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Title Page

Functional Deficiencies and Chronic Diseases among Indian Older Adults: A Sex-Stratified Cross-Sectional Decomposition Analysis

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Functional Deficiencies and Chronic Diseases among the Indian Elderly: A Sex-Stratified Cross-Sectional Decomposition Analysis

Abstract

Objectives: The elderly bears the burden of morbidity disproportionately where poverty worsens the condition. Stratified by sex, this study decomposes income-related inequalities for functional deficiencies and chronic diseases among older adults, and identifies the degree to which social and demographic determinants contribute to these inequalities.

Design: A nationally representative cross-sectional study.

Participants: Data required for this study were retrieved from the World Health Organization (WHO) Study on Global AGEing and Adult Health (SAGE) Wave 1. A total sample of 3753 individuals (male: 1979; and female: 1774) aged 60 years and older were included.

Measures: Functional deficiency and presence of chronic diseases were analyzed.

Method: The method proposed by Adam Wagstaff and his colleagues was used to attain the study objective.

Results: Compared to males, females were disproportionately affected by both functional deficiencies and chronic diseases. Results from decomposition analysis indicate that the relative contribution of socio-demographic factors to functional deficiencies was highest among those with poor economic status (38.5%), followed by illiteracy (22.5%) which collated to 61 per cent to total explained inequalities. Similarly, for chronic diseases, about 93 per cent of the relative contribution was shared by those with poor economic status (42.3%), rural residence (30.5%) and illiteracy (20.3%).

Conclusion: Pro-poor intervention strategies should be designed to address functional deficiencies and chronic diseases, with special attention to women. While designing the intervention, the socioeconomic gradient of targeted population should be considered.

Keywords: functional deficiency, chronic diseases, gender, older adults, India

Strength and Limitations of this study

- This is the first study that examines the decomposes the socioeconomic inequality in functional deficiency and chronic illness separately for male and female older population.
- Findings revealed pro-poor inequality in Instrumental Activity of Daily Living (IADL) deficiency and pro-rich inequality in the presence of chronic health among both older men and women in India.
- Poor economic status, illiteracy and rural residence were major contributors to overall IADL deficiency among men. But in case of women, rural residence, belonging to Scheduled Castes/Scheduled Tribes and being Muslim contributed significantly to IADL deficiency.
- The findings further suggest that poor economic status, followed by rural residence and illiteracy contributed the highest in explaining overall inequality in chronic health among both men and women.
- The cross-sectional study design prevents establishment of any causal inferences from the study results.

Introduction

Globally, compared to males, older females experience lower mortality rates and in a few cases, lower prevalence of chronic diseases [1–4]. Contrary to this, functional limitation and physical disability among women was reported higher than that among men, particularly in low-and-middle income countries [5,6]. Existing evidence shows that the difference in male-female functional limitation could be explained in terms of higher prevalence and severity of arthritis and musculoskeletal disease [4,7] among women along with psychosocial factors – women are more likely to over-report ill health and functional limitations, whereas men would under-report their weaknesses [8]. This pattern may be more evident in low-and-middle income countries where gender norms significantly determine demographic, health and socioeconomic outcomes.

Examining disparities in socioeconomic status and its effect on health outcomes in less developing societies is high priority on global agenda. A study has shown that poor economic status contributes to over half of the inequality in self-rated health among older adults in India, followed by illiteracy and rural residence [9]. However, the distribution of socioeconomic resources between men and women is not the same, which gives rise to different explanations for the existing socioeconomic inequalities in health by gender. Of the total elderly population in India, nearly half of the Indian elderly, mostly women are dependents, often due to widowhood, divorce, or separation [10]. Majority of elderly women are deprived of economic security and prone to receiving poor healthcare [10]. If results for male and female participants are not studied separately, aggregate results may mask important clinical differences in the mechanism of functional deficiency and chronic diseases [11].

Stratified by sex, this study decomposes income-related inequalities for functional deficiencies and chronic diseases among older adults, and identifies the degree to which social

and demographic determinants contribute to these inequalities. It is hoped that this study will strengthen the evidence to prepare and design a rehabilitation programme to improve the functional capacity and management of chronic diseases among the elderly in India. The National Health Policy of India 2017 acknowledges the healthcare needs of the aging population in India and recommends a focused intervention (Ministy of Health & Family Welfare, 2017) to tackle the rising burden of functional deficiency and chronic diseases [13].

Methods

Study Population

Data required for this study were retrieved from the World Health Organization (WHO) Study on Global AGEing and Adult Health (SAGE) Wave 1, collected between 2007 and 2008 in India. SAGE is a nationally representative multi-country (China, Ghana, India, Mexico, Russian Federation, and South Africa) study to monitor the health and well-being of adult populations aged 50 years and older [14]. In India, respondents were selected from six states –Assam, Karnataka, Maharashtra, Rajasthan, Uttar Pradesh, and West Bengal, using a multistage, stratified, random sampling design with every individual having a known non-zero probability of being selected. Overall, the individual response rate was 92 per cent. More about sampling process and SAGE India survey can be obtained from the published official report [14,15]. This study followed the United Nation's agreed age cut-off for defining older population (60 years and older). A total sample3753 individuals (male: 1979; and female: 1774) aged 60 years and older were included.

Functional Deficiency and Chronic Disease

Two health outcome events - functional deficiency and presence of chronic diseases were analyzed. Functional deficiency was measured in terms of estimating Instrumental Activity of Daily Living (IADL). IADL measures the ability to perform relatively complex activities of daily living. IADL is composed of five items that cover higher level instrumental tasks including heavy or light household work, laundry, preparing meals, shopping for daily necessities, getting around outside, travelling, managing money and using a telephone [15]. The respondents were asked if they had any difficulty doing these instrumental tasks during the thirty days preceding the survey, and their responses were categorized into none, mild, moderate, severe, and extreme/cannot do. For this study, the responses were grouped into different difficulty levels -no difficulty (when the response was none or mild or moderate=0) and difficulty (when the response was severe or extreme=1). The computed value of the sum of dichotomized five variables ranges from 0 to 5, where the higher score indicates poor physical functioning. Besides IADL, respondents were asked if they were diagnosed with any of the following chronic medical conditions (as conveyed by a health care professional that they had the given health condition): angina, asthma, stroke, depression, chronic lung disease and hypertension. The affirmative response against any of these medical conditions was considered presence of chronic disease.

Covariates

Guided by the existing literature, individual and household level binary (1 and 0) covariates that could explain maximum dimensions of inequality were considered. The covariates are sex of the respondent (male, and female), current marital status (married, and unmarried), social group (Scheduled Caste/Scheduled Tribe, and Non-scheduled Caste/Tribe), religion (Muslim, and Others), education of the respondent (illiterate and literate), economic status (poor and non-poor), residence (rural and urban) and tobacco use (never, and ever or current). In dichotomous

covariates, the assigned value 1 represents the older population in a disadvantaged socioeconomic group, and the assigned value of 0 indicates the older population in an advantageous position.

Historically, Scheduled Castes and Scheduled Tribes are identified by the Government of India as socially and economically backward social groups and considered to be in need of protection from social injustice and exploitation, whereas non-Scheduled Caste/Tribes enjoy a higher status in the social group hierarchy. Economic groups (poor and non-poor) were derived from the household wealth index provided in the dataset, using WHO standard approach to estimating income from indicator variables [16]. For the decomposition analysis, the top two quintiles (representing 40% of economic status) were grouped as non-poor, and the bottom three quintiles (representing 60% of economic status) were combined as poor.

Analytical Approach

Stratified by sex, a decomposition analysis was conducted to measure the contribution of select covariates to explain the burden of IADL and presence of chronic diseases in several steps. First, the Concentration Index (CI) was estimated to quantify the degree of socioeconomic-related inequality in health variable [17], IADL and chronic diseases. It can be computed as twice the (weighted) covariance of the health variable and individual's relative rank in the economic gradient, divided by the variable mean according to Equation (1) [18]. The value of the CI ranges between -1 and +1, where negative values explain a variable that is concentrated among disadvantaged people and positive values indicate the opposite. In the absence of inequality, the CI will be zero [17].

$$C = \frac{2}{\mu}\mathrm{cov}_w(y_i, R_i) \qquad (1)$$

where y_i and R_i are, respectively, the health status of the i^{th} individual and the fractional rank of the i^{th} individual (for weighted data) in terms of the index of household economic status; μ is the (weighted) mean of the health of the sample and cov_w denotes the weighted covariance.

The method proposed by Wagstaff and colleagues (2003) [19] was used to decompose socioeconomic inequality in poor health into its determinants. This analysis allows estimating how determinants proportionally contribute to inequality in a health variable. They have showed that for any linear regression model, link the health variable of interest, *y*, to a set of *k* health determinants, x_k:

$$y_i = \alpha + \sum_{k=1} \beta_k x_{k_i} + \varepsilon_i \qquad (2)$$

Where ε is an error term. Given the relationship between y_i and x_{k_i} in Equation (2), the CI for y (C) can be written as:

$$C = \sum_{k=1} \left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k + \frac{GC_\varepsilon}{\mu} = C_{\hat{y}} + \frac{GC_\varepsilon}{\mu}, \quad (3)$$

Where μ is the mean of y, $\bar{x}_k$ is the mean of x_k, C_k is the CI for x_k (defined analogously to C). In the last term (which can be computed as a residual), GC_ε is the generalized concentration index for ε_i.

Equation (3) shows that C can be thought of as being made up of two components. The first is the deterministic, or 'explained', component. This is equal to a weighted sum of the concentration indices of the regressors, where the weights are simply the elasticities associated with a percentage change in the explanatory variable) $\left(\frac{\beta_k \bar{x}_k}{\mu}\right)$ of y with respect to each x_k.

(Elasticity is a unit-free measure of (partial) association that is the percentage change in the dependent variable IADL or presence of chronic illness) The second is a residual, or 'unexplained', component. This reflects the inequality in health that cannot be explained by systematic variation in the $\mathbf{x_k}$ across socioeconomic groups. To do a decomposition analysis, the following steps are required:

i. Regress the health variable against its determinants through an appropriate model. This results in finding the coefficients of the explanatory variables (β_k).

ii. Calculate the means of the health variable and each of its determinants (μand $\bar{x}_k$).

iii. Calculate the concentration indices for the health variable and for the determinants (C and $\mathbf{C}_k$) using Equation (1)—as well as the generalized CI of the error term ($\mathbf{GC}_\varepsilon$). The CI of each determinant can be calculated using the Equation (1) where y_i and μ are now the value of that determinant for the i^{th} individual and the determinant mean, respectively. At this stage, the values of all the variables included in Equation (3) are known.

iv. Finally, the pure contribution of each determinant included in the model to the inequality in the health variable can be quantified through the following steps:

(a) Calculate the absolute contribution of each determinant by multiplying the health variable elasticity with respect to that determinant and its CI $\left(\frac{\beta_k \bar{x}_k}{\mu}\right)\mathbf{C}_k$

(b) Calculate the *percentage* contribution of each determinant simply through dividing its absolute contribution by the CI of the health variable $\frac{\left(\frac{\beta_k \bar{x}_k}{\mu}\right)\mathbf{C}_k}{\mathbf{C}}$.

Moreover, since the inequality in predicted ill-health will be described given the observed values of the X variable, attention is focused on the first term in the decomposition equation - the predicted inequality as measured by $\mathbf{C}_{\hat{y}}$

$$C_{\hat{y}} = \sum_{k=1} \left(\frac{\beta_k \bar{x}_k}{\mu} \right) C_k \qquad (4)$$

Ethics statement

This study used the World Health Organization (WHO) Study on Global AGEing and Adult Health (SAGE) Wave 1 data available in the public domain, for use by researchers. Information on individual is available with all identifiers removed, thus no ethical clearance is required. Ethical clearance was obtained from local research review boards for each participating SAGE site, in addition to the WHO Ethical Review Committee. Informed consent was obtained from each respondent prior to enrolment.

Results

Table 1 presents the sample distribution of population aged 60 and above covered in SAGE survey. Nearly, three-fifth of the sample size belonged to the age group 60-69 years among both male and female. Over half of the women (54%) in the same were widowed as compared to just 11% among men. Every three out of four women in the sample did not attend any formal level of schooling, whereas the corresponding figure among men was 36%. Majority of older population resides in rural areas (70%). Tobacco use among men was 75% while it was 38% among women.

The decomposition analysis has been interpreted based on three components: mean, marginal effects and CIs. Negative CI for IADL (or functional deficiencies) indicates that inequality was concentrated among the poor, and positive CI for chronic diseases among the rich indicates the higher burden. Positive (negative) contributions of association can be interpreted by indicating that the total health inequality would be lower (higher) if that association had no

impact on the health outcome (instead of that reflected in marginal effects). The contributions are a mixture of positives and negatives and then sum to 100. The positive percentages were adjusted on *pro rata* basis, to offset the negative percentages as the positive percentages exaggerate the importance of the determinants. Each health outcome analysis was trailed by a gender based comparison to comprehend if there were any real contrasts among the contributions of various social-demographic constituents amongst men and women in their more established life towards income health inequality.

Results of the relative contribution of socio-demographic factors to functional deficiencies was highest among poor economic status (39 per cent), followed by illiteracy (23 per cent) which collated to 61 per cent of total explained inequalities **(Table 2)**. Findings show that nine selected covariates together explained 82 per cent of the total inequalities. Specific analysis in terms of sex highlights major contrasts, where the positive adjusted percentile contribution by poor economic status for male was 61.8 per cent, whereas it was negative for females and thus, adjusted on the pro-rata basis for other positive contribution factors. The highest percentile contribution in functional deficiencies among females was rural resident (50 per cent), which is substantially low at 5 per cent among males. The second point of comparison is illiteracy, which was 27 per cent for males and only 0.1 per cent among females.

In case of chronic health condition **(Table 3)**, about 93 per cent of the relative contribution of socio-demographic factors was together shared by three factors – poor economic status (42%), rural residence (31%) and illiteracy (20%). Sex wise comparison suggests that among both male and female, poor economic status (45% and 41%) contributed highest, followed by rural place of residence (31% and 27%) and illiteracy (18% and 22%) respectively. However, among females, the contribution of social groups (SCs/STs) was noticeable (9%).

