Gender differences in age at onset of non-communicable diseases among older adults in India: Role of differential exposure and differential vulnerabilities

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Abstract

Gender inequality in health is increasingly being researched, but there is still a lack of robust empirical evidence on the gender-specific pattern of the onset of non-communicable diseases and its explanatory factors. Therefore, this study is designed specifically to address two critical research questions: (1) Does the onset of NCDs differ between genders? If yes, then (2) What factors contribute to it? For the empirical analysis, we used the data from the Longitudinal Aging Study in India Wave 1 (2017-18). The study employs bivariate, Kaplan-Meier survival analysis and Cox proportional hazards model estimates. Further, multivariate decomposition analysis was used to estimate the relative contribution of key exposure and adaptive capacity variables to explain the gender gap in the onset of non-communicable diseases. The analytical framework was designed for using two theoretical hypotheses: differential exposure and differential vulnerability. Our results indicate that women have a higher risk of early onset of NCDs than men, with a mean age at onset of 53.2 years for men and 51.8 years for women. This difference was highest in cancer and arthritis but insignificant in neurological disorders and diabetes. The relative risk of early onset of any NCDs than the median age at onset was 2.4 times (HR 2.36; 95% 2.26,2.47) higher among women than men, even after adjusting for differential exposure and adaptive capacity variables. Mechanisms wise, differential exposure in terms of work status and marital status and differences in adaptive capacities like age by gender contribute maximum in explaining the higher relative risk of early onset of NCDs among women. The study advances that although women may have certain biological advantages in survival rates, societal norms and gender stereotypes play a substantial role in contributing to the early onset of NCDs among women than men in India.

Keywords: Non-communicable diseases, Onset, Gender, older adults, Differential vulnerability, India

Introduction

The world is undergoing a major demographic shift, with people living longer and the proportion of older individuals within the total population rising rapidly (Lutz et al.,2008a. Bloom & Luca, 2016; Balachandran et al.,2020). Notably, developing countries are witnessing rapid population aging. While it took more than 200 years in England and France and 150 years in the USA for the elderly population to double from 7% to 14%, China achieved this in just 49 years, and India in only 30 years (Goli et al. 2019). Aging has traditionally been assessed through demographic indicators, such as the shift in the population's age distribution towards older ages (Gavrilov et al,2003), increase in the population's median age (United States Census Bureau,2017), increase in average life expectancy (Ryder,1975; Gavrilov et al,2003), number of remaining years left to live (Sanderson & Scherbov,2005) and changes in the ratio between older and working-age individuals (McNicoll,2002; Lutz et al.,2008b). However, increased life expectancy does not necessarily equate to healthy life expectancy, as despite longer lifespans, a substantial part of individuals' lives is often impacted by non-communicable diseases and disabilities (Boutayeb & Boutayeb,2005; Howse,2006; Thomas et al.,2014). Evidence also suggests that many countries with chronologically older populations, such as Japan and the Netherlands, have a lower ageing burden because the onset of ageing-related disease occurs later. At the same time, many countries with a younger age structure, such as Indonesia and Lesotho, have a greater ageing burden because the onset of ageing-related disease occurs earlier (Skirbekk et al.,2022). Therefore, the age at the onset of non-communicable disease becomes pivotal in unraveling the intricate relationship between life expectancy and healthy life expectancy (Brink et al.,2013 & Beltran et al.,2014) as it marks the beginning of a decline in functional health, potentially leading to limitations in independence and overall wellbeing.

'Healthy life years' is an important indicator, determining whether increased longevity is an opportunity or a threat to the stability of societies which depends not only on whether populations are living longer but also on whether they are experiencing the negative health effects of ageing (López et al.,2013, Beard, et al.,2016, Blachandran et al.,2024). Skirbekk et al. (2022) proposed a new metric, the health-adjusted dependency ratio (HADR), which accounts not only for the demographic structure of the population but also for its ageing-related health burden, explicitly considering how the onset of non-communicable diseases affects individuals' ability to remain productive and independent. Furthermore, Lutz and his colleagues designed a well-being indicator called 'Years of Good Life (YoGL)' for assessing sustainable progress, emphasizing not just longevity but also the quality of life (Lutz et al., 2021). The early onset of non-communicable diseases often leads to severe activity limitations, reducing YoGL and impacting the overall quality of life. Hence, understanding the age at the onset of non-communicable diseases is crucial for improving YoGL, as it directly influences the number of years individuals can live without significant health-related constraints.

