their greater dependence on healthcare systems and increased healthcare needs.

ANOVA results further demonstrated statistically significant variation in healthcare access among respondent groups. For children, healthcare accessibility showed significant variation ($F = 12.93$, $p = 0.006$), while among elderly respondents, healthcare access exhibited even stronger statistical significance ($F = 11.50$, $p < 0.001$). These findings indicate that healthcare access was unevenly distributed and strongly influenced by demographic and socio-economic circumstances (Table 10).

Table 10. Healthcare Access and Utilization Indicators.

Indicator	Children	Elderly
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Healthcare Access (WMS)	1.63	3.19
ANOVA (F-value)	12.93	11.50
Significance (p-value)	0.006*	<0.001*

Significant at $p < 0.05$.

The results highlight the importance of healthcare accessibility as a critical component of urban resilience. Limited access to healthcare services increased vulnerability not only to COVID-19 but also to a wide range of chronic and non-communicable health conditions.

Health Insurance Coverage

Health insurance coverage remained relatively limited among vulnerable populations and represented one of the weakest dimensions of health protection. A substantial proportion of respondents reported either lacking insurance coverage or possessing only partial access to government-sponsored health schemes. The absence of financial protection increased out-of-pocket healthcare expenditures and heightened economic vulnerability during periods of medical need.

Among children, only 13.0% reported access to health insurance, while 67.0% lacked any form of coverage. The corresponding WMS value was only 0.16, indicating extremely low levels of financial health protection. Similar patterns were observed among elderly respondents, where health insurance access remained inadequate despite their greater healthcare requirements (Table 11).

ANOVA results revealed statistically significant variation in health insurance access among elderly respondents ($F = 3.30$, $p = 0.045$), indicating unequal distribution of insurance coverage across the study population.

Table 11. Health Insurance Coverage among Children (n = 200).

Category	Frequency	Percentage
No Insurance	134	67.0
Not Sure	40	20.0
Yes	26	13.0

The findings suggest that inadequate insurance coverage substantially increased vulnerability by limiting access to healthcare services and increasing financial stress associated with medical expenditures.

Mental Health Vulnerability

Mental health emerged as one of the most significant dimensions of health vulnerability during the pandemic. Respondents reported experiences of anxiety, depression, loneliness, stress, uncertainty, sleep disturbances, and emotional distress associated with prolonged lockdowns, educational disruptions, economic insecurity, and social isolation.

Among children, mental health vulnerability recorded a WMS value of 3.04, indicating moderate-to-high psychological impacts. Similarly, elderly respondents recorded a WMS value of 2.90, reflecting substantial emotional and psychological challenges during the pandemic period. The findings indicate that mental health outcomes were strongly influenced by social isolation, fear of infection, educational disruption, financial uncertainty, and declining social interaction.

ANOVA analysis confirmed statistically significant variation in mental health outcomes across respondent groups. For children, mental health ratings demonstrated strong statistical significance ($F = 20.69$, $p < 0.001$), while elderly respondents recorded similarly significant variation ($F = 14.83$, $p < 0.001$). These findings indicate that psychological impacts were not evenly distributed and varied according to socio-economic and demographic circumstances (Table 12).

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Table 12. Mental Health Vulnerability Indicators.

Indicator	Children	Elderly
Mental Health WMS	3.04	2.90
ANOVA (F-value)	20.69	14.83
Significance (p-value)	<0.001*	<0.001*

Significant at $p < 0.05$.

The findings suggest that mental health represents a critical but often overlooked dimension of vulnerability during public health emergencies. Psychological wellbeing was closely associated with socio-economic conditions, indicating that economic insecurity and health vulnerability frequently reinforced one another.

3.3.5 Statistical Validation of Health Vulnerability

To evaluate the relative severity of health vulnerability dimensions, weighted mean scores and inferential statistical analyses were examined. Healthcare access, mental health, and health insurance coverage demonstrated significant variability across respondent groups. The results indicate that while healthcare accessibility and mental health concerns constituted major health-related challenges, inadequate insurance coverage remained one of the most persistent structural vulnerabilities (Table 13).