Discussion

Although, health disparities by socioeconomic group have been firmly established with years of research, difference in functional ability and chronic health by sex remains inconclusive among older adults in low and middle-income countries. We believe that this is the first study on sex stratified decomposing socioeconomic inequality in functional deficiency and chronic illness among older adults in India.

The findings show pro-poor inequality in IADL (or functional) deficiency and pro-rich inequality in the presence of chronic health. Determinants such as poor economic status, illiteracy and rural residence were major contributors to overall IADL deficiency, and there is a similar pattern among men. However, in the case of women, rural residence, belonging to SCs/STs social groups and being Muslim contributed significantly to IADL deficiency. The findings further suggest that poor economic status, followed by rural residence and illiteracy contributed the highest in explaining overall inequality in chronic health. Available evidence from India and other low-and-middle income countries highlighted low economic status [20,21], poor education [22,23] and residential segregation [24–26], as key predictors of functional ability and presence of chronic health among older adults. But, hardly any study ever attempted to quantify the contribution of these factors.

About half of the inequality in functional deficiency and nearly 30 percent in case of chronic illness among women were contributed by place of residence. This could be explained in terms of excess engagement of women workforce participation in informal rural activities throughout their life as compared to urban women, coupled with widespread lower position of women. For instance, in rural areas, women contribute significantly as agricultural labourers and are involved in core household management tasks including livestock rearing, collection of firewood, fetching water etc. even in later life [27]. Their healthcare needs and nutritional

requirements during childhood and adulthood have largely been neglected, along with lack of economic security, mobility, and poor social interactions within community [28]. The high contribution of rural areas in both IADL and chronic illness could also be due to inadequate healthcare infrastructure, poor accessibility and sub-standard quality of care [29,30]. This situation put women at a disproportionate disadvantage compared to their urban counterparts with better civic infrastructure, improved health facilities and regular check-ups. Thus, the combined effect of heavy physical activities and widespread gender neglect in health and nutrition put rural women at a higher risk of functional limitations during later life as compared to their urban counterparts.

The combined influence of social group (SCs/STs) and religion (Muslim) contributes to over 30 per cent of the inequality in IADL disability among women. There were similar observations by other Indian studies among older population, where particular social groups were more disadvantaged in health and healthcare [31]. Complex interactions exist between gender, social groups (castes) and religion in India where substantial inequality is present by gender, access to education, economic status, and social groups [32]. The SC/ST and Muslim population, particularly women, are disadvantaged socioeconomically compared to other social groups. Historically, they are socially excluded, illiterate and mainly engage in informal sectors or as agricultural labourers [32]. Thus, there is the likelihood of reporting physical deficiency among women belonging to these social and religious groups. However, more research is required to establish this fact, at least in the case of Muslim women. Although, in recent years many affirmative initiatives have been launched to ensure better education, occupation and livelihood opportunities to those belonging to SCs/STs, especially women, it is too early to expect any major change in such a short period.

Economic status was found to be the major contributor in explaining inequality in both IADL and chronic illness among older adults. However, sex stratified analysis suggests that household economic status was a major factor in both IADL and chronic illness among males. But, in the case of women, household economic status and not IADL deficiency largely contributed to chronic illness. Earlier evidence supports these results and states that lack of economic support to older adults increases the likelihood of underutilization of healthcare services in case of any morbidity/illness [25]. Studies argue that when it comes to interaction between gender and wealth, Indian women are at a disadvantage due to the long history of patriarchal kinship and economic structure at the household level, which must have limited autonomy among women [33–35]. Studies have documented that women in South Asia are having restricted access to, and control over, resources within the household [32], have poor access to preventive and curative care as they are economically dependent on their husbands, or on the male heads of household [36] and are most vulnerable when healthcare has to be purchased out-of-pocket or through private insurance [37–39]. Resource-poor older individuals had lower use of healthcare despite their illness and this could be affecting women adversely considering the inadequate social protection plan, coupled with poor performance, specifically for the economically disadvantaged older people [40]. This was reflected in earlier studies too.

The strengths and limitations of the study need to be highlighted. The methodological strength of the present study included application of the concentration index. It is sensitive to changes in outcome distribution (IADL and chronic illness) of the population across socioeconomic groups. Another major strength of this study is the nationally representative sample of older population drawn from SAGE survey. SAGE is one of the prominent sources of data that provides a great amount health and related information pertaining to the older population in India. It has addressed major data gaps in terms of growing socioeconomic

inequalities in health in low and middle-income countries like India [14]. As far as the limitations are concerned, first, the findings based on regression-based decomposition models lack any causal interpretations between correlated and inequalities in health outcomes. Second, the study does not include any variables related to psychosocial factors and the health system. Third, the cross-sectional study design prevents establishment of any causal inferences from the study results.

Contributors: LS and RKR contributed in conceptualising the study.LS, lead and corresponding author, had full access to the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. RKR and PKS contributed to the interpretation of the data, and critically revised all versions of the manuscript and approved the final version.

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Data sharing statement: The data sets used and/or analysed during this study are available from the corresponding author on reasonable request.

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Table 1. SAGE India Sample Distribution for Population aged 60 and above (N=3753)

	Males (N=1979)		Females (N=1774)		Total	
Background Characteristics	***n***	***%***	***n***	***%***	***n***	***%***
Age of the respondent						
60-64	615	30.0	613	33.8	1,228	31.9
65-69	589	29.3	500	25.8	1,089	27.5
70-74	395	21.2	335	20.1	730	20.6
75-79	206	11.8	153	9.0	359	10.4
80+	174	7.6	173	11.1	347	9.4
Marital Status						
Unmarried	32	1.5	9	1.2	36	1.4
Married	1660	87.8	812	44.7	2,477	66.1
Widowed	287	10.5	953	54.0	1,240	32.5
Education of the Respondent						
No formal education	745	36.3	1320	75.6	2,149	56.2
Less than primary	317	12.9	159	9.6	446	11.2
Completed primary	341	19.5	161	8.9	494	14.2
Completed secondary	234	13.0	59	2.4	275	7.6
Completed HS	203	11.8	52	2.2	234	6.9
Completed college/university/post grad	139	6.3	23	1.1	155	3.7
Religion of the Respondent						
Hinduism	1603	83.7	1473	86.9	3,076	85.3
Islam	245	12.6	170	10.3	415	11.5
Others	63	3.6	60	2.7	123	3.2
Ethnicity of the Respondent						
Scheduled Tribe	114	5.4	73	4.5	187	5.0
Scheduled Caste	329	16.8	284	16.8	613	16.8
No Caste or Tribe	340	12.9	325	14.8	665	13.9
Others	1122	64.8	1013	63.9	2,135	64.3
Place of Residence						
Urban	472	29.6	501	30.4	973	30.1
Rural	1507	70.3	1273	69.5	2,780	69.9
Wealth Quintile						
Poorest	387	22.5	363	24.8	750	23.7
Poor	403	22.6	344	21.9	747	22.3
Middle	358	17.5	346	19.4	704	18.5
Higher	382	17.5	309	15.9	691	16.8
Highest	381	19.7	341	17.7	722	18.8
Tobacco Use						
No	523	24.7	1110	62.3	1,633	43.5
Former/Current	1387	75.2	592	37.6	1,979	56.5

Table 2: Gender Stratified Effects and Contribution of Predictor Variables based on Decomposition Analysis for IADL among Older Population aged 60 years and above, WHO-SAGE 2007-08

Covariates	Mean	Beta	CI	Contribution to CI	% Contribution	Adjusted % Contribution
			Total			
Poor	0.4142	0.1074	-0.5799	-0.0340	38.6483	38.5170
Tobacco	0.5479	0.0411	-0.0634	-0.0019	2.1393	2.1321
Illiterate	0.6796	0.1649	-0.1344	-0.0198	22.5606	22.4840
SC/ST	0.2222	0.0525	-0.2490	-0.0038	4.3492	4.3344
Muslim	0.1148	0.2793	-0.1268	-0.0054	6.0893	6.0686
Rural	0.7407	0.1564	-0.1090	-0.0166	18.9122	18.8480
Married	0.6539	-0.2226	0.0292	-0.0056	6.3588	6.3372
Older(70+)	0.3826	0.4741	0.0013	0.0003	-0.3409	
Female	0.4727	0.1719	-0.0105	-0.0011	1.2832	1.2788
IADL	**0.7598**		**-0.1076**	**-0.0879**	**100.0**	**100.0**
			Male			
Poor	0.4134	0.2522	-0.5780	-0.0949	62.9016	61.8327
Tobacco	0.7262	0.0000	-0.0548	0.0000	0.0003	
Illiterate	0.5406	0.2334	-0.2048	-0.0407	26.9793	26.5208
SC/ST	0.2325	-0.0295	-0.2413	0.0026	-1.7290	
Muslim	0.1282	0.1145	-0.1052	-0.0024	1.6120	1.5846
Rural	0.7615	0.0623	-0.1047	-0.0078	5.1789	5.0909
Married	0.8388	-0.2003	0.0130	-0.0034	2.2837	2.2449
Older(70+)	0.3916	0.4016	-0.0169	-0.0042	2.7732	2.7261
IADL	**0.6347**		**-0.1872**	**-0.1509**	**100.0**	**100.0**
			Female			
Poor	0.4151	-0.0566	-0.5820	0.0152	-45.3771	
Tobacco	0.3478	0.0699	-0.0941	-0.0025	7.5951	4.7415
Illiterate	0.8356	0.0010	-0.0803	-0.0001	0.2262	0.1412
SC/ST	0.2106	0.1452	-0.2592	-0.0088	26.3168	16.4289
Muslim	0.0998	0.5090	-0.1608	-0.0091	27.1160	16.9279
Rural	0.7176	0.2896	-0.1153	-0.0266	79.5168	49.6405
Married	0.4476	-0.2436	0.0536	-0.0065	19.4146	12.1201
Older(70+)	0.3726	0.5512	0.0217	0.0050	-14.8083	
IADL	**0.9001**		**-0.0420**	**-0.0335**	**100.0**	**100.0**

Table 3: Gender Stratified Effects and Contribution of Predictor Variables based on Decomposition Analysis for Presence of Chronic Disease of all the Older Population aged 60 years and above, WHO-SAGE 2007-08

Covariates	Mean	Beta	CI	Contribution to CI	% Contribution	Adjusted % Contribution
			Total			
Poor	0.4142	-0.1129	-0.5799	0.0629	42.6012	42.2482
Tobacco	0.5479	0.0153	-0.0634	-0.0012	-0.8357	
Illiterate	0.6796	-0.1427	-0.1344	0.0302	20.4715	20.3018
SC/ST	0.2222	-0.0705	-0.2490	0.0090	6.1249	6.0741
Muslim	0.1148	-0.0285	-0.1268	0.0010	0.6508	0.6454
Rural	0.7407	-0.2423	-0.1090	0.0454	30.7336	30.4789
Married	0.6539	0.0051	0.0292	0.0002	0.1524	0.1511
Older(70+)	0.3826	0.0908	0.0013	0.0001	0.0685	0.0679
Female	0.4727	-0.0042	-0.0105	0.0000	0.0328	0.0325
Presence of Chronic Disease	**0.4311**		**0.1509**	**0.1477**	**100.0**	**100.0**
			Male			
Poor	0.4134	-0.1187	-0.5780	0.0627	45.7501	45.0346
Tobacco	0.7262	-0.0056	-0.0548	0.0005	0.3567	0.3512
Illiterate	0.5406	-0.1041	-0.2048	0.0255	18.5924	18.3016
SC/ST	0.2325	-0.0337	-0.2413	0.0042	3.0454	2.9978
Muslim	0.1282	-0.0740	-0.1052	0.0022	1.6098	1.5846
Rural	0.7615	-0.2473	-0.1047	0.0436	31.7806	31.2836
Married	0.8388	0.0258	0.0130	0.0006	0.4537	0.4466
Older (70+)	0.3916	0.1489	-0.0169	-0.0022	-1.5887	
Presence of Chronic Disease	**0.4522**		**0.1400**	**0.1371**	**100.0**	**100.0**
			Female			
Poor	0.4151	-0.1145	-0.5820	0.0679	42.5976	41.1463
Tobacco	0.3478	0.0357	-0.0941	-0.0029	-1.7993	
Illiterate	0.1450	-0.2257	-0.0803	0.0372	23.3234	22.5288
SC/ST	0.2106	-0.1103	-0.2592	0.0148	9.2683	8.9525
Muslim	0.0998	0.0342	-0.1608	-0.0013	-0.8443	
Rural	0.7176	-0.2206	-0.1153	0.0448	28.0940	27.1369
Married	0.4476	-0.0239	0.0536	-0.0014	-0.8835	
Older (70+)	0.3726	0.0196	0.0217	0.0004	0.2437	0.2354
Presence of chronic disease	**0.4076**		**0.1635**	**0.1594**	**100.0**	**100.0**

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Title Page

Socioeconomic Inequality in Functional Deficiencies and Chronic Diseases among Older Indian Adults: A Sex-stratified Cross-sectional Decomposition Analysis

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Socioeconomic Inequality in Functional Deficiencies and Chronic Diseases among Older Indian Adults: A Sex-stratified Cross-sectional Decomposition Analysis

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Abstract

Objectives: The elderly with adverse socioeconomic conditions suffer disproportionately from poor quality of life. Stratified by sex, this study decomposes income-related inequalities for functional deficiencies and chronic diseases among older adults, and identifies the degree to which social and demographic factors contribute to these inequalities.

Design: Cross-sectional study.

Participants: Data used for this study were retrieved from the World Health Organization (WHO) Study on Global AGEing and Adult Health (SAGE) Wave 1. A total of 3753 individuals (male: 1979; and female: 1774) aged ≥60 years were found eligible for the analysis.

Measures: Functional deficiency and presence of chronic diseases.

Method: The decomposition method proposed by Adam Wagstaff and his colleagues was used. The method allows estimating how determinants of health proportionally contribute to inequality in a health variable.

Results: Compared to males, females were disproportionately affected by both functional deficiencies and chronic diseases. The relative contribution of socio-demographic factors to functional deficiencies was highest among those with poor economic status (38.5%), followed by those who were illiterate (22.5%), which collated to 61 percent to the total explained inequalities. Similarly, for chronic diseases, about 93 percent of the relative contribution was shared by those with poor economic status (42.3%), rural residence (30.5%) and illiteracy (20.3%).