In addition to the concern of whether increased life expectancy equates to healthy life expectancy, these issues are further compounded by cultural neglect rooted in gender norms and traditions, as women's biological advantages are offset by the social disadvantages they face (Doyal, 2004). Therefore, it is important to point out at this juncture how gender-sensitive

role affects the onset of non-communicable diseases among older adults, particularly in low- and middle-income countries like India, where gender norms are firmly ingrained in the culture. In India, besides the increasing proportion of older adults in higher age groups, specifically among women, the disparities based on gender create additional layers of disadvantageousness to older adults' health.

In the past two decades, numerous studies have explored gender differences across various health measures, considering the age spectrum in diverse geographical and social contexts (Arber 1997; Bird & Rieker 1999; Wang et al.,2009; Rueda et al.,2009; Dahlin and Härkönen 2013; Salk, Hyde, and Abramson 2017). A bourgeoning number of studies have been documenting the apparent paradox of gender differences in health, with men having shorter lives but women experiencing a higher prevalence of several health problems in later life (Nathanson, 1975; Verbrugge, 1985, Case & Paxson,2005; Bastos et al.,2015, Phillips et al.,2023). Mounting research has identified several social, genetic, and biological risk factors that influence these gender-health associations (Bird and Rieker 1999; Verbrugge 1989). However, within the traditional literature that continues to exert significant influence on our understanding of the gender disparity in health (Macintyre et al., 1996), sufficient attention has not been paid to the role of gender-sensitive patterns in the onset of non-communicable diseases, particularly in India. For instance, how the onset of non-communicable diseases is sensitive to gender roles and social hierarchies specific to gender status. In an attempt to address this issue, this paper will first discuss how health is structured by gender, which is pertinent to understanding the gendered pattern in the onset of non-communicable diseases. Next, it will discuss the mechanisms behind the gendering of men's and women's roles in the onset of non-communicable diseases using two hypotheses: 'differential exposure' and 'differential vulnerability'.

Explaining mechanisms of gender differences in health: A theoretical framework

Gender norms, roles, socialization, power dynamics, and disparities in access to and control over resources all contribute to differences in vulnerabilities and susceptibilities to illness. Within the realm of social factors, researchers commonly attribute disparities in the health of men and women to two prevailing hypotheses: gender-related differential 'exposure' and differential 'vulnerability' (Denton et al., 2004; Chun et al., 2008; Read & Gorman,2010).

The "differential exposure hypothesis" suggests that gender disparities in health stem from heterogeneous and varying levels of exposure to gender-related social factors (Ross and Bird 1994; Arber and Cooper 1999; Denton et al 2004). This exposure encompasses differences in men's and women's socio-economic experiences, including labour force participation, division of labour, access to material resources, and other social factors influencing health and well-being. Additionally, it involves divergent exposure to various health-risk behaviours, such as smoking and drinking, which in turn results in different health outcomes. For instance, women's greater exposure to lower socioeconomic status compared to men may lead to a health disadvantage, while their lower exposure to negative health behaviors (such as smoking and drinking) may drive a health advantage.

The *"vulnerability hypothesis"* posits that, although men and women may be exposed to similar risk factors, differences in their responses or reactions to the material, behavioural, and psychosocial conditions that influence health, result in gender differences in health outcomes (McDonough & Walters 2001). For example, widowhood affects men and women in distinct ways. Women often encounter economic hardships due to widowhood, while men typically experience a reduction in social support from following widowhood (Umberson et al.,1992). In addition, women have been shown to suffer the consequences of psychosocial risks more so than their male counterparts (Shye et al.,1995).

Gender and onset of non-communicable disease

Globally, indicators of non-communicable diseases highlight significant disparities between men and women throughout the life course. Gender roles and social marginalization expose men and women to different non-communicable disease risks (WHO,2012). Certain expectations about masculinity and femininity might influence choices related to physical activity, diet, and substance use, all of which can contribute to the risk of developing non-communicable diseases differently in men and women (WHO,2012). Although there is considerable literature on gender differences in non-communicable diseases in both developed (Vlassoff,2007, Syed et al.,2019) and developing countries (Van et al.,2006, Santosa et al.,2020), studies on the gendering of men and women's roles in the onset of non-communicable diseases is relatively scarce specifically in developing countries.