Table 13. Statistical Summary of Major Health Vulnerability Indicators.

Indicator	WMS	ANOVA (F)	p-value	Additional Findings
Healthcare Access (Children)	1.63	12.93	0.006*	Limited service utilization
Healthcare Access (Elderly)	3.19	11.50	<0.001*	High healthcare dependency
Mental Health (Children)	3.04	20.69	<0.001*	Significant psychological impacts
Mental Health (Elderly)	2.90	14.83	<0.001*	Social isolation effects
Health Insurance Access	0.16	3.30	0.045*	Low financial protection

Significant at $p < 0.05$.

Overall, the findings demonstrate that health vulnerability during the COVID-19 pandemic was multidimensional and shaped by the interaction of chronic illness burdens, healthcare accessibility challenges, limited insurance coverage, and psychological distress. These factors collectively increased susceptibility to adverse health outcomes and reinforced existing socio-economic inequalities among vulnerable populations in Delhi.

Composite Analysis of Socio-Economic and Health Vulnerability

To identify the most critical dimensions of vulnerability experienced during the COVID-19 pandemic, a composite assessment was undertaken using Weighted Mean Score (WMS), descriptive statistics, Analysis of Variance (ANOVA), Chi-square tests, and logistic regression models. The analysis reveals substantial variation in the intensity and distribution of socio-economic and health vulnerabilities across vulnerable population groups. The findings demonstrate that vulnerability was multidimensional, with educational disruption, inflation-induced economic stress, mental health deterioration, healthcare accessibility, and limited insurance coverage emerging as the most prominent challenges.

Descriptive Statistics of Major Vulnerability Indicators

The descriptive statistics reveal considerable variation in vulnerability patterns across the surveyed groups. Among children, educational disruption emerged as the most severe vulnerability dimension with a WMS of 3.54, followed by wellbeing change (3.42) and resilience strategy effectiveness (3.21). These findings indicate that school closures, social restrictions, and disruptions in daily routines

substantially affected children's educational attainment and psychosocial wellbeing during the pandemic. Mental health (3.04) and social skills disruption (3.02) further demonstrate the broader developmental consequences of prolonged lockdown measures. In contrast, healthcare access (1.63), health insurance coverage (0.16), and mental health support utilization (0.17) recorded comparatively low scores, suggesting limited engagement with formal healthcare and support systems among children.

For elderly respondents, inflation impact emerged as the most critical vulnerability indicator, recording the highest WMS value of 4.07, which falls within the high vulnerability category. This reflects the substantial economic pressure experienced by older adults due to rising prices and increased household expenditures during the pandemic. Resilience strategy effectiveness (3.66), support system effectiveness (3.33), and healthcare access frequency (3.19) recorded moderate to high scores, indicating the important role of family networks and social support mechanisms in mitigating pandemic impacts. Mental health (2.90) and wellbeing change (2.55) suggest moderate psychological and social impacts among elderly populations. However, health insurance access remained low (0.26), highlighting limited financial protection against health-related shocks.

The comparative results indicate that vulnerability was not uniform across respondent groups but manifested through different pathways. While children experienced predominantly educational and psychosocial vulnerabilities, elderly respondents were more strongly affected by economic stress and healthcare-related challenges. The available findings for slum dwellers further indicate that inflation represented a major source of economic vulnerability (WMS = 4.05), reflecting the fragile livelihood conditions that characterize informal urban settlements. Together, these results demonstrate the multidimensional nature of vulnerability and justify the need for group-specific policy interventions addressing both socio-economic and health-related risks (Table 14).

Table 14. Descriptive Statistics of Major Vulnerability Indicators by Respondent Group.