Conclusion: Pro-poor intervention strategies could be designed to address functional deficiencies and chronic diseases, with special attention to women.

Keywords: functional deficiency, chronic diseases, gender, older adults, India

Strengths and Limitations of this Study

- This study, the first of its kind, examines the decomposition of socioeconomic inequality in functional deficiency and chronic illness separately for males and females, among the older population.
- The findings revealed pro-poor inequality in Instrumental Activity of Daily Living (IADL) deficiency and pro-rich inequality in the presence of chronic diseases among both older men and women in India.
- Poor economic status, illiteracy and rural residence were major contributors to overall IADL deficiency among men.
- The cross-sectional study design prevents establishment of any causal inferences from the study results.

Introduction

Globally, older females experience lower mortality rates and in a few cases, lower prevalence of chronic diseases as compared to their male counterparts [1–4]. Contrary to this, functional limitation and physical disability among women has been higher than that among men, particularly in low and middle income countries [5,6]. Existing evidence shows that the difference in male-female functional limitation could be explained in terms of higher prevalence and severity of arthritis and musculoskeletal disease [4,7] among women along with psychosocial factors – women are more likely to over-report ill health and functional limitations, whereas men would under-report their weaknesses [8]. This pattern may be more evident in low-and-middle income countries where gender norms significantly determine demographic, health and socioeconomic outcomes.

Examining disparities in socioeconomic status and their effect on health outcomes in developing societies is high on the list of priorities in the global agenda. A study has shown that poor economic status contributes to over half of the inequality in self-rated health among older adults in India, followed by illiteracy and rural residence [9]. However, the distribution of socioeconomic resources between men and women is not the same, which gives rise to different explanations for the existing socioeconomic inequalities in health by gender. Of the total elderly population in India, nearly half of the Indian elderly, mostly women are dependents, often due to widowhood, divorce, or separation [10]. The majority of elderly women are deprived of economic security and receive poor healthcare [10]. If results for male and female participants are not studied separately, aggregate results may mask imperative disparities in the mechanism of functional deficiency and chronic diseases [11].

Stratified by sex, this study decomposes income-related inequalities for functional deficiencies and chronic diseases among older adults, and identifies the degree to which social and demographic determinants contribute to these inequalities.

This study has the following objectives:

1. To examine the differences in functional deficiency and chronic diseases among older men and women separately

2. To estimate the relative contribution of socioeconomic and demographic factors to the overall functional deficiencies and chronic diseases, separately among men and women.

This study hopes to collate and analyze data to prepare and design programmes to improve the functional capacity and management of chronic diseases among the elderly in India. The National Health Policy (NHP) of India, 2017 acknowledges the healthcare needs of the aging population in India and recommends focused interventions [12] to tackle the rising burden of functional deficiency and chronic diseases [13].

Methods

Study Population

Data required for this study were retrieved from the World Health Organization (WHO) Study on Global AGEing and Adult Health (SAGE) Wave 1, collected between 2007 and 2010 in India. SAGE is a nationally representative multi-country (China, Ghana, India, Mexico, Russian Federation, and South Africa) study to monitor the health and well-being of adult populations aged 50 years and older [14]. In India, respondents were selected from six states – Assam, Karnataka, Maharashtra, Rajasthan, Uttar Pradesh, and West Bengal using a multistage, stratified, random sampling design with every individual having a known non-zero probability of being selected. Overall, the individual response rate was 92 percent. More about the sampling process and SAGE India survey can be obtained from the published official report [14,15]. This study followed the United Nation's agreed cut-off age for defining older population (60 years and older). A total sample of 3,753 individuals (male: 1979; and female: 1774) aged 60 years and older were included.

Functional Deficiency and Chronic Disease

Two health outcome events, functional deficiency and presence of chronic diseases, were analyzed. Functional deficiency was measured in terms of Instrumental Activity of Daily Living (IADL). IADL measures the ability to perform relatively complex activities of daily living [16]. Studies have identified a hierarchical structure within the disablement process model from health to disability, and concluded that the first level of disability includes persons with only mobility impairment [17]. The next level in the progression includes those with impairment in mobility

plus a limitation in an IADL. Finally, level three includes those with mobility, IADL, and basic difficulties in daily activities [17,18]. Although, IADL may not assess functional limitation in basic tasks such as sitting or standing for a long period, bathing, dressing and so on, it provides a basic understanding of the onset of functional difficulties among older adults [19]. In the WHO-SAGE survey, IADL is composed of five items that cover higher-level instrumental tasks [15]. The respondents were asked if they had any difficulty doing the following instrumental tasks during the thirty days preceding the survey:

1. …in taking care of your household responsibilities?
2. …in joining community activities (for example, festivities, religious or other activities) in the same way as anyone else can?
3. …in your day to day work
4. …in reaching your destination, using private or public transport if needed?
5. …in getting out of your home?

The responses were categorized into 'none', 'mild', 'moderate', 'severe', and 'extreme'/'cannot do'. For this study, the responses were grouped into different difficulty levels –

- No difficulty (when the response was none or mild or moderate=0)
- Difficulty (when the response was severe or extreme=1).

The computed value of the sum of dichotomized five variables ranges from 0 to 5, where the higher score indicates poor physical functioning.

Besides IADL, respondents were asked if they were diagnosed with any of the following chronic medical conditions (as conveyed by a health care professional that they had the given health condition): angina, asthma, stroke, depression, chronic lung disease and hypertension. An affirmative response regarding any of these medical conditions confirmed the presence of chronic disease.

Covariates

Guided by existing literature, individual and household level binary (1 or 0) covariates that could explain maximum dimensions of inequality were considered. The covariates are sex of the respondent (male or female), current marital status (married or unmarried), social group (Scheduled Caste/Scheduled Tribe or Non-scheduled Caste/Tribe), religion (Muslim or Others), education of the respondent (illiterate or literate), economic status (poor or non-poor), residence (rural or urban) and tobacco use (never, and ever or current). In dichotomous covariates, the assigned value, '1' represents the older population in a disadvantaged socioeconomic group, and the assigned value of '0' indicates the older population in an advantageous position.

The critical role of marital status for a woman in Indian society has been documented not only in terms of lower access to material resources, but also her own social position within-and-outside the family [20]. Studies from India [21] and elsewhere [22] show that both objective and subjective health measures along with healthcare use are substantially lower among older widowed women than among their married counterparts [23,24].

Previous literature suggests the protective effect of education on an individual's health, which operates in several ways. For instance, education may positively affect health through postponing the onset of functional limitations and chronic conditions [25], improve health through better management of illnesses, and enhance individual capability to cope with negative emotions [26]. Considering fewer resources, such as power, authority, earnings, household income, and wealth among women, the role of education appears to be vital in explaining women's health in low-and-middle income countries like India [27,28]. Among lifestyle factors physical inactivity, unhealthy diet, consumption of alcohol and use of tobacco have been found to be prominent risk factors for non-communicable diseases [29,30]. In India, smoking is higher among men and they smoke throughout their lives. Women smoke less than men but tend to become smokers at an older age [31,32].

Over 70 percent of the population lives in rural areas in India. Owing to variations in social experience, healthcare, pension policies, state provisions, rural and urban differences in health among older adults are critical. Moreover, with the increase of rural to urban migration among

the young population for better education, employment and living opportunities, the older population left behind in rural areas is at risk [33].

Historically, Scheduled Castes and Scheduled Tribes are identified by the Government of India as socially and economically backward social groups and considered to be in need of protection from social injustice and exploitation, whereas non-Scheduled Caste/Tribes enjoy a higher status in the social group hierarchy. Economic groups (poor or non-poor) were derived from the household wealth index provided in the dataset by using the WHO standard approach to estimate income from selected indicator variables [34]. For the decomposition analysis, the top two quintiles (representing 40% of economic status) were grouped as non-poor, and the bottom three quintiles (representing 60% of economic status) were combined as poor.

Analytical Approach

Stratified by sex, a decomposition analysis was conducted to measure the contribution of select covariates to explain the burden of IADL and presence of chronic diseases in several steps. First, the Concentration Index (CI) was estimated to quantify the degree of socioeconomic-related inequality in the health variable [35], IADL and chronic diseases. It can be computed as twice the (weighted) covariance of the health variable and individual's relative rank in the economic gradient, divided by the variable mean according to Equation (1) [36]. The value of the CI ranges between -1 and +1, where negative values explain a variable that is concentrated among disadvantaged people and positive values indicate the opposite. In the absence of inequality, the CI will be zero [35].

$$\mathbf{C} = \frac{2}{\mu}\mathbf{cov}_w(\mathbf{y}_i, \mathbf{R}_i) \qquad (1)$$

where $\mathbf{y}_i$ and $\mathbf{R}_i$ are, respectively, the health status of the i^{th} individual and the fractional rank of the i^{th} individual (for weighted data) in terms of the index of household economic status; μ is the (weighted) mean of the health of the sample and $\mathbf{cov}_w$ denotes the weighted covariance.

The method proposed by Wagstaff and colleagues (2003) [37] was used to decompose socioeconomic inequality in poor health into its determinants. This analysis allows estimating how determinants proportionally contribute to inequality in a health variable. They have showed

that for any linear regression model, link the health variable of interest, *y*, to a set of *k* health determinants, x_k:

$$y_i = \alpha + \sum_{k=1} \beta_k x_{k_i} + \varepsilon_i \qquad (2)$$

Where ε is an error term. Given the relationship between y_i and x_{k_i} in Equation (2), the CI for y (C) can be written as:

$$C = \sum_{k=1} \left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k + \frac{GC_\varepsilon}{\mu} = C_y + \frac{GC_\varepsilon}{\mu}, \quad (3)$$

Where μ is the mean of y, $\bar{x}_k$ is the mean of x_k, C_k is the CI for x_k (defined analogously to C). In the last term (which can be computed as a residual), GC_ε is the generalized concentration index for ε_i.

Equation (3) shows that C can be thought of as being made up of two components. The first is the deterministic, or 'explained', component. This is equal to a weighted sum of the concentration indices of the regressors, where the weights are simply the elasticities associated with a percentage change in the explanatory variable) $\left(\frac{\beta_k \bar{x}_k}{\mu}\right)$ of y with respect to each x_k. (Elasticity is a unit-free measure of (partial) association that is the percentage change in the dependent variable IADL or presence of chronic illness) The second is a residual, or 'unexplained', component. This reflects the inequality in health that cannot be explained by systematic variation in the x_k across socioeconomic groups. To do a decomposition analysis, the following steps are required:

i. Regress the health variable against its determinants through an appropriate model. This results in finding the coefficients of the explanatory variables (β_k).
ii. Calculate the means of the health variable and each of its determinants (μ and $\bar{x}_k$).
iii. Calculate the concentration indices for the health variable and for the determinants (C and C_k) using Equation (1)—as well as the generalized CI of the error term (GC_ε). The CI of each determinant can be calculated using the Equation (1) where y_i and μ are now the

value of that determinant for the i^{th} individual and the determinant mean, respectively. At this stage, the values of all the variables included in Equation (3) are known.

iv. Finally, the pure contribution of each determinant included in the model to the inequality in the health variable can be quantified through the following steps:

(a) Calculate the absolute contribution of each determinant by multiplying the health variable elasticity with respect to that determinant and its CI $\left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k$

(b) Calculate the *percentage* contribution of each determinant simply through dividing its absolute contribution by the CI of the health variable $\frac{\left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k}{C}$.

Moreover, since the inequality in predicted ill-health will be described given the observed values of the X variable, attention is focused on the first term in the decomposition equation - the predicted inequality as measured by $C_{\hat{y}}$

$$C_{\hat{y}} = \sum_{k=1} \left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k \qquad (4)$$

Ethics Statement

This study used the World Health Organization (WHO) Study on Global AGEing and Adult Health (SAGE) Wave 1 data available in the public domain for use by researchers, thus no ethical clearance is required for this study. Ethical clearance was obtained from local research review boards for each participating SAGE site, in addition to the WHO Ethical Review Committee. Informed consent was obtained from each respondent prior to enrolment.

Results

Table 1 presents the sample distribution of population aged 60 and above covered in SAGE survey. Nearly, three-fifth of the sample size belonged to the age group 60-69 years among both male and female. Over half of the women (54%) were widowed as compared to just 11 percent among men. Every three out of four women in the sample did not attend any formal level of schooling, whereas the corresponding figure among men was 36 percent. Majority of older population resides in rural areas (70%). Tobacco use among men was 75 percent, while it was 38 percent among women.

The decomposition analysis has been interpreted based on three components: mean, marginal effects and CIs. Negative CI for IADL (or functional deficiencies) indicates that inequality was concentrated among the poor, and positive CI for chronic diseases among the rich, which indicates a higher burden. Positive (negative) contributions of association can be interpreted by indicating that the total health inequality would be lower (higher) if that association had no impact on the health outcome (instead of that reflected in marginal effects). The contributions are a mixture of positives and negatives, and then sum up to 100. The positive percentages were adjusted on *pro rata* basis to offset the negative percentages, as the positive percentages exaggerate the importance of the determinants. Each health outcome analysis was trailed by a gender-based comparison to comprehend if there were any real contrasts among the contributions of various social-demographic constituents amongst men and women in their income health inequality.

Results of the relative contribution of sociodemographic factors to functional deficiencies were highest among those with a poor economic status (39 per cent), followed by those who were illiterate (23 per cent), which collated to 61 percent of total explained inequalities **(Table 2)**. Findings show that nine selected covariates together explained 82 percent of the total inequalities. Specific analysis in terms of sex highlights major contrasts, where the positive adjusted percentile contribution by poor economic status for males was 61.8 percent, whereas it was negative for females and thus, adjusted on the pro rata basis for the other positive contribution factors. The highest percentile contribution in functional deficiencies among females was rural resident (50 per cent), which was substantially low at 5 percent among males. The second point of comparison was illiteracy, which was 27 percent for males and only 0.1 percent for females. Among females, Muslims accounted for 17 percent of the total inequality in functional deficiency and SC/ST social groups, another 16 percent.

In case of chronic health condition **(Table 3)**, about 93 percent of the relative contribution of socio-demographic factors was shared by three factors – poor economic status (42%), rural residence (31%) and illiteracy (20%). Sex wise comparison suggests that among both male and female, poor economic status (45% and 41%) contributed the highest, followed by rural place of residence (31% and 27%) and illiteracy (18% and 22%) respectively. However, among females, the contribution of social groups (SCs/STs) was noticeable (9%).