Some studies conducted in developed countries reported that cardiovascular disease tends to develop later in women than men (Rossouw,2002 & Mass,2010). Another study found that men tend to experience dementia approximately three years earlier than women (Brinks,2013).
To the best of our knowledge, no study in India examined the gendered pattern in the onset of non-communicable disease. Studies on gender-sensitive roles and related exposure in the onset of non-communicable diseases are important to identify how underlying social mechanisms, beyond biological distinctions, contribute to gender differences in the onset of these diseases, particularly in India, where social prejudices against women are culturally entrenched. Under this prevailing knowledge gap, this study seeks to address two critical research questions: (1) does the onset of non-communicable diseases differ between genders; if yes, (2) what factors contribute to it? Using two prevailing hypotheses, differential exposure and differential vulnerability.

Methods

Data

The data used in this study were from Wave 1 (2017-18) of the Longitudinal Ageing Study in India (LASI). LASI Wave 1 is a collaborative effort by the International Institute for Population Sciences (IIPS), Harvard T.H. Chan School of Public Health (HSPH), and the University of Southern California (USC) (IIPS,2020).

LASI is a nationally representative survey of the older population aged 45 years and above for India and its states and union territories. The survey collects information on diseases, functional health, healthcare, and older adults' social and economic profile based on internationally comparable measures.

The LASI adopted a multistage stratified area probability cluster sampling design. The survey was conducted in a sample of 42,949 households and 72,250 individuals aged 45 years and above and their spouses, irrespective of age, across all states and union territories of India at the baseline. However, considering the empirical approach of this study, we restricted the samples of both respondent and their spouses to age 45 years and above. Respondents who had never been diagnosed with any NCDs were also excluded from the analyses. After excluding the missing/wrongly entered/invalid observations, the final analytical sample size was 30168. Among them, men and women were 13006 and 17162 respectively. Figure 1 illustrates the flowchart of sample selection for this study.