Vulnerability Indicator	Children (n=200)	Elderly (n=200)	Women (n=200)	Slum Dwellers (n=200)
Educational Disruption	3.54	—	—	—
Wellbeing Change	3.42	2.55	—	—
Resilience Strategy Effectiveness	3.21	3.66	—	—
Mental Health Rating	3.04	2.90	—	—
Social Skills/Social Isolation	3.02	0.54	—	—
Inflation Impact	2.90	4.07	—	4.05
Support System Effectiveness	—	3.33	—	—
Healthcare Access Frequency	1.63	3.19	—	—
Chronic Health Conditions	0.31	—	—	—
Mental Health Support Seeking	0.17	—	—	—
Health Insurance Access	0.16	0.26	—	—
Lost Job During Lockdown	—	0.31	—	—

Comparative Ranking of Vulnerability Indicators

Weighted Mean Score analysis was employed to determine the relative severity of vulnerability indicators among children and elderly respondents. The results reveal distinct vulnerability profiles

for the two groups.

Among children, educational disruption emerged as the most severe vulnerability indicator (WMS = 3.54), followed by wellbeing change (WMS = 3.42), resilience strategy effectiveness (WMS = 3.21), and mental health impacts (WMS = 3.04). The relatively high scores associated with educational disruption and psychological wellbeing indicate that school closures, restricted mobility, social isolation, and digital inequalities significantly affected children's development and quality of life during the pandemic.

In contrast, elderly respondents exhibited a predominantly economic and health-related vulnerability profile. Inflation impact recorded the highest WMS value (4.07), indicating severe financial stress associated with rising living costs and reduced purchasing power. Resilience strategies effectiveness (WMS = 3.66), support systems effectiveness (WMS = 3.33), and healthcare access (WMS = 3.19) were also highly ranked, demonstrating the importance of social support networks and healthcare services in mitigating vulnerability among older adults (Table 15).

Table 15. Weighted Mean Score Ranking of Major Vulnerability Indicators.

Rank	Children	WMS	Elderly	WMS
1	Educational Disruption	3.54	Inflation Impact	4.07
2	Wellbeing Change	3.42	Resilience Strategies	3.66
3	Resilience Strategies	3.21	Support Systems	3.33
4	Mental Health	3.04	Healthcare Access	3.19
5	Social Skills Impact	3.02	Mental Health	2.90
6	Inflation Impact	2.90	Wellbeing Change	2.55

The results indicate that educational and psychosocial vulnerabilities dominated among children, whereas economic stress and healthcare-related concerns were more prominent among elderly respondents. These findings highlight the heterogeneous nature of vulnerability and the need for population-specific interventions.

Statistical Assessment of Educational Vulnerability

Educational disruption represented the strongest socio-economic vulnerability identified in the study. Among children, 57.5% reported that their education was either significantly affected (26.0%) or extremely affected (31.5%) by the pandemic, while only 11.0% reported no educational impact.

The weighted mean score of 3.54 indicates a high level of educational disruption. ANOVA results revealed statistically significant variation in educational impacts ($F = 4.012$, $p = 0.020$), suggesting that educational experiences differed significantly across respondent characteristics. Although Chi-square analysis did not reveal a statistically significant association ($\chi^2 = 8.014$, $p = 0.784$), logistic regression analysis demonstrated a significant model fit ($R^2 = 0.040$), indicating that educational vulnerability was partially influenced by demographic factors, although substantial unexplained variability remained (Table 16).

Table 16. Statistical Summary of Educational Vulnerability.

Indicator	Value
Weighted Mean Score (WMS)	3.54
Children Significantly/Extremely Affected (%)	57.5
ANOVA (F)	4.012
p-value	0.020*
Chi-Square (χ^2)	8.014
Chi-Square p-value	0.784

Logistic Regression R ²	0.040
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Significant at $p < 0.05$.

The findings suggest that educational inequalities were substantially amplified during the pandemic, particularly among children from economically disadvantaged households and digitally constrained environments.

Mental Health and Psychological Vulnerability

Mental health emerged as one of the most significant health-related dimensions of vulnerability. Children recorded a WMS value of 3.04, while elderly respondents recorded a WMS value of 2.90, indicating moderate-to-high psychological impacts among both groups.