Discussion and Conclusion

Although, health disparities by socioeconomic group have been firmly established with years of research, difference in functional ability and chronic health by sex remains inconclusive among older adults in low and middle-income countries. We believe that this is the first study on sex stratified decomposing socioeconomic inequality in functional deficiency and chronic illness among older adults in India.

The findings show pro-poor inequality in IADL (or functional) deficiency and pro-rich inequality in the presence of chronic illness among older adults sample. Determinants such as poor economic status, illiteracy and rural residence were major contributors to overall IADL deficiency, and there is a similar pattern among men. However, in the case of women, rural residence, belonging to SCs/STs social groups, and being Muslim contributed significantly to IADL deficiency. The findings further suggest that poor economic status, followed by rural residence and illiteracy contributed the highest in explaining overall inequality in chronic health. Available evidence from India and other low and middle income countries highlighted low economic status [27,38], poor education [39,40] and residential segregation [41–43], as key predictors of functional ability and presence of chronic health among older adults. But, hardly any study ever attempted to quantify the contribution of these factors.

Place of residence contributed to about 50 percent of the inequality in functional deficiency and nearly 30 percent in case of chronic illness among women. This could perhaps be attributed to excess engagement of women workforce participation in informal rural activities throughout their life as compared to urban women. For instance, in rural areas, women contribute significantly as agricultural labourers and are involved in core household management tasks including livestock rearing, collection of firewood and fetching water even in later life [44]. Their healthcare needs and nutritional requirements during childhood and adulthood have largely been neglected, along with lack of economic security, mobility, and poor social interactions within community [45]. The high contribution of rural areas in both IADL and chronic illness could be due to inadequate healthcare infrastructure, poor accessibility and sub-standard quality of care [46,47]. This situation put women at a disproportionate disadvantage compared to their urban counterparts with better civic infrastructure, improved health facilities and regular check-

ups. Thus, the combined effect of heavy physical activities and widespread gender neglect in health and nutrition put rural women at a higher risk of functional limitations during later life as compared to their urban counterparts.

The combined influence of social group (SCs/STs) and religion (Muslim) contributes to over 30 percent of the inequality in IADL disability among women. There were similar observations by other Indian studies among older population, where particular social groups were more disadvantaged in health and healthcare [48]. Complex interactions exist between social groups (castes) and religion in India where substantial inequality is present by gender, access to education, economic status, and social groups [49]. The SC/ST and Muslim population, particularly women, are disadvantaged socioeconomically compared to other social groups. Historically, they are socially excluded, illiterate and mainly engage in the informal sectors or as agricultural labourers [49]. Thus, there is the likelihood of reporting physical deficiency among women belonging to these social and religious groups. However, more research is required to establish this fact, at least in the case of Muslim women. Although, in recent years many affirmative initiatives have been launched to ensure better education, occupation and livelihood opportunities to those belonging to SCs/STs, especially women, it is too early to expect any major change.

Economic status was found to be the major contributor in explaining inequality in both IADL and chronic illness among older adults. However, sex stratified analysis suggests that household economic status was a major factor in both IADL and chronic illness among males. But, in the case of women, household economic status and not IADL deficiency contributed to chronic illness. Earlier evidence supports these results and states that lack of economic support to older adults increases the likelihood of underutilization of healthcare services in case of any morbidity/illness [42]. Studies argue that when it comes to interaction between gender and wealth, Indian women are at a disadvantage due to the long history of patriarchal kinship and economic structure at the household level, which must have limited autonomy among women [50–52]. Studies have documented that women in South Asia have restricted access to, and control over, resources within the household [49], poor access to preventive and curative care as they are economically dependent on their husbands or on the male heads of household [53] and are most vulnerable when healthcare has to be purchased out-of-pocket or through private

insurance [54–56]. Resource-poor older individuals had lower use of healthcare despite their illness and this could be affecting women adversely considering the inadequate social protection plan, coupled with poor performance, specifically for the economically disadvantaged older people [57]. This was reflected in earlier studies too.

Strengths and Limitations

The strengths and limitations of the study need to be highlighted. The methodological strength of the present study includes application of the concentration index. It is sensitive to changes in outcome distribution (IADL and chronic illness) of the population across socioeconomic groups. Also, the application of decomposition analysis [37] to examine the contribution of socioeconomic factors to the overall health inequality between the poor and the rich strengthens the findings of this study. Another major strength of this study is the nationally representative sample of older population drawn from the SAGE survey. SAGE is one of the prominent sources of data that provides a great amount of health and related information pertaining to the older population in India. It has addressed major data gaps in terms of growing socioeconomic inequalities in health in low and middle income countries like India [14]. The study has used diagnosed chronic morbidity rather than reported to reduce any bias in the responses.

As far as the limitations are concerned, first, the findings based on regression-based decomposition models lack any causal interpretations. Second, the study does not include any variables related to psychosocial factors and the health system, which might explain both functional limitations and chronic illness among older adults. Third, the cross-sectional study design prevents establishment of any causal inferences from the study results. Finally, health measures could have been affected by the type and composition of individual's social network [33], has not been considered in this analysis.

Contributors: LS and PKS contributed in conceptualising the study. LS and RG had full access to the data and take responsibility for the integrity of the data and the accuracy of the data analysis. RKR and PKS contributed to the interpretation of the data, and critically revised all versions of the manuscript. LS, RG, RKR and PKS approved the final version of the manuscript.

Competing interests: None declared.

Patient and Public Involvement: This study is a part of the large-scale multi country survey conducted by World Health Organization (WHO). The data is available in public domain for the use of researchers upon request (http://www.who.int/healthinfo/sage/en/). The WHO-SAGE survey participants in all selected countries were informed about the survey, design, purpose, and how it would benefit to the society at large. The survey was conducted under the supervision of respective national governments. The study protocol does not include disseminating the results to individuals study participants.

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Data sharing statement: The data sets used and/or analysed during this study are available from the corresponding author on reasonable request.

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Table 1. Sample Distribution for Population aged 60 and above, WHO-SAGE, India

	Males		Females		Total	
Background Characteristics	***n***	***%***	***n***	***%***	***n***	***%***
Age of the Respondent						
60-64	615	30.0	613	33.8	1,228	31.9
65-69	589	29.3	500	25.8	1,089	27.5
70-74	395	21.2	335	20.1	730	20.6
75-79	206	11.8	153	9.0	359	10.4
80+	174	7.6	173	11.1	347	9.4
Marital Status						
Unmarried	32	1.5	9	1.2	36	1.4
Married	1660	87.8	812	44.7	2,477	66.1
Widowed	287	10.5	953	54.0	1,240	32.5
Education of the Respondent						
No formal education	745	36.3	1320	75.6	2,149	56.2
Less than primary	317	12.9	159	9.6	446	11.2
Completed primary	341	19.5	161	8.9	494	14.2
Completed secondary	234	13.0	59	2.4	275	7.6
Completed HS	203	11.8	52	2.2	234	6.9
Completed college/university/post grad	139	6.3	23	1.1	155	3.7
Religion of the Respondent						
Hinduism	1603	83.7	1473	86.9	3,076	85.3
Islam	245	12.6	170	10.3	415	11.5
Others	63	3.6	60	2.7	123	3.2
Ethnicity of the Respondent						
Scheduled Tribe	114	5.4	73	4.5	187	5.0
Scheduled Caste	329	16.8	284	16.8	613	16.8
No Caste or Tribe	340	12.9	325	14.8	665	13.9
Others	1122	64.8	1013	63.9	2,135	64.3
Place of Residence						
Urban	472	29.6	501	30.4	973	30.1
Rural	1507	70.3	1273	69.5	2,780	69.9
Wealth Quintile						
Poorest	387	22.5	363	24.8	750	23.7
Poor	403	22.6	344	21.9	747	22.3
Middle	358	17.5	346	19.4	704	18.5
Higher	382	17.5	309	15.9	691	16.8
Highest	381	19.7	341	17.7	722	18.8
Tobacco Use						
No	523	24.7	1110	62.3	1,633	43.5
Former/Current	1387	75.2	592	37.6	1,979	56.5
Total	**1979**		**1774**		**3753**	

Table 2: Gender Stratified Effects and Contribution of Predictor Variables based on Decomposition Analysis for IADL among Older Population aged 60 years and above, WHO-SAGE 2007-08

Covariates	Mean	Beta	CI	Contribution to CI	% Contribution	Adjusted % Contribution
			Total			
Poor	0.414	0.107^	-0.580	-0.034	38.648	38.517
Tobacco use	0.548	0.041	-0.063	-0.002	2.139	2.132
Illiterate	0.680	0.165#	-0.134	-0.020	22.561	22.484
SC/ST	0.222	0.053	-0.249	-0.004	4.349	4.334
Muslim	0.115	0.279#	-0.127	-0.005	6.089	6.069
Rural	0.741	0.156#	-0.109	-0.017	18.912	18.848
Married	0.654	-0.223#	0.029	-0.006	6.359	6.337
Older (70+)	0.383	0.474#	0.001	0.001	-0.341	
Female	0.473	0.172#	-0.011	-0.001	1.283	1.279
IADL	**0.760**		**-0.108**	**-0.0879**	**100.0**	**100.0**
			Male			
Poor	0.413	0.252#	-0.578	-0.095	62.902	61.833
Tobacco use	0.726	0.000	-0.055	0.000	0.000	
Illiterate	0.541	0.233#	-0.205	-0.041	26.979	26.521
SC/ST	0.233	-0.030	-0.241	0.003	-1.729	
Muslim	0.128	0.115	-0.105	-0.002	1.612	1.585
Rural	0.762	0.062	-0.105	-0.008	5.179	5.091
Married	0.839	-0.200#	0.013	-0.003	2.284	2.245
Older (70+)	0.392	0.402#	-0.017	-0.004	2.773	2.726
IADL	**0.635**		**-0.187**	**-0.151**	**100.0**	**100.0**
			Female			
Poor	0.415	-0.057	-0.582	0.015	-45.377	
Tobacco use	0.348	0.070	-0.094	-0.003	7.595	4.742
Illiterate	0.836	0.001	-0.080	-0.000	0.226	0.141
SC/ST	0.211	0.145*	-0.259	-0.009	26.317	16.429
Muslim	0.100	0.509#	-0.161	-0.009	27.116	16.928
Rural	0.717	0.290#	-0.115	-0.027	79.517	49.641
Married	0.448	-0.244#	0.054	-0.007	19.415	12.120
Older (70+)	0.373	0.551#	0.022	0.005	-14.808	
IADL	**0.900**		**-0.042**	**-0.034**	**100.0**	**100.0**

Note: Significant levels - <0.01 = #; <0.05 = ^; <0.10 = *

Table 3: Gender Stratified Effects and Contribution of Predictor Variables based on Decomposition Analysis for Presence of Chronic Disease of all the Older Population aged 60 years and above, WHO-SAGE 2007-08

Covariates	Mean	Beta	CI	Contribution to CI	% Contribution	Adjusted % Contribution
			Total			
Poor	0.414	-0.113#	-0.580	0.063	42.601	42.248
Tobacco	0.548	0.015	-0.063	-0.001	-0.836	
Illiterate	0.680	-0.143#	-0.134	0.030	20.472	20.302
SC/ST	0.222	-0.071^	-0.249	0.009	6.125	6.074
Muslim	0.115	-0.029	-0.127	0.001	0.651	0.645
Rural	0.741	-0.242#	-0.109	0.045	30.734	30.479
Married	0.654	0.005	0.029	0.000	0.152	0.151
Older(70+)	0.383	0.091#	0.001	0.000	0.069	0.068
Female	0.473	-0.004	-0.011	0.000	0.033	0.033
Chronic Disease	**0.431**		**0.151**	**0.148**	**100.0**	**100.0**
			Male			
Poor	0.413	-0.119#	-0.578	0.063	45.750	45.035
Tobacco	0.726	-0.006	-0.055	0.000	0.357	0.351
Illiterate	0.541	-0.104#	-0.205	0.026	18.592	18.302
SC/ST	0.233	-0.034	-0.241	0.004	3.045	2.998
Muslim	0.128	-0.074	-0.105	0.002	1.610	1.585
Rural	0.762	-0.247#	-0.105	0.044	31.781	31.284
Married	0.839	0.026	0.013	0.001	0.454	0.447
Older (70+)	0.392	0.149#	-0.017	-0.002	-1.589	
Chronic Disease	**0.452**		**0.140**	**0.137**	**100.0**	**100.0**
			Female			
Poor	0.415	-0.115#	-0.582	0.068	42.598	41.146
Tobacco	0.348	0.036	-0.094	-0.003	-1.799	
Illiterate	0.145	-0.226#	-0.080	0.037	23.323	22.529
SC/ST	0.211	-0.110^	-0.259	0.015	9.268	8.953
Muslim	0.100	0.034	-0.161	-0.001	-0.844	
Rural	0.718	-0.221#	-0.115	0.045	28.094	27.137
Married	0.448	-0.024	0.054	-0.001	-0.884	
Older (70+)	0.373	0.020	0.022	0.000	0.244	0.235
Chronic disease	**0.408**		**0.164**	**0.159**	**100.0**	**100.0**

Note: Significant levels - <0.01 = #; <0.05 = ^; <0.10 = *

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Title Page

Socioeconomic Inequality in Functional Deficiencies and Chronic Diseases among Older Indian Adults: A Sex-stratified Cross-sectional Decomposition Analysis

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Abstract

Objectives: Older adults with adverse socioeconomic conditions suffer disproportionately from a poor quality of life. Stratified by sex, income-related inequalities have been decomposed for functional deficiencies and chronic diseases among older adults, and the degree to which social and demographic factors contribute to these inequalities were identified in this study.

Design: Cross-sectional study.

Participants: Data used for this study were retrieved from the World Health Organization (WHO) Study on Global AGEing and Adult Health (SAGE) Wave 1. A total of 3753 individuals (male: 1979; and female: 1774) aged ≥60 years were found eligible for the analysis.

Measures: Instrumental Activity of Daily Living (IADL) deficiency and presence of chronic diseases.

Method: The decomposition method proposed by Adam Wagstaff and his colleagues was used. The method allows estimating how determinants of health contribute proportionally to inequality in a health variable.

Results: Compared to males, females were disproportionately affected by both functional deficiencies and chronic diseases. The relative contribution of socio-demographic factors to IADL deficiency was highest among those with poor economic status (38.5%), followed by those who were illiterate (22.5%), which collated to 61 percent of the total explained inequalities. Similarly, for chronic diseases, about 93 percent of the relative contribution was shared by those with poor economic status (42.3%), rural residence (30.5%) and illiteracy (20.3%). Significant difference in predictors was evident between men and women in IADL deficiency and chronic illness.

Conclusion: Pro-poor intervention strategies could be designed to address functional deficiencies and chronic diseases, with special attention to women.

Keywords: functional deficiency, chronic diseases, gender, older adults, India

Strengths and Limitations of this Study

- This study, the first of its kind, examines the decomposition of socioeconomic inequality in functional deficiency and chronic illness separately for older males and females.
- The findings revealed pro-poor inequality in Instrumental Activity of Daily Living (IADL) deficiency and pro-rich inequality in the occurrence of chronic diseases among both older men and women in India.
- While being poor and illiterate contributed highest to the IADL deficiency among men, rural residence followed by social group and religion contributed most among women.
- Being poor, lives in rural areas and illiterate contributed significantly to the chronic illness among men, whereas among women it was poor economic status, rural residence and illiteracy.
- The cross-sectional study design prevents establishment of any causal inferences from the study results.

Introduction

Globally, older females experience lower mortality rates and in a few cases, lower prevalence of chronic diseases as compared to their male counterparts [1–4]. Contrary to this, functional limitation and physical disability among women has been higher than that among men, particularly in low and middle income countries [5,6]. Existing evidence shows that the difference in male-female functional limitation could be explained in terms of higher prevalence and severity of arthritis and musculoskeletal disease [4,7] among women along with psychosocial factors – women are more likely to over-report ill health and functional limitations, whereas men would under-report their weaknesses [8]. This pattern may be more evident in low-and-middle income countries where gender norms significantly determine demographic, health and socioeconomic outcomes.

Examining disparities in socioeconomic status and their effect on health outcomes in developing societies is high on the list of priorities in the global agenda. A study has shown that poor economic status contributes to over half of the inequality in self-rated health among older adults in India, followed by illiteracy and rural residence [9]. However, the distribution of socioeconomic resources between men and women is not the same, which gives rise to different explanations for the existing socioeconomic inequalities in health by gender. Of the total older adult population in India, nearly half of them, mostly women are dependants, often due to widowhood, divorce, or separation [10]. Majority of older adult women are deprived of economic security and receive poor healthcare [10]. If results for male and female participants are not studied separately, aggregate results may mask imperative disparities in the mechanism of functional deficiency and chronic diseases [11].

Stratified by sex, income-related inequalities for functional deficiencies and chronic diseases among older adults are decomposed, and the degree to which social and demographic determinants contribute to these inequalities is identified.

This study has the following objectives:

1. To examine the differences in functional deficiency and chronic diseases among older men and women separately

2. To estimate the relative contribution of socioeconomic and demographic factors to the overall functional deficiencies and chronic diseases, separately among men and women.

This study hopes to collate and analyse data to prepare and design programmes to improve the functional capacity and management of chronic diseases among the older adults in India. The National Health Policy (NHP) of India, 2017 acknowledges the healthcare needs of the aging population in India and recommends focused interventions [12] to tackle the rising burden of functional deficiency and chronic diseases [13].

Methods

Study Population

Data required for this study were retrieved from the World Health Organization (WHO) Study on Global AGEing and Adult Health (SAGE) Wave 1, collected between 2007 and 2010 in India. SAGE is a nationally representative multi-country (China, Ghana, India, Mexico, Russian Federation, and South Africa) study to monitor the health and well-being of adult population aged 50 years and older [14]. In India, respondents were selected from six states – Assam, Karnataka, Maharashtra, Rajasthan, Uttar Pradesh, and West Bengal using a multistage, stratified, random sampling design with every individual having a known non-zero probability of being selected. Overall, the individual response rate was 92 percent. More about the sampling process and SAGE India survey can be obtained from the official report [14,15]. This study followed the United Nation's agreed cut-off age for defining older population (60 years and older). A total 3,753 individuals (male: 1979; and female: 1774) aged 60 years and older were included in this study.

Functional Deficiency and Chronic Disease

Two health outcome events, functional deficiency and presence of chronic diseases, were analyzed. Functional deficiency was measured in terms of Instrumental Activity of Daily Living (IADL). IADL measures the ability to perform relatively complex activities of daily living [16]. Studies have identified a hierarchical structure within the disablement process model from health to disability, and concluded that the first level of disability includes persons with only mobility impairment [17]. The next level in the progression includes those with impairment in mobility

plus a limitation in an IADL. Finally, level three includes those with mobility, IADL, and basic difficulties in daily activities [17,18]. Although, IADL may not assess functional limitation in basic tasks such as sitting or standing for a long period, bathing, dressing and so on, it provides a basic understanding of the onset of functional difficulties among older adults [19]. This study follows the WHO-SAGE definition of IADL. In the WHO-SAGE survey, IADL is composed of five items that cover higher-level instrumental tasks [15]. The respondents were asked if they had any difficulty doing the following instrumental tasks during the thirty days preceding the survey:

1. …in taking care of your household responsibilities?
2. …in joining community activities (for example, festivities, religious or other activities) in the same way as anyone else can?
3. …in your day to day work
4. …in reaching your destination, using private or public transport if needed?
5. …in getting out of your home?

The responses were categorized into 'none', 'mild', 'moderate', 'severe', and 'extreme'/'cannot do'. For this study, the responses were grouped into different difficulty levels –

- No difficulty (when the response was none or mild or moderate=0)
- Difficulty (when the response was severe or extreme=1).

The computed value of the sum of dichotomized five variables ranges from 0 to 5, where the higher score indicates poor physical functioning.

Besides IADL, respondents were asked if they were diagnosed with any of the following chronic medical conditions (as conveyed by a health care professional): angina, asthma, stroke, depression, chronic lung disease and hypertension. An affirmative response regarding any of these medical conditions confirmed the presence of chronic disease.

Covariates

Guided by existing literature, individual and household level binary (1 or 0) covariates that could explain maximum dimensions of inequality were considered. The covariates are sex of the respondent (male or female), current marital status (married or unmarried), social group (Scheduled Caste/Scheduled Tribe or Non-scheduled Caste/Tribe), religion (Muslim or Others), education of the respondent (illiterate or literate), economic status (poor or non-poor), residence (rural or urban) and tobacco use (never, and ever or current). In dichotomous covariates, the assigned value, '1' represents the older population in a disadvantaged socioeconomic group, and the assigned value of '0' indicates the older population in an advantageous position.

The critical role of marital status for a woman in Indian society has been documented in terms of lower access to material resources, and her own social position within and outside the family [20]. Studies from India [21] and elsewhere [22] show that both objective and subjective health measures along with healthcare use are substantially lower among older widowed women than among their married counterparts [23,24].

Earlier literature suggests the protective effect of education on an individual's health, which operates in several ways. For instance, education may positively affect health through postponing the onset of functional limitations and chronic conditions [25], improve health through better management of illnesses, and enhance individual capability to cope with negative emotions [26]. Considering fewer resources, such as power, authority, earnings, household income, and wealth among women, the role of education appears to be vital in explaining women's health in low-and-middle income countries like India [27,28]. Among lifestyle factors physical inactivity, unhealthy diet, consumption of alcohol and use of tobacco have been found to be prominent risk factors for non-communicable diseases [29,30]. In India, smoking is higher among men and they smoke throughout their lives. Women smoke less than men but tend to become smokers at an older age [31,32].

Over 70 percent of the population lives in rural areas in India. Owing to variations in social experience, healthcare, pension policies, state provisions, rural and urban differences in health among older adults are critical. Moreover, with the increase of rural to urban migration among

the young population for better education, employment and living opportunities, the older population left behind in rural areas is at risk [33].

Historically, Scheduled Castes and Scheduled Tribes are identified by the Government of India as socially and economically backward social groups and considered to be in need of protection from social injustice and exploitation, whereas non-Scheduled Caste/Tribes enjoy a higher status in the social hierarchy. Economic groups (poor or non-poor) were derived from the household wealth index provided in the dataset by using the WHO standard approach to estimate income from selected indicator variables [34]. For the decomposition analysis, the top two quintiles (representing 40% of economic status) were grouped as non-poor, and the bottom three quintiles (representing 60% of economic status) were combined as poor.

Analytical Approach

Stratified by sex, a decomposition analysis was conducted to measure the contribution of select covariates to explain the burden of IADL and presence of chronic diseases in several steps. First, the Concentration Index (CI) was estimated to quantify the degree of socioeconomic-related inequality in the health variable [35], IADL and chronic diseases. It can be computed as twice the (weighted) covariance of the health variable and individual's relative rank in the economic gradient, divided by the variable mean according to Equation (1) [36]. The value of the CI ranges between -1 and +1, where negative values explain a variable that is concentrated among disadvantaged people and positive values indicate the opposite. In the absence of inequality, the CI will be zero [35].

$$C = \frac{2}{\mu}\mathrm{cov}_w(y_i, R_i) \qquad (1)$$

where y_i and R_i are, respectively, the health status of the i^{th} individual and the fractional rank of the i^{th} individual (for weighted data) in terms of the index of household economic status; μ is the (weighted) mean of the health of the sample and cov_w denotes the weighted covariance.

The method proposed by Wagstaff and colleagues (2003) [37] was used to decompose socioeconomic inequality in poor health into its determinants. This analysis allows estimating how determinants contribute proportionally to inequality in a health variable. They have showed

that for any linear regression model, link the health variable of interest, *y*, to a set of *k* health determinants, x_k:

$$y_i = \alpha + \sum_{k=1} \beta_k x_{k_i} + \varepsilon_i \qquad (2)$$

Where ε is an error term. Given the relationship between y_i and x_{k_i} in Equation (2), the CI for y (C) can be written as:

$$C = \sum_{k=1} \left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k + \frac{GC_\varepsilon}{\mu} = C_{\hat{y}} + \frac{GC_\varepsilon}{\mu}, \quad (3)$$

Where μ is the mean of y, $\bar{x}_k$ is the mean of x_k, C_k is the CI for x_k (defined analogously to C). In the last term (which can be computed as a residual), GC_ε is the generalized concentration index for ε_i.

Equation (3) shows that C can be thought of as being made up of two components. The first is the deterministic, or 'explained', component. This is equal to a weighted sum of the concentration indices of the regressors, where the weights are simply the elasticities associated with a percentage change in the explanatory variable) $\left(\frac{\beta_k \bar{x}_k}{\mu}\right)$ of y with respect to each x_k. (Elasticity is a unit-free measure of (partial) association that is the percentage change in the dependent variable IADL or presence of chronic illness). The second is a residual, or 'unexplained', component. This reflects the inequality in health that cannot be explained by systematic variation in the x_k across socioeconomic groups. To do a decomposition analysis, the following steps are required:

i. Regress the health variable against its determinants through an appropriate model. This results in finding the coefficients of the explanatory variables (β_k).
ii. Calculate the means of the health variable and each of its determinants (μ and $\bar{x}_k$).
iii. Calculate the concentration indices for the health variable and for the determinants (C and C_k) using Equation (1)—as well as the generalized CI of the error term (GC_ε). The CI of each determinant can be calculated using the Equation (1) where y_i and μ are now the

value of that determinant for the i^{th} individual and the determinant mean, respectively. At this stage, the values of all the variables included in Equation (3) are known.

iv. Finally, the pure contribution of each determinant included in the model to the inequality in the health variable can be quantified through the following steps:

(a) Calculate the absolute contribution of each determinant by multiplying the health variable elasticity with respect to that determinant and its CI $\left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k$

(b) Calculate the *percentage* contribution of each determinant simply through dividing its absolute contribution by the CI of the health variable $\frac{\left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k}{C}$.

Moreover, since the inequality in predicted ill-health will be described given the observed values of the X variable, attention is focused on the first term in the decomposition equation - the predicted inequality as measured by $C_{\hat{y}}$

$$C_{\hat{y}} = \sum_{k=1} \left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k \qquad (4)$$

Ethics Statement

This study used the World Health Organization (WHO) Study on Global AGEing and Adult Health (SAGE) Wave 1 data available in the public domain for use by researchers (http://www.who.int/healthinfo/sage/en/), thus no ethical clearance is required for this study. The WHO-SAGE survey participants in all selected countries were informed about the survey, design, purpose, and how it would benefit society at large. The survey was conducted under the supervision of the respective national governments.

Patient and Public Involvement

This study did not involve any patient and/or public.

Results

Table 1 presents the sample distribution of population aged 60 and above covered in the SAGE survey. Nearly, three-fifths of the sample size belonged to the age group 60-69 years among both male and female. Over half of the women (54%) were widowed as compared to just 11 percent among men. Every three out of four women in the sample did not attend any formal level of

schooling, whereas the corresponding figure among men was 36 percent. Majority of the older population resides in rural areas (70%). Nearly 75 percent of the men used tobacco, while among women, it was 38 percent.

The decomposition analysis has been interpreted based on three components: mean, marginal effects and CIs. Negative CI for IADL (or functional deficiencies) indicates that inequality was concentrated among the poor, and positive CI for chronic diseases among the rich, which indicates a higher burden. Positive (negative) contributions of association can be interpreted by indicating that the total health inequality would be lower (higher) if that association had no impact on the health outcome (instead of that reflected in marginal effects). The contributions are a mixture of positives and negatives, which sum up to 100. The positive percentages were adjusted on a *pro rata* basis to offset the negative percentages, as the positive percentages exaggerate the importance of the determinants. Each health outcome analysis was trailed by a gender-based comparison to comprehend if there were any real contrasts among the contributions of various socio-demographic constituents amongst men and women in their income health inequality.

Results of the relative contribution of sociodemographic factors to functional deficiencies were highest among those with poor economic status (39 per cent), followed by those who were illiterate (23 per cent), which collated to 61 percent of total explained inequalities **(Table 2)**. Findings show that nine selected covariates together explained 82 percent of the total inequalities. Sex stratified analysis highlights major contrasts, where the positive adjusted percentile contribution by poor economic status for males was 61.8 percent, whereas it was negative for females and thus, adjusted on the *pro rata* basis for other positive contribution factors (**Table 3**). The highest percentile contribution in functional deficiencies among females was rural resident (50 per cent), which was substantially low at 5 percent among males. The second point of comparison was illiteracy, which was 27 percent for males and only 0.1 percent for females. Among females, Muslims accounted for 17 percent of the total inequality in functional deficiency and SC/ST social groups, another 16 percent.