ANOVA results revealed highly significant variation in mental health outcomes among children ($F = 20.69$, $p < 0.001$) and elderly respondents ($F = 14.83$, $p < 0.001$), demonstrating that psychological wellbeing was strongly influenced by social and economic circumstances. However, logistic regression analysis did not reveal statistically significant gender differences in mental health outcomes ($p = 0.429$), suggesting that mental health impacts were widespread and not confined to a particular gender group (Table 7).

Table 17. Statistical Summary of Mental Health Vulnerability.

Indicator	Children	Elderly
WMS	3.04	2.90
ANOVA (F)	20.69	14.83
p-value	<0.001*	<0.001*
Logistic Regression (p-value)	0.429	0.429

Significant at $p < 0.05$.

The findings indicate that psychological distress constituted a major hidden burden of the pandemic and was closely linked to educational disruption, social isolation, economic uncertainty, and health concerns.

Healthcare Accessibility and Financial Protection

Healthcare access and financial protection emerged as critical determinants of health vulnerability. Among children, healthcare access recorded a relatively low WMS value of 1.63, indicating restricted utilization of healthcare services. In contrast, elderly respondents recorded a WMS value of 3.19, reflecting greater healthcare dependence and healthcare needs.

ANOVA results revealed significant variation in healthcare accessibility among children ($F = 12.93$, $p = 0.006$) and elderly respondents ($F = 11.50$, $p < 0.001$). Despite these differences, logistic regression analysis did not reveal significant gender effects on healthcare access ($p = 0.865$).

Health insurance coverage emerged as one of the weakest dimensions of resilience. Among children, 67.0% reported having no health insurance, while only 13.0% reported insurance coverage. The corresponding WMS value of 0.16 reflects extremely low financial protection against healthcare expenditures (Table 18).

Table 18. Statistical Summary of Healthcare Vulnerability.

Indicator	Children	Elderly
Healthcare Access (WMS)	1.63	3.19
ANOVA (F)	12.93	11.50
p-value	0.006*	<0.001*
Health Insurance Coverage (%)	13.0	26.0

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Health Insurance WMS	0.16	0.26
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Significant at $p < 0.05$.

These findings indicate that limited healthcare accessibility and inadequate financial protection substantially increased vulnerability during the pandemic.

Logistic Regression Analysis of Vulnerability Determinants

Ordinal and multinomial logistic regression models were employed to examine whether gender significantly influenced vulnerability outcomes. The results indicate that most vulnerability dimensions did not exhibit statistically significant gender differences.

Educational disruption demonstrated a statistically significant model fit ($F = 4.012$, $p = 0.020$) with a modest explanatory power ($R^2 = 0.040$). Similarly, health insurance access exhibited a significant gender effect (Wald $\chi^2 = 4.164$, $p = 0.041$; $R^2 = 0.028$). In contrast, mental health rating ($p = 0.429$), healthcare access ($p = 0.865$), inflation impact ($p = 0.248$), and resilience strategy effectiveness ($p = 0.648$) did not demonstrate statistically significant gender differences (Table 19).

Table 19. Logistic Regression Results for Major Vulnerability Indicators.

Dependent Variable	Test Statistic	p-value	R ²
Educational Disruption	$F = 4.012$	0.020*	0.040
Health Insurance Access	Wald $\chi^2 = 4.164$	0.041*	0.028
Mental Health Rating	Wald $\chi^2 = 0.625$	0.429	0.012
Healthcare Access	Wald $\chi^2 = 0.029$	0.865	0.006
Inflation Impact	Wald $\chi^2 = 1.337$	0.248	0.015
Resilience Strategies	Wald $\chi^2 = 0.208$	0.648	0.009

Significant at $p < 0.05$.

Overall, the composite analysis demonstrates that vulnerability during the COVID-19 pandemic was multidimensional and unevenly distributed across vulnerable populations. Educational disruption, inflation-induced economic stress, mental health deterioration, healthcare accessibility challenges, and inadequate insurance coverage emerged as the most significant determinants of vulnerability. The combined evidence from WMS rankings, ANOVA, Chi-square tests, and logistic regression models confirms that both socio-economic and health vulnerabilities were strongly interconnected and collectively shaped the experiences of vulnerable populations during the pandemic.