In case of chronic health condition **(Table 4)**, about 93 percent of the relative contribution of socio-demographic factors was shared by three factors – poor economic status (42%), rural residence (31%) and illiteracy (20%). Sex-wise comparison (**Table 5**) suggests that among both

male and female, poor economic status (45% and 41%) contributed the highest, followed by rural place of residence (31% and 27%) and illiteracy (18% and 22%) respectively. However, among females, the contribution of social groups (SCs/STs) was noticeable (9%).

Discussion and Conclusion

Although, health disparities by socioeconomic group have been firmly established with years of research, difference in functional ability and chronic health by sex remains inconclusive among older adults in low and middle-income countries. We believe that this is the first study on sex stratified decomposing socioeconomic inequality in functional deficiency and chronic illness among older adults in India.

The findings show pro-poor inequality in IADL (or functional) deficiency and pro-rich inequality in the presence of chronic illness among older adults sample. Determinants such as poor economic status, illiteracy and rural residence were major contributors to overall IADL deficiency, and there is a similar pattern among men. However, in the case of women, rural residence, belonging to SCs/STs social groups, and being Muslim contributed significantly to IADL deficiency. The findings further suggest that poor economic status, followed by rural residence and illiteracy contributed the highest in explaining overall inequality in chronic health. Available evidence from India and other low and middle income countries highlighted low economic status [27,38], poor education [39,40] and residential segregation [41–43], as key predictors of functional ability and presence of chronic health among older adults. But, hardly any study ever attempted to quantify the contribution of these factors.

Place of residence contributed to about 50 percent of the inequality in functional deficiency, and nearly 30 percent in case of chronic illness among women. This could perhaps be attributed to excess engagement of women in informal rural activities throughout their life as compared to urban women. For instance, in rural areas, women contribute significantly as agricultural labourers and are involved in core household management tasks including livestock rearing, collection of firewood and fetching water even in later life [44]. Their healthcare needs and nutritional requirements during childhood and adulthood have largely been neglected, in addition to lack of economic security, mobility, and poor social interactions within the community [45]. The high contribution of rural areas in both IADL and chronic illness could be due to inadequate

healthcare infrastructure, poor accessibility and sub-standard quality of care [46,47]. This situation put women at a disproportionate disadvantage compared to their urban counterparts with better civic infrastructure, improved health facilities and regular check-ups. Thus, the combined effect of heavy physical activities and widespread gender neglect in health and nutrition put rural women at a higher risk of functional limitations during later life as compared to their urban counterparts.

The combined influence of social group (SCs/STs) and religion (Muslim) contributes to over 30 percent of the inequality in IADL disability among women. There were similar observations by other Indian studies among older population, where particular social groups were more disadvantaged in health and healthcare [48]. Complex interactions exist between social groups (castes) and religion in India where substantial inequality is present by gender, access to education, economic status, and social groups [49]. The SC/ST and Muslim population, particularly women, are disadvantaged socioeconomically compared to other social groups. Historically, they are socially excluded, illiterate and mainly engage in the informal sectors or as agricultural labourers [49]. Thus, there is the likelihood of reporting physical deficiency among women belonging to these social and religious groups. However, more research is required to establish this fact, at least in the case of Muslim women. Although, in recent years many affirmative initiatives have been launched to ensure better education, occupation and livelihood opportunities to those belonging to SCs/STs, especially women, it is too early to expect any major change.

Economic status was found to be the major contributor in explaining inequality in both IADL and chronic illness among older adults. However, sex stratified analysis suggests that household economic status was a major factor in both IADL and chronic illness among males. But, in the case of women, household economic status and not IADL deficiency contributed to chronic illness. Earlier evidence supports these results and states that lack of economic support to older adults increased the likelihood of underutilization of healthcare services in case of any morbidity/illness [42]. Studies argue that when it comes to interaction between gender and wealth, Indian women are at a disadvantage due to the long history of patriarchal kinship and economic structure at the household level [50–52]. Studies have documented that women in South Asia have restricted access to, and control over, resources within the household [49], poor

access to preventive and curative care as they are economically dependent on their husbands or on the male heads of household [53] and are most vulnerable when healthcare has to be purchased out-of-pocket or through private insurance [54–56]. Resource-poor older individuals had lower use of healthcare despite their illness and this could be affecting women adversely considering the inadequate social protection plan, coupled with poor performance, specifically for the economically disadvantaged older people [57]. This was reflected in earlier studies too.

Strengths and Limitations

The strengths and limitations of the study need to be highlighted. The methodological strength of the present study includes application of the concentration index. It is sensitive to changes in the outcome distribution (IADL and chronic illness) of the population across socioeconomic groups. The application of decomposition analysis [37] to examine the contribution of socioeconomic factors to the overall health inequality between the poor and the rich strengthens the findings of this study. Another major strength of this study is the nationally representative sample of older population drawn from the SAGE survey. SAGE is one of the prominent sources of data that provides substantial health and related information pertaining to the older population in India. It has addressed major data gaps in terms of growing socioeconomic inequalities in health in low and middle income countries like India [14]. The study has used diagnosed chronic morbidity rather than reported to reduce any bias in the responses.

As far as the limitations are concerned, first, the findings based on regression-based decomposition models lack any causal interpretations. Second, the study does not include any variables related to psychosocial factors and the health system, which might explain both functional limitations and chronic illness among older adults. Third, the cross-sectional study design prevents establishment of any causal inferences from the study results. Finally, how health measures could have been affected by the type and composition of an individual's social network [33], has not been considered in this analysis.

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Table 1. Sample Distribution for Population aged 60 and above, WHO-SAGE, India

	Males		Females		Total	
Background Characteristics	*n*	*%*	*n*	*%*	*n*	*%*
Age of the Respondent						
60-64	615	30.0	613	33.8	1,228	31.9
65-69	589	29.3	500	25.8	1,089	27.5
70-74	395	21.2	335	20.1	730	20.6
75-79	206	11.8	153	9.0	359	10.4
80+	174	7.6	173	11.1	347	9.4
Marital Status						
Unmarried	32	1.5	9	1.2	36	1.4
Married	1660	87.8	812	44.7	2,477	66.1
Widowed	287	10.5	953	54.0	1,240	32.5
Education of the Respondent						
No formal education	745	36.3	1320	75.6	2,149	56.2
Less than primary	317	12.9	159	9.6	446	11.2
Completed primary	341	19.5	161	8.9	494	14.2
Completed secondary	234	13.0	59	2.4	275	7.6
Completed HS	203	11.8	52	2.2	234	6.9
Completed college/university/post grad	139	6.3	23	1.1	155	3.7
Religion of the Respondent						
Hinduism	1603	83.7	1473	86.9	3,076	85.3
Islam	245	12.6	170	10.3	415	11.5
Others	63	3.6	60	2.7	123	3.2
Ethnicity of the Respondent						
Scheduled Tribe	114	5.4	73	4.5	187	5.0
Scheduled Caste	329	16.8	284	16.8	613	16.8
No Caste or Tribe	340	12.9	325	14.8	665	13.9
Others	1122	64.8	1013	63.9	2,135	64.3
Place of Residence						
Urban	472	29.6	501	30.4	973	30.1
Rural	1507	70.3	1273	69.5	2,780	69.9
Wealth Quintile						
Poorest	387	22.5	363	24.8	750	23.7
Poor	403	22.6	344	21.9	747	22.3
Middle	358	17.5	346	19.4	704	18.5
Higher	382	17.5	309	15.9	691	16.8
Highest	381	19.7	341	17.7	722	18.8
Tobacco Use						
No	523	24.7	1110	62.3	1,633	43.5
Former/Current	1387	75.2	592	37.6	1,979	56.5
Total	**1979**		**1774**		**3753**	

Table 2: Contribution of Predictor Variables based on Decomposition Analysis for IADL among Older Population aged 60 years and above, WHO-SAGE 2007-08

Covariates	Mean	Beta	CI	Contribution to CI	% Contribution	Adjusted % Contribution
Poor	0.41	0.107^	-0.58	-0.03	38.65	38.52
Tobacco use	0.55	0.04	-0.06	0.00	2.14	2.13
Illiterate	0.68	0.165#	-0.13	-0.02	22.56	22.48
SC/ST	0.22	0.05	-0.25	0.00	4.35	4.33
Muslim	0.12	0.279#	-0.13	-0.01	6.09	6.07
Rural	0.74	0.156#	-0.11	-0.02	18.91	18.85
Married	0.65	-0.223#	0.03	-0.01	6.36	6.34
Older (70+)	0.38	0.474#	0.00	0.00	-0.34	
Female	0.47	0.172#	-0.01	0.00	1.28	1.28
IADL	**0.76**		**-0.11**	**-0.09**	**100.0**	**100.0**

Significant levels: <0.01 = #; <0.05 = ^; <0.10 = *

Table 3: Sex Stratified Contribution of Predictor Variables based on Decomposition Analysis for IADL among Older Population aged 60 years and above, WHO-SAGE 2007-08

Covariates	Mean	Beta	CI	Contribution to CI	% Contribution	Adjusted % Contribution
			Male			
Poor	0.41	0.252#	-0.58	-0.10	62.90	61.83
Tobacco use	0.73	0.00	-0.06	0.00	0.00	
Illiterate	0.54	0.233#	-0.21	-0.04	26.98	26.52
SC/ST	0.23	-0.03	-0.24	0.00	-1.73	
Muslim	0.13	0.12	-0.11	0.00	1.61	1.59
Rural	0.76	0.06	-0.11	-0.01	5.18	5.09
Married	0.84	-0.200#	0.01	0.00	2.28	2.25
Older (70+)	0.39	0.402#	-0.02	0.00	2.77	2.73
IADL	**0.6**		**-0.2**	**-0.2**	**100.0**	**100.0**
			Female			
Poor	0.42	-0.06	-0.58	0.02	-45.38	
Tobacco use	0.35	0.07	-0.09	0.00	7.60	4.74
Illiterate	0.84	0.00	-0.08	0.00	0.23	0.14
SC/ST	0.21	0.145*	-0.26	-0.01	26.32	16.43
Muslim	0.10	0.509#	-0.16	-0.01	27.12	16.93
Rural	0.72	0.290#	-0.12	-0.03	79.52	49.64
Married	0.45	-0.244#	0.05	-0.01	19.42	12.12
Older (70+)	0.37	0.551#	0.02	0.01	-14.81	
IADL	**0.90**		**-0.04**	**-0.03**	**100.0**	**100.0**

Significant levels: <0.01 = #; <0.05 = ^; <0.10 = *

Table 4: Contribution of Predictor Variables based on Decomposition Analysis for Chronic Disease of all the Older Population aged 60 years and above, WHO-SAGE 2007-08

Covariates	Mean	Beta	CI	Contribution to CI	% Contribution	Adjusted % Contribution
Poor	0.41	-0.113#	-0.58	0.06	42.60	42.25
Tobacco	0.55	0.02	-0.06	0.00	-0.84	
Illiterate	0.68	-0.143#	-0.13	0.03	20.47	20.30
SC/ST	0.22	-0.071^	-0.25	0.01	6.13	6.07
Muslim	0.12	-0.03	-0.13	0.00	0.65	0.65
Rural	0.74	-0.242#	-0.11	0.05	30.73	30.48
Married	0.65	0.01	0.03	0.00	0.15	0.15
Older (70+)	0.38	0.091#	0.00	0.00	0.07	0.07
Female	0.47	0.00	-0.01	0.00	0.03	0.03
Chronic Disease	**0.43**		**0.15**	**0.15**	**100.0**	**100.0**

Significant levels: <0.01 = #; <0.05 = ^; <0.10 = *

Table 5: Sex Stratified Contribution of Predictor Variables based on Decomposition Analysis for Chronic Disease of all the Older Population aged 60 years and above, WHO-SAGE 2007-08

Covariates	Mean	Beta	CI	Contribution to CI	% Contribution	Adjusted % Contribution
			Male			
Poor	0.41	-0.119#	-0.58	0.06	45.75	45.04
Tobacco	0.73	-0.01	-0.06	0.00	0.36	0.35
Illiterate	0.54	-0.104#	-0.21	0.03	18.59	18.30
SC/ST	0.23	-0.03	-0.24	0.00	3.05	3.00
Muslim	0.13	-0.07	-0.11	0.00	1.61	1.59
Rural	0.76	-0.247#	-0.11	0.04	31.78	31.28
Married	0.84	0.03	0.01	0.00	0.45	0.45
Older (70+)	0.39	0.149#	-0.02	0.00	-1.59	
Chronic Disease	**0.45**		**0.14**	**0.14**	**100.0**	**100.0**
			Female			
Poor	0.42	-0.115#	-0.58	0.07	42.60	41.15
Tobacco	0.35	0.04	-0.09	0.00	-1.80	
Illiterate	0.15	-0.226#	-0.08	0.04	23.32	22.53
SC/ST	0.21	-0.110^	-0.26	0.02	9.27	8.95
Muslim	0.10	0.03	-0.16	0.00	-0.84	
Rural	0.72	-0.221#	-0.12	0.05	28.09	27.14
Married	0.45	-0.02	0.05	0.00	-0.88	
Older (70+)	0.37	0.02	0.02	0.00	0.24	0.24
Chronic Disease	**0.41**		**0.16**	**0.16**	**100.0**	**100.0**

Significant levels: <0.01 = #; <0.05 = ^; <0.10 = *

STROBE Statement

Checklist of items that should be included in reports of observational studies

Section/Topic	Item No	Recommendation	Reported on Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4,5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5,6,7
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7,8
Bias	9	Describe any efforts to address potential sources of bias	10
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8,9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	9
		(*e*) Describe any sensitivity analyses	9

Section/Topic	Item No	Recommendation	Reported on Page No
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10,11
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	11
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10,11
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

**Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.*

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Socioeconomic Inequality in Functional Deficiencies and Chronic Diseases among Older Indian Adults: A Sex-stratified Cross-sectional Decomposition Analysis

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Abstract

Objectives: Older adults with adverse socioeconomic conditions suffer disproportionately from a poor quality of life. Stratified by sex, income-related inequalities have been decomposed for functional deficiencies and chronic diseases among older adults, and the degree to which social and demographic factors contribute to these inequalities were identified in this study.

Design: Cross-sectional study.

Participants: Data used for this study were retrieved from the World Health Organization (WHO) Study on Global AGEing and Adult Health (SAGE) Wave 1. A total of 3753 individuals (male: 1979; and female: 1774) aged ≥60 years were found eligible for the analysis.

Measures: Instrumental Activity of Daily Living (IADL) deficiency and presence of chronic diseases.

Method: The decomposition method proposed by Adam Wagstaff and his colleagues was used. The method allows estimating how determinants of health contribute proportionally to inequality in a health variable.

Results: Compared to males, females were disproportionately affected by both functional deficiencies and chronic diseases. The relative contribution of socio-demographic factors to IADL deficiency was highest among those with poor economic status (38.5%), followed by those who were illiterate (22.5%), which collated to 61 percent of the total explained inequalities. Similarly, for chronic diseases, about 93 percent of the relative contribution was shared by those with poor economic status (42.3%), rural residence (30.5%) and illiteracy (20.3%). Significant difference in predictors was evident between men and women in IADL deficiency and chronic illness.

Conclusion: Pro-poor intervention strategies could be designed to address functional deficiencies and chronic diseases, with special attention to women.

Keywords: functional deficiency, chronic diseases, gender, older adults, India

Strengths and Limitations of this Study

- This study, the first of its kind, examines the decomposition of socioeconomic inequality in functional deficiency and chronic illness separately for older males and females.
- The findings revealed pro-poor inequality in Instrumental Activity of Daily Living (IADL) deficiency and pro-rich inequality in the occurrence of chronic diseases among both older men and women in India.
- While being poor and illiterate contributed highest to the IADL deficiency among men, rural residence followed by social group and religion contributed most among women.
- Being poor, lives in rural areas and illiterate contributed significantly to the chronic illness among men, whereas among women it was poor economic status, rural residence and illiteracy.
- The cross-sectional study design prevents establishment of any causal inferences from the study results.

Introduction

Globally, older females experience lower mortality rates and in a few cases, lower prevalence of chronic diseases as compared to their male counterparts [1–4]. Contrary to this, functional limitation and physical disability among women has been higher than that among men, particularly in low and middle income countries [5,6]. Existing evidence shows that the difference in male-female functional limitation could be explained in terms of higher prevalence and severity of arthritis and musculoskeletal disease [4,7] among women along with psychosocial factors – women are more likely to over-report ill health and functional limitations, whereas men would under-report their weaknesses [8]. This pattern may be more evident in low-and-middle income countries where gender norms significantly determine demographic, health and socioeconomic outcomes.

Examining disparities in socioeconomic status and their effect on health outcomes in developing societies is high on the list of priorities in the global agenda. A study has shown that poor economic status contributes to over half of the inequality in self-rated health among older adults in India, followed by illiteracy and rural residence [9]. However, the distribution of socioeconomic resources between men and women is not the same, which gives rise to different explanations for the existing socioeconomic inequalities in health by gender. Of the total older adult population in India, nearly half of them, mostly women are dependants, often due to widowhood, divorce, or separation [10]. Majority of older adult women are deprived of economic security and receive poor healthcare [10]. If results for male and female participants are not studied separately, aggregate results may mask imperative disparities in the mechanism of functional deficiency and chronic diseases [11].

Stratified by sex, income-related inequalities for functional deficiencies and chronic diseases among older adults are decomposed, and the degree to which social and demographic determinants contribute to these inequalities is identified.

This study has the following objectives:

1. To examine the differences in functional deficiency and chronic diseases among older men and women separately

2. To estimate the relative contribution of socioeconomic and demographic factors to the overall functional deficiencies and chronic diseases, separately among men and women.

This study hopes to collate and analyse data to prepare and design programmes to improve the functional capacity and management of chronic diseases among the older adults in India. The National Health Policy (NHP) of India, 2017 acknowledges the healthcare needs of the aging population in India and recommends focused interventions [12] to tackle the rising burden of functional deficiency and chronic diseases [13].

Methods

Study Population

Data required for this study were retrieved from the World Health Organization (WHO) Study on Global AGEing and Adult Health (SAGE) Wave 1, collected between 2007 and 2010 in India. SAGE is a nationally representative multi-country (China, Ghana, India, Mexico, Russian Federation, and South Africa) study to monitor the health and well-being of adult population aged 50 years and older [14]. In India, respondents were selected from six states – Assam, Karnataka, Maharashtra, Rajasthan, Uttar Pradesh, and West Bengal using a multistage, stratified, random sampling design with every individual having a known non-zero probability of being selected. Overall, the individual response rate was over 92 percent. More about the sampling process and SAGE India survey can be obtained from the official report [14,15]. This study followed the United Nation's agreed cut-off age for defining older population (60 years and older). A total 3,753 individuals (male: 1979; and female: 1774) aged 60 years and older were included in this study.

Functional Deficiency and Chronic Disease

Two health outcome events, functional deficiency and presence of chronic diseases, were analyzed. Functional deficiency was measured in terms of Instrumental Activity of Daily Living (IADL). IADL measures the ability to perform relatively complex activities of daily living [16]. Studies have identified a hierarchical structure within the disablement process model from health to disability, and concluded that the first level of disability includes persons with only mobility impairment [17]. The next level in the progression includes those with impairment in mobility

plus a limitation in an IADL. Finally, level three includes those with mobility, IADL, and basic difficulties in daily activities [17,18]. Although, IADL may not assess functional limitation in basic tasks such as sitting or standing for a long period, bathing, dressing and so on, it provides a basic understanding of the onset of functional difficulties among older adults [19]. This study follows the WHO-SAGE definition of IADL. In the WHO-SAGE survey, IADL is composed of five items that cover higher-level instrumental tasks [15]. The respondents were asked if they had any difficulty doing the following instrumental tasks during the thirty days preceding the survey:

1. …in taking care of your household responsibilities?
2. …in joining community activities (for example, festivities, religious or other activities) in the same way as anyone else can?
3. …in your day to day work
4. …in reaching your destination, using private or public transport if needed?
5. …in getting out of your home?

The responses were categorized into 'none', 'mild', 'moderate', 'severe', and 'extreme'/'cannot do'. For this study, the responses were grouped into different difficulty levels –

- No difficulty (when the response was none or mild or moderate=0)
- Difficulty (when the response was severe or extreme=1).

The computed value of the sum of dichotomized five variables ranges from 0 to 5, where the higher score indicates poor physical functioning.

Besides IADL, respondents were asked if they were diagnosed with any of the following chronic medical conditions (as conveyed by a health care professional): angina, asthma, stroke, depression, chronic lung disease and hypertension. An affirmative response regarding any of these medical conditions confirmed the presence of chronic disease.

Covariates

Guided by existing literature, individual and household level binary (1 or 0) covariates that could explain maximum dimensions of inequality were considered. The covariates are sex of the respondent (male or female), current marital status (married or unmarried), social group (Scheduled Caste/Scheduled Tribe or Non-scheduled Caste/Tribe), religion (Muslim or Others), education of the respondent (illiterate or literate), economic status (poor or non-poor), residence (rural or urban) and tobacco use (never, and ever or current). In dichotomous covariates, the assigned value, '1' represents the older population in a disadvantaged socioeconomic group, and the assigned value of '0' indicates the older population in an advantageous position.

The critical role of marital status for a woman in Indian society has been documented in terms of lower access to material resources, and her own social position within and outside the family [20]. Studies from India [21] and elsewhere [22] show that both objective and subjective health measures along with healthcare use are substantially lower among older widowed women than among their married counterparts [23,24].

Earlier literature suggests the protective effect of education on an individual's health, which operates in several ways. For instance, education may positively affect health through postponing the onset of functional limitations and chronic conditions [25], improve health through better management of illnesses, and enhance individual capability to cope with negative emotions [26]. Considering fewer resources, such as power, authority, earnings, household income, and wealth among women, the role of education appears to be vital in explaining women's health in low-and-middle income countries like India [27,28]. Among lifestyle factors physical inactivity, unhealthy diet, consumption of alcohol and use of tobacco have been found to be prominent risk factors for non-communicable diseases [29,30]. In India, smoking is higher among men and they smoke throughout their lives. Women smoke less than men but tend to become smokers at an older age [31,32].

Over 70 percent of the population lives in rural areas in India. Owing to variations in social experience, healthcare, pension policies, state provisions, rural and urban differences in health among older adults are critical. Moreover, with the increase of rural to urban migration among

the young population for better education, employment and living opportunities, the older population left behind in rural areas is at risk [33].

Historically, Scheduled Castes and Scheduled Tribes are identified by the Government of India as socially and economically backward social groups and considered to be in need of protection from social injustice and exploitation, whereas non-Scheduled Caste/Tribes enjoy a higher status in the social hierarchy. Economic groups (poor or non-poor) were derived from the household wealth index provided in the dataset by using the WHO standard approach to estimate income from selected indicator variables [34]. For the decomposition analysis, the top two quintiles (representing 40% of economic status) were grouped as non-poor, and the bottom three quintiles (representing 60% of economic status) were combined as poor.

Analytical Approach

Stratified by sex, a decomposition analysis was conducted to measure the contribution of select covariates to explain the burden of IADL and presence of chronic diseases in following steps [35]. First, to quantify the extent of socioeconomic inequality in IADL and chronic diseases outcomes we used Concentration Index (CI) [36]. It could be computed as twice the weighted covariance of health outcomes and relative ranking of individuals in economic gradient divided by variable mean as mentioned in Equation (1) [37]. The range of CI varies between -1 and +1, where a negative value refers that the poor health outcomes concentrated among the disadvantage group and positive values refers the opposite. The zero value of CI shows absence of inequality [36].

$$C = \frac{2}{\mu}\mathrm{cov}_w(y_i, R_i) \qquad (1)$$

where, y_i and R_i are the poor IADL or presence of chronic diseases of the i^{th} individual and the fractional rank of i^{th} individual of the index of household economic status for weighted data; μ is the (weighted) mean of both health outcomes of the sample and cov_w denotes the weighted covariance.

Study applied decomposition method developed by Wagstaff and colleagues (2003) [38] to decompose socioeconomic inequality in poor IADL or presence of chronic diseases into its

determinants. The method enables to show how factors contribute proportionally to health inequality. For instance, any linear regression model link the outcome of interest, *y*, to a set of *k* determinants, x_k as:

$$y_i = \alpha + \sum_{k=1} \beta_k x_{k_i} + \varepsilon_i \qquad (2)$$

Where, ε is an error term. Given the relationship between y_i and x_{k_i} in Equation (2), the CI for y (C) can be written as:

$$C = \sum_{k=1} \left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k + \frac{GC_\varepsilon}{\mu} = C_{\hat{y}} + \frac{GC_\varepsilon}{\mu}, \quad (3)$$

Where μ is the mean of y, $\bar{x}_k$ is the mean of x_k , C_k is the CI for x_k (defined analogously to C), and in the last term, GC_ε is the generalized concentration index for ε_i .

In equation (3), C can be thought of as being made up of two components – 'explained' and 'unexplained' components. The 'explained' or 'deterministic' component is similar to weighted sum of the CIs of the regressors where the weights are simply the elasticities associated with a percentage change in the explanatory variable $\left(\frac{\beta_k \bar{x}_k}{\mu}\right)$ of *y* with respect to each x_k . On the other hand, 'unexplained' or 'residual' refers inequality in outcome that cannot be described by systematic variation in the x_k across different socioeconomic groups.

To do a decomposition analysis, the following steps are required

i. The outcome variable against its factors needs to be regress to find out the coefficients of the explanatory variables (β_k).
ii. Calculate mean of the outcomes and each of its factors (μ and $\bar{x}_k$).
iii. Using the Equation (1) where y_i and μ are determinant for the i[th] individual and the determinant mean, respectively. The values of all variables included in Equation (3) are known.
iv. At last, the net contribution of each factor can be quantified in two following steps:

a. Computing net contribution of each factor by multiplying the health outcomes elasticity with respect to that factor and its CI $\left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k$

b. Calculate the *percentage* contribution of each factor through dividing its net contribution by the CI of the health outcome $\frac{\left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k}{C}$.

Ethics Statement

This study used the World Health Organization (WHO) Study on Global AGEing and Adult Health (SAGE) Wave 1 data available in the public domain for use by researchers (http://www.who.int/healthinfo/sage/en/), thus no ethical clearance is required for this study. The WHO-SAGE survey participants in all selected countries were informed about the survey, design, purpose, and how it would benefit society at large. The survey was conducted under the supervision of the respective national governments.

Patient and Public Involvement

This study did not involve any patient and/or public.

Results

Table 1 presents the sample distribution of population aged 60 and above covered in the SAGE survey. Nearly, three-fifths of the sample size belonged to the age group 60-69 years among both male and female. Over half of the women (54%) were widowed as compared to just 11 percent among men. Every three out of four women in the sample did not attend any formal level of schooling, whereas the corresponding figure among men was 36 percent. Majority of the older population resides in rural areas (70%). Nearly 75 percent of the men used tobacco, while among women, it was 38 percent.

The decomposition analysis has been interpreted based on three components: mean, marginal effects and CIs. Negative CI for IADL (or functional deficiencies) indicates that inequality was concentrated among the poor, and positive CI for chronic diseases among the rich, which indicates a higher burden. Positive (negative) contributions of association can be interpreted by indicating that the total health inequality would be lower (higher) if that association had no impact on the health outcome (instead of that reflected in marginal effects). The contributions are

a mixture of positives and negatives, which sum up to 100. The positive percentages were adjusted on a *pro rata* basis to offset the negative percentages, as the positive percentages exaggerate the importance of the determinants. Each health outcome analysis was trailed by a gender-based comparison to comprehend if there were any real contrasts among the contributions of various socio-demographic constituents amongst men and women in their income health inequality.