DISCUSSION

Socio-Economic Vulnerability and Urban Inequality

The findings demonstrate that the COVID-19 pandemic intensified pre-existing socio-economic inequalities among vulnerable populations in Delhi. Income insecurity, inflationary pressures, housing precarity, and educational disruption emerged as the dominant dimensions of vulnerability, confirming that the impacts of the pandemic extended far beyond immediate health concerns. The survey revealed that a substantial proportion of respondents belonged to low-income households, particularly among slum dwellers, children, and elderly populations. More than two-thirds (66.0%) of slum-dweller households reported monthly incomes below ₹10,000, indicating limited economic resilience during prolonged lockdowns and disruptions to economic activity.

The Weighted Mean Score analysis further highlights the magnitude of economic vulnerability. Inflation impact emerged as the most severe vulnerability indicator among elderly respondents (WMS

= 4.07) and among the highest-ranked indicators among slum dwellers (WMS = 4.05). ANOVA results demonstrated statistically significant variation in inflation-related impacts among elderly respondents ($F = 3.30$, $p = 0.008$) and slum dwellers ($F = 4.00$, $p = 0.002$), indicating that the economic consequences of the pandemic were unevenly distributed across vulnerable groups. These findings suggest that rising living costs substantially reduced household purchasing power and amplified pre-existing socio-economic disadvantages.

The concentration of vulnerability among households dependent on informal employment reflects the structural characteristics of Delhi's urban economy. Informal workers typically lack employment security, social protection, savings, and institutional support mechanisms, making them particularly susceptible to economic shocks. Similar patterns have been reported across developing countries, where lockdown measures disproportionately affected marginalized populations dependent on informal livelihoods. The findings therefore support broader arguments within urban vulnerability research that economic resilience is strongly conditioned by labour market structures and access to social protection systems.

Housing conditions further reinforced socio-economic vulnerability. Women exhibited particularly high levels of housing insecurity, with 22.0% reporting homelessness and 21.0% residing in shelters or institutional accommodation. All respondents classified as slum dwellers resided within informal settlements characterized by overcrowding and limited infrastructure. These findings indicate that vulnerability is not solely determined by income but is strongly influenced by residential environments, housing quality, and access to urban services. Consequently, the pandemic acted as a stress test for existing urban inequalities, exposing the unequal distribution of resources, opportunities, and resilience capacities across Delhi's urban landscape.

Educational Disruption and the Digital Divide

Educational disruption emerged as the most severe vulnerability dimension among children, recording the highest Weighted Mean Score in the entire study (WMS = 3.54). More than half of surveyed children (57.5%) reported that their education was significantly or extremely affected during the pandemic, indicating widespread interruptions to learning processes and educational continuity.

The statistical analysis further supports the significance of educational vulnerability. ANOVA results revealed statistically significant variation in educational impacts ($F = 4.012$, $p = 0.020$), suggesting that educational disruption was strongly associated with underlying socio-economic inequalities. Although the logistic regression model exhibited relatively low explanatory power ($R^2 = 0.040$), it nevertheless identified educational disruption as one of the few vulnerability dimensions significantly associated with demographic characteristics.

The findings highlight the importance of the digital divide as a critical mechanism through which educational inequalities were reproduced during the pandemic. Access to online learning depended heavily on household income, digital devices, internet connectivity, housing conditions, and parental support. Children residing in economically disadvantaged households therefore faced greater educational losses than those with better access to technological resources.

From a geographical perspective, educational vulnerability reflects broader inequalities in digital infrastructure and educational opportunities. Unequal access to technological resources across neighbourhoods contributed to differentiated educational experiences during the pandemic. Consequently, educational disruption may generate long-term implications for human capital formation, educational attainment, and social mobility among vulnerable populations.

Health Vulnerability and Unequal Access to Healthcare

The study reveals significant disparities in healthcare accessibility, health insurance coverage, and chronic disease management among vulnerable populations. Healthcare access emerged as a critical dimension of vulnerability, particularly among elderly respondents who recorded a relatively high

WMS score (3.19), reflecting greater healthcare needs and dependence on healthcare services.

ANOVA results demonstrated statistically significant variation in healthcare accessibility among children ($F = 12.93$, $p = 0.006$) and elderly respondents ($F = 11.50$, $p < 0.001$), indicating substantial differences in healthcare experiences across vulnerable groups. These findings suggest that healthcare access during the pandemic was shaped by multiple socio-economic factors, including income, mobility restrictions, healthcare infrastructure, and transportation availability.

Health insurance coverage emerged as one of the weakest dimensions of resilience within the study population. Among children, 67.0% reported having no health insurance coverage, while only 13.0% reported access to insurance. The extremely low WMS score for health insurance access (0.16) highlights the limited financial protection available to vulnerable households during a major public health emergency. Logistic regression analysis further revealed a statistically significant association between demographic characteristics and health insurance access (Wald $\chi^2 = 4.164$, $p = 0.041$), although the explanatory power remained modest ($R^2 = 0.028$).

These findings support vulnerability theory, which argues that exposure to hazards alone does not determine outcomes; rather, vulnerability is shaped by differential access to resources, services, and institutional support mechanisms. In the context of Delhi, healthcare accessibility and financial protection remain unevenly distributed, contributing to unequal health outcomes during crises.

Mental Health as a Hidden Dimension of Vulnerability

Mental health emerged as one of the most significant yet often overlooked dimensions of vulnerability during the COVID-19 pandemic. Children and elderly respondents both reported substantial psychological impacts associated with social isolation, uncertainty, educational disruption, economic stress, and concerns regarding personal health and safety. Mental health recorded relatively high WMS scores among children (3.04) and elderly respondents (2.90), indicating moderate-to-high levels of psychological distress.

The statistical evidence further reinforces the significance of mental health vulnerability. ANOVA results revealed highly significant variation in mental health outcomes among children ($F = 20.69$, $p < 0.001$) and elderly respondents ($F = 14.83$, $p < 0.001$). These results suggest that psychological wellbeing was strongly influenced by underlying socio-economic and demographic circumstances. However, logistic regression analysis did not identify statistically significant gender differences in mental health outcomes ($p = 0.429$), indicating that psychological impacts were experienced broadly across vulnerable populations.

The findings demonstrate that mental health outcomes were closely linked to socio-economic conditions. Households experiencing income insecurity, employment disruption, housing instability, and educational interruption frequently reported greater psychological stress and emotional strain. These results highlight the interconnected nature of socio-economic and health vulnerabilities and demonstrate that psychological wellbeing represents a critical component of resilience during crises.

Implications for Urban Resilience and Vulnerability Reduction

The findings collectively demonstrate that vulnerability during the COVID-19 pandemic was multidimensional, spatially differentiated, and socially uneven. Educational disruption, inflation-induced economic stress, healthcare accessibility challenges, inadequate insurance coverage, and mental health deterioration emerged as the most significant vulnerability dimensions. The statistical evidence derived from WMS analysis, ANOVA, and logistic regression models confirms that vulnerability was not randomly distributed but concentrated among populations characterized by socio-economic disadvantage and limited access to institutional support.

These findings have important implications for urban resilience planning in Delhi and other rapidly urbanizing metropolitan regions. Strengthening social protection systems, expanding healthcare accessibility, improving insurance coverage, reducing digital inequalities, and integrating mental

health services into disaster management frameworks are essential for enhancing resilience among vulnerable populations. Future public health preparedness strategies should therefore adopt a multidimensional vulnerability framework that recognizes the interconnected nature of socio-economic and health risks rather than treating them as separate policy domains.