Results of the relative contribution of sociodemographic factors to functional deficiencies were highest among those with poor economic status (39 per cent), followed by those who were illiterate (23 per cent), which collated to 61 percent of total explained inequalities **(Table 2)**. Findings show that nine selected covariates together explained 82 percent of the total inequalities. Sex stratified analysis highlights major contrasts, where the positive adjusted percentile contribution by poor economic status for males was 61.8 percent, whereas it was negative for females and thus, adjusted on the *pro rata* basis for other positive contribution factors (**Table 3**). The highest percentile contribution in functional deficiencies among females was rural resident (50 per cent), which was substantially low at 5 percent among males. The second point of comparison was illiteracy, which was 27 percent for males and only 0.1 percent for females. Among females, Muslims accounted for 17 percent of the total inequality in functional deficiency and SC/ST social groups, another 16 percent.

In case of chronic health condition **(Table 4)**, about 93 percent of the relative contribution of socio-demographic factors was shared by three factors – poor economic status (42%), rural residence (31%) and illiteracy (20%). Sex-wise comparison (**Table 5**) suggests that among both male and female, poor economic status (45% and 41%) contributed the highest, followed by rural place of residence (31% and 27%) and illiteracy (18% and 22%) respectively. However, among females, the contribution of social groups (SCs/STs) was noticeable (9%).

Discussion and Conclusion

Although, health disparities by socioeconomic group have been firmly established with years of research, difference in functional ability and chronic health by sex remains inconclusive among older adults in low and middle-income countries. We believe that this is the first study on sex stratified decomposing socioeconomic inequality in functional deficiency and chronic illness among older adults in India.

The findings show pro-poor inequality in IADL (or functional) deficiency and pro-rich inequality in the presence of chronic illness among older adults sample. Determinants such as poor economic status, illiteracy and rural residence were major contributors to overall IADL deficiency, and there is a similar pattern among men. However, in the case of women, rural residence, belonging to SCs/STs social groups, and being Muslim contributed significantly to IADL deficiency. The findings further suggest that poor economic status, followed by rural residence and illiteracy contributed the highest in explaining overall inequality in chronic health. Available evidence from India and other low and middle income countries highlighted low economic status [27,39], poor education [40,41] and residential segregation [42–44], as key predictors of functional ability and presence of chronic health among older adults. But, hardly any study ever attempted to quantify the contribution of these factors.

Place of residence contributed to about 50 percent of the inequality in functional deficiency, and nearly 30 percent in case of chronic illness among women. This could perhaps be attributed to excess engagement of women in informal rural activities throughout their life as compared to urban women. For instance, in rural areas, women contribute significantly as agricultural labourers and are involved in core household management tasks including livestock rearing, collection of firewood and fetching water even in later life [45]. Their healthcare needs and nutritional requirements during childhood and adulthood have largely been neglected, in addition to lack of economic security, mobility, and poor social interactions within the community [46]. The high contribution of rural areas in both IADL and chronic illness could be due to inadequate healthcare infrastructure, poor accessibility and sub-standard quality of care [47,48]. This situation put women at a disproportionate disadvantage compared to their urban counterparts with better civic infrastructure, improved health facilities and regular check-ups. Thus, the combined effect of heavy physical activities and widespread gender neglect in health and nutrition put rural women at a higher risk of functional limitations during later life as compared to their urban counterparts.

The combined influence of social group (SCs/STs) and religion (Muslim) contributes to over 30 percent of the inequality in IADL disability among women. There were similar observations by other Indian studies among older population, where particular social groups were more

disadvantaged in health and healthcare [49]. Complex interactions exist between social groups (castes) and religion in India where substantial inequality is present by gender, access to education, economic status, and social groups [50]. The SC/ST and Muslim population, particularly women, are disadvantaged socioeconomically compared to other social groups. Historically, they are socially excluded, illiterate and mainly engage in the informal sectors or as agricultural labourers [50]. Thus, there is the likelihood of reporting physical deficiency among women belonging to these social and religious groups. However, more research is required to establish this fact, at least in the case of Muslim women. Although, in recent years many affirmative initiatives have been launched to ensure better education, occupation and livelihood opportunities to those belonging to SCs/STs, especially women, it is too early to expect any major change.

Economic status was found to be the major contributor in explaining inequality in both IADL and chronic illness among older adults. However, sex stratified analysis suggests that household economic status was a major factor in both IADL and chronic illness among males. But, in the case of women, household economic status and not IADL deficiency contributed to chronic illness. Earlier evidence supports these results and states that lack of economic support to older adults increased the likelihood of underutilization of healthcare services in case of any morbidity/illness [43]. Studies argue that when it comes to interaction between gender and wealth, Indian women are at a disadvantage due to the long history of patriarchal kinship and economic structure at the household level [51–53]. Studies have documented that women in South Asia have restricted access to, and control over, resources within the household [50], poor access to preventive and curative care as they are economically dependent on their husbands or on the male heads of household [54] and are most vulnerable when healthcare has to be purchased out-of-pocket or through private insurance [55–57]. Resource-poor older individuals had lower use of healthcare despite their illness and this could be affecting women adversely considering the inadequate social protection plan, coupled with poor performance, specifically for the economically disadvantaged older people [58]. This was reflected in earlier studies too.

Strengths and Limitations

The strengths and limitations of the study need to be highlighted. The methodological strength of the present study includes application of the concentration index. It is sensitive to changes in the

outcome distribution (IADL and chronic illness) of the population across socioeconomic groups. The application of decomposition analysis [38] to examine the contribution of socioeconomic factors to the overall health inequality between the poor and the rich strengthens the findings of this study. Another major strength of this study is the nationally representative sample of older population drawn from the SAGE survey. SAGE is one of the prominent sources of data that provides substantial health and related information pertaining to the older population in India. It has addressed major data gaps in terms of growing socioeconomic inequalities in health in low and middle income countries like India [14]. The study has used diagnosed chronic morbidity rather than reported to reduce any bias in the responses.

As far as the limitations are concerned, first, the findings based on regression-based decomposition models lack any causal interpretations. Second, the study does not include any variables related to psychosocial factors and the health system, which might explain both functional limitations and chronic illness among older adults. Third, the cross-sectional study design prevents establishment of any causal inferences from the study results. Finally, how health measures could have been affected by the type and composition of an individual's social network [33], has not been considered in this analysis.

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Table 1. Sample Distribution for Population aged 60 and above, WHO-SAGE, India

	Males		Females		Total	
Background Characteristics	*n*	*%*	*n*	*%*	*n*	*%*
Age of the Respondent						
60-64	615	30.0	613	33.8	1,228	31.9
65-69	589	29.3	500	25.8	1,089	27.5
70-74	395	21.2	335	20.1	730	20.6
75-79	206	11.8	153	9	359	10.4
80+	174	7.6	173	11.1	347	9.4
Marital Status						
Unmarried	32	1.5	9	1.2	36	1.4
Married	1660	87.8	812	44.7	2,477	66.1
Widowed	287	10.5	953	54	1,240	32.5
Education of the Respondent						
No formal education	745	36.3	1320	75.6	2,149	56.2
Less than primary	317	12.9	159	9.6	446	11.2
Completed primary	341	19.5	161	8.9	494	14.2
Completed secondary	234	13.0	59	2.4	275	7.6
Completed HS	203	11.8	52	2.2	234	6.9
Completed college/university/post grad	139	6.3	23	1.1	155	3.7
Religion of the Respondent						
Hinduism	1603	83.7	1473	86.9	3,076	85.3
Islam	245	12.6	170	10.3	415	11.5
Others	63	3.6	60	2.7	123	3.2
Ethnicity of the Respondent						
Scheduled Tribe	114	5.4	73	4.5	187	5.0
Scheduled Caste	329	16.8	284	16.8	613	16.8
No Caste or Tribe	340	12.9	325	14.8	665	13.9
Others	1122	64.8	1013	63.9	2,135	64.3
Place of Residence						
Urban	472	29.6	501	30.4	973	30.1
Rural	1507	70.3	1273	69.5	2,780	69.9
Wealth Quintile						
Poorest	387	22.5	363	24.8	750	23.7
Poor	403	22.6	344	21.9	747	22.3
Middle	358	17.5	346	19.4	704	18.5
Higher	382	17.5	309	15.9	691	16.8
Highest	381	19.7	341	17.7	722	18.8
Tobacco Use						
No	523	24.7	1110	62.3	1,633	43.5
Former/Current	1387	75.2	592	37.6	1,979	56.5
Total	**1979**		**1774**		**3753**	

Table 2: Contribution of Predictor Variables based on Decomposition Analysis for IADL among Older Population aged 60 years and above, WHO-SAGE 2007-08

Covariates	Mean	Beta	CI	Contribution to CI	% Contribution	Adjusted % Contribution
Poor	0.41	0.107^	-0.58	-0.03	38.65	38.52
Tobacco use	0.55	0.04	-0.06	0.00	2.14	2.13
Illiterate	0.68	0.165#	-0.13	-0.02	22.56	22.48
SC/ST	0.22	0.05	-0.25	0.00	4.35	4.33
Muslim	0.12	0.279#	-0.13	-0.01	6.09	6.07
Rural	0.74	0.156#	-0.11	-0.02	18.91	18.85
Married	0.65	-0.223#	0.03	-0.01	6.36	6.34
Older (70+)	0.38	0.474#	0.00	0.00	-0.34	
Female	0.47	0.172#	-0.01	0.00	1.28	1.28
IADL	**0.76**		**-0.11**	**-0.09**	**100.0**	**100.0**

Significant levels: <0.01 = #; <0.05 = ^; <0.10 = *

Table 3: Sex Stratified Contribution of Predictor Variables based on Decomposition Analysis for IADL among Older Population aged 60 years and above, WHO-SAGE 2007-08

Covariates	Mean	Beta	CI	Contribution to CI	% Contribution	Adjusted % Contribution
			Male			
Poor	0.41	0.252#	-0.58	-0.10	62.90	61.83
Tobacco use	0.73	0.00	-0.06	0.00	0.00	
Illiterate	0.54	0.233#	-0.21	-0.04	26.98	26.52
SC/ST	0.23	-0.03	-0.24	0.00	-1.73	
Muslim	0.13	0.12	-0.11	0.00	1.61	1.59
Rural	0.76	0.06	-0.11	-0.01	5.18	5.09
Married	0.84	-0.200#	0.01	0.00	2.28	2.25
Older (70+)	0.39	0.402#	-0.02	0.00	2.77	2.73
IADL	**0.6**		**-0.2**	**-0.2**	**100.0**	**100.0**
			Female			
Poor	0.42	-0.06	-0.58	0.02	-45.38	
Tobacco use	0.35	0.07	-0.09	0.00	7.60	4.74
Illiterate	0.84	0.00	-0.08	0.00	0.23	0.14
SC/ST	0.21	0.145*	-0.26	-0.01	26.32	16.43
Muslim	0.10	0.509#	-0.16	-0.01	27.12	16.93
Rural	0.72	0.290#	-0.12	-0.03	79.52	49.64
Married	0.45	-0.244#	0.05	-0.01	19.42	12.12
Older (70+)	0.37	0.551#	0.02	0.01	-14.81	
IADL	**0.90**		**-0.04**	**-0.03**	**100.0**	**100.0**

Significant levels: <0.01 = #; <0.05 = ^; <0.10 = *

Table 4: Contribution of Predictor Variables based on Decomposition Analysis for Chronic Disease of all the Older Population aged 60 years and above, WHO-SAGE 2007-08

Covariates	Mean	Beta	CI	Contribution to CI	% Contribution	Adjusted % Contribution
Poor	0.41	-0.113#	-0.58	0.06	42.60	42.25
Tobacco	0.55	0.02	-0.06	0.00	-0.84	
Illiterate	0.68	-0.143#	-0.13	0.03	20.47	20.30
SC/ST	0.22	-0.071^	-0.25	0.01	6.13	6.07
Muslim	0.12	-0.03	-0.13	0.00	0.65	0.65
Rural	0.74	-0.242#	-0.11	0.05	30.73	30.48
Married	0.65	0.01	0.03	0.00	0.15	0.15
Older (70+)	0.38	0.091#	0.00	0.00	0.07	0.07
Female	0.47	0.00	-0.01	0.00	0.03	0.03
Chronic Disease	**0.43**		**0.15**	**0.15**	**100.0**	**100.0**

Significant levels: <0.01 = #; <0.05 = ^; <0.10 = *

Table 5: Sex Stratified Contribution of Predictor Variables based on Decomposition Analysis for Chronic Disease of all the Older Population aged 60 years and above, WHO-SAGE 2007-08

Covariates	Mean	Beta	CI	Contribution to CI	% Contribution	Adjusted % Contribution
			Male			
Poor	0.41	-0.119#	-0.58	0.06	45.75	45.04
Tobacco	0.73	-0.01	-0.06	0.00	0.36	0.35
Illiterate	0.54	-0.104#	-0.21	0.03	18.59	18.30
SC/ST	0.23	-0.03	-0.24	0.00	3.05	3.00
Muslim	0.13	-0.07	-0.11	0.00	1.61	1.59
Rural	0.76	-0.247#	-0.11	0.04	31.78	31.28
Married	0.84	0.03	0.01	0.00	0.45	0.45
Older (70+)	0.39	0.149#	-0.02	0.00	-1.59	
Chronic Disease	**0.45**		**0.14**	**0.14**	**100.0**	**100.0**
			Female			
Poor	0.42	-0.115#	-0.58	0.07	42.60	41.15
Tobacco	0.35	0.04	-0.09	0.00	-1.80	
Illiterate	0.15	-0.226#	-0.08	0.04	23.32	22.53
SC/ST	0.21	-0.110^	-0.26	0.02	9.27	8.95
Muslim	0.10	0.03	-0.16	0.00	-0.84	
Rural	0.72	-0.221#	-0.12	0.05	28.09	27.14
Married	0.45	-0.02	0.05	0.00	-0.88	
Older (70+)	0.37	0.02	0.02	0.00	0.24	0.24
Chronic Disease	**0.41**		**0.16**	**0.16**	**100.0**	**100.0**

Significant levels: <0.01 = #; <0.05 = ^; <0.10 = *

STROBE Statement

Checklist of items that should be included in reports of observational studies

Section/Topic	Item No	Recommendation	Reported on Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4,5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5,6,7
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7,8
Bias	9	Describe any efforts to address potential sources of bias	10
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8,9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	9
		(*e*) Describe any sensitivity analyses	9

Section/Topic	Item No	Recommendation	Reported on Page No
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10,11
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	11
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10,11
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

**Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.*

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.