CONCLUSION

This study examined the socio-economic and health dimensions of vulnerability among vulnerable populations in Delhi during the COVID-19 pandemic. Drawing upon primary survey data collected from 800 respondents comprising children, women, elderly individuals, and slum dwellers across eleven districts of Delhi, the study explored how existing social and economic inequalities influenced vulnerability during an unprecedented public health crisis. The findings demonstrate that vulnerability during pandemics is multidimensional and arises from the interaction of economic insecurity, housing precarity, educational disruption, healthcare accessibility, health protection mechanisms, and psychological wellbeing.

The results reveal that socio-economic vulnerability constituted one of the most significant consequences of the pandemic. Income insecurity, inflationary pressures, employment instability, inadequate housing conditions, and educational disruption collectively reduced the ability of households to cope with lockdown restrictions and economic uncertainty. The analysis showed that economically disadvantaged populations, particularly slum dwellers and elderly respondents, experienced the highest levels of financial stress. Inflation impact emerged as the most severe vulnerability indicator among elderly respondents (WMS = 4.07), while educational disruption recorded the highest vulnerability score among children (WMS = 3.54). More than half of surveyed children reported significant disruptions to their education, highlighting the long-term implications of unequal access to digital learning resources and educational infrastructure.

Health vulnerability represented a second major dimension of risk. Significant challenges were observed in relation to healthcare accessibility, health insurance coverage, chronic illness management, and mental health. Statistical analysis revealed significant variation in healthcare accessibility among children ($F = 12.93$, $p = 0.006$) and elderly respondents ($F = 11.50$, $p < 0.001$), indicating unequal access to health services during the pandemic. Health insurance coverage remained particularly limited, with only a small proportion of respondents reporting adequate financial protection against healthcare expenditures. Mental health emerged as a critical but often overlooked dimension of vulnerability, with children and elderly respondents recording relatively high levels of psychological distress. The significant ANOVA results for mental health among children ($F = 20.69$, $p < 0.001$) and elderly respondents ($F = 14.83$, $p < 0.001$) demonstrate the profound psychological consequences associated with social isolation, educational disruption, health concerns, and economic uncertainty.

The study contributes to the broader literature on vulnerability and urban resilience by providing empirical evidence that pandemic-related risks are unevenly distributed across social groups and are strongly shaped by underlying socio-economic and health inequalities. The findings reinforce vulnerability theory by demonstrating that exposure to a hazard alone does not determine outcomes; rather, vulnerability is mediated through access to resources, healthcare services, social support systems, and institutional protection mechanisms. The study further highlights the importance of adopting an integrated vulnerability framework that recognizes the interconnected nature of socio-economic and health risks.

From a policy perspective, the findings emphasize the need for targeted and inclusive interventions aimed at strengthening resilience among vulnerable populations. Expanding social protection programmes, improving healthcare accessibility, increasing health insurance coverage, reducing digital inequalities in education, and integrating mental health services into emergency response frameworks are essential measures for reducing vulnerability during future crises. Particular attention

should be directed toward children, elderly populations, slum residents, and low-income households, who experienced disproportionately higher levels of vulnerability throughout the pandemic.

Despite its contributions, the study has certain limitations. The analysis is based on cross-sectional survey data and therefore captures respondents' experiences at a particular point in time rather than long-term vulnerability trajectories. Additionally, although respondents were surveyed across eleven districts of Delhi, the study did not undertake detailed neighbourhood-level spatial analysis or geospatial modelling of vulnerability patterns. Future research may incorporate GIS, vulnerability mapping techniques, and longitudinal datasets to examine the spatial dynamics of socio-economic and health vulnerability in greater detail.

Overall, the study concludes that the COVID-19 pandemic exposed and intensified existing inequalities within Delhi's urban landscape. Economic insecurity, inadequate housing, limited healthcare accessibility, insufficient financial protection, and psychological distress collectively shaped the vulnerability experiences of marginalized populations. Building resilient cities therefore requires not only strengthening public health systems but also addressing the structural inequalities that underpin vulnerability. A multidimensional and equity-oriented approach to urban planning, social protection, and public health policy will be essential for enhancing resilience and ensuring more effective responses to future public health emergencies.

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