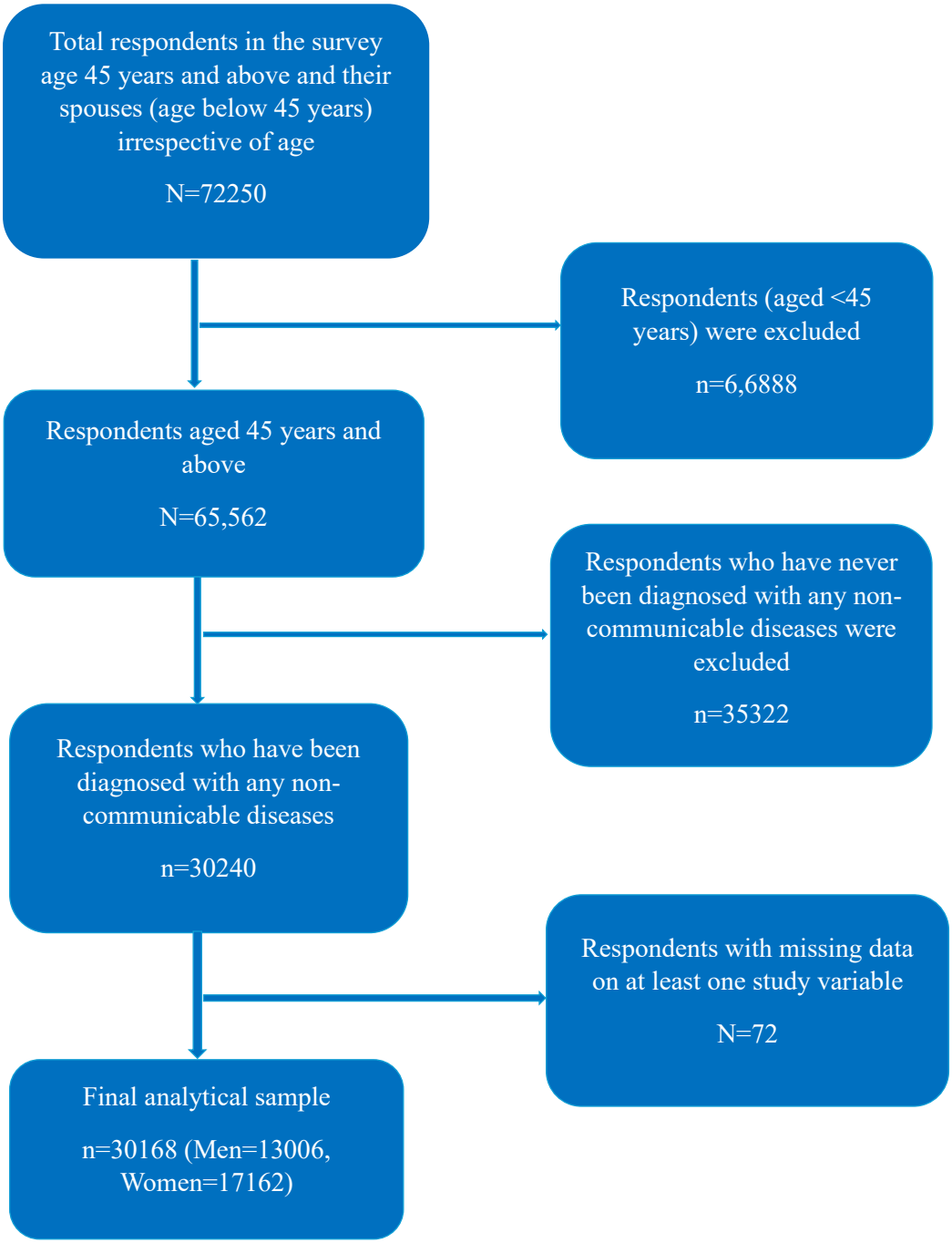


Figure 1: Flowchart illustrating the sample selection process for the study

Description of variables

Our primary dependent variable is a measure of the onset of NCDs. LASI collected information on the age at onset of NCDs by asking respondents, "When were you first diagnosed (by health professionals) with the specific chronic disease in years or age? Six medically diagnosed self-reported NCDs, such as cardiovascular diseases, cancer, chronic obstructive pulmonary diseases, diabetes, arthritis, and neurological/psychiatric disorders, were used in this study. It is important to note that definitions of age at onset of a disease vary across the literature. Some studies define it as the age at which the first symptom of the illness appears, while others use the time of the first hospitalization or the first symptom in connection with the first hospitalization (Johnston & Logan, 2008; Capistrant,2014).

Explanatory variables

The framework used in this study hypothesizes that gender differences in health are, in part, a function of sociodemographic factors (age, place of residence, religion, caste, marital status, region) and socioeconomic status (work status, education, and wealth status). We have considered this socio-economic and demographic covariate as exposure variables and adaptive capacity variables for the vulnerability to the onset of NCDs. These covariates were selected based on a review of the previous literature (Sen & Östlin, 2008; Ganguly, 2023). Specifically, we included place of residence, religion, caste, marital status, living arrangement, working status, and region as exposure variables. Place of residence was categorised as – 'rural' and 'urban'; religion was categorised as 'Hindu', 'Muslim', 'Christian', and 'others'; caste was categorised as 'SC', 'ST', 'OBC' and Others; marital status was categorised as 'currently-married', 'widowed' and others (never-married, divorced, separated, live-in-relationship); the living arrangement was categorised as 'living alone', 'living with a spouse and children', and 'living with children and others'; work status was categorised as 'never worked', 'ever worked' but 'currently not working' and 'currently working'. The region was categorized as 'North,' 'Central,' 'East,' 'West', 'North-east' and 'South'.

Further, we have considered age, education, and economic status as adaptive capacity variables. Age is not merely a measure of chronological progression but also reflects the cumulative experiences, exposures, and adaptations that influence health outcomes. Biological ageing processes, such as hormonal changes and immune system alterations, interact with social factors and shape adaptive capacities. Additionally, social roles and expectations, which evolve with age, affect access to resources, healthcare, and social support, further modulating adaptive capacity. Therefore, we have considered age as an adaptive capacity variable for the onset of NCDs. The age variable was categorised into four groups- 45-49,50-54,55-59,60 and above.

Education enhances personal agency, enabling individuals to make informed health decisions and embrace healthier lifestyles (Cutler & Lleras-Muney, 2010). Educated individuals are more likely to comprehend health information, pursue preventive care, and adopt health-promoting behaviors, all of which enhance their ability to adapt to and manage health risks. Education

level was categorised as 'No education,' 'Less than 5 years of schooling,' '5 to 9 years of schooling,' and '10 & above years of schooling'.

Economic status is a critical adaptive resource that influences health trajectories over time. Economic stability enables individuals to accumulate health-promoting resources and build resilience against health adversities. Conversely, economic instability can lead to chronic stress and limited access to health resources, which further increases the risk of NCDs. In this study, the Monthly Per-capita expenditure (MPCE) quintile variable is considered a proxy for economic status, as most developing countries do not have authentic individual and household income data. The MPCE quintile variable (*i.e.* Q1 — Poorest, Q2 — Poorer, Q3 — Middle, Q4 — Richer and Q5 — Richest). The definition and coding of key variables used in the analysis are provided in Supplementary Table 1. Figure 2 shows the conceptual framework of the gender differences in exposure, adaptive capacity, and vulnerability to the onset of non-communicable diseases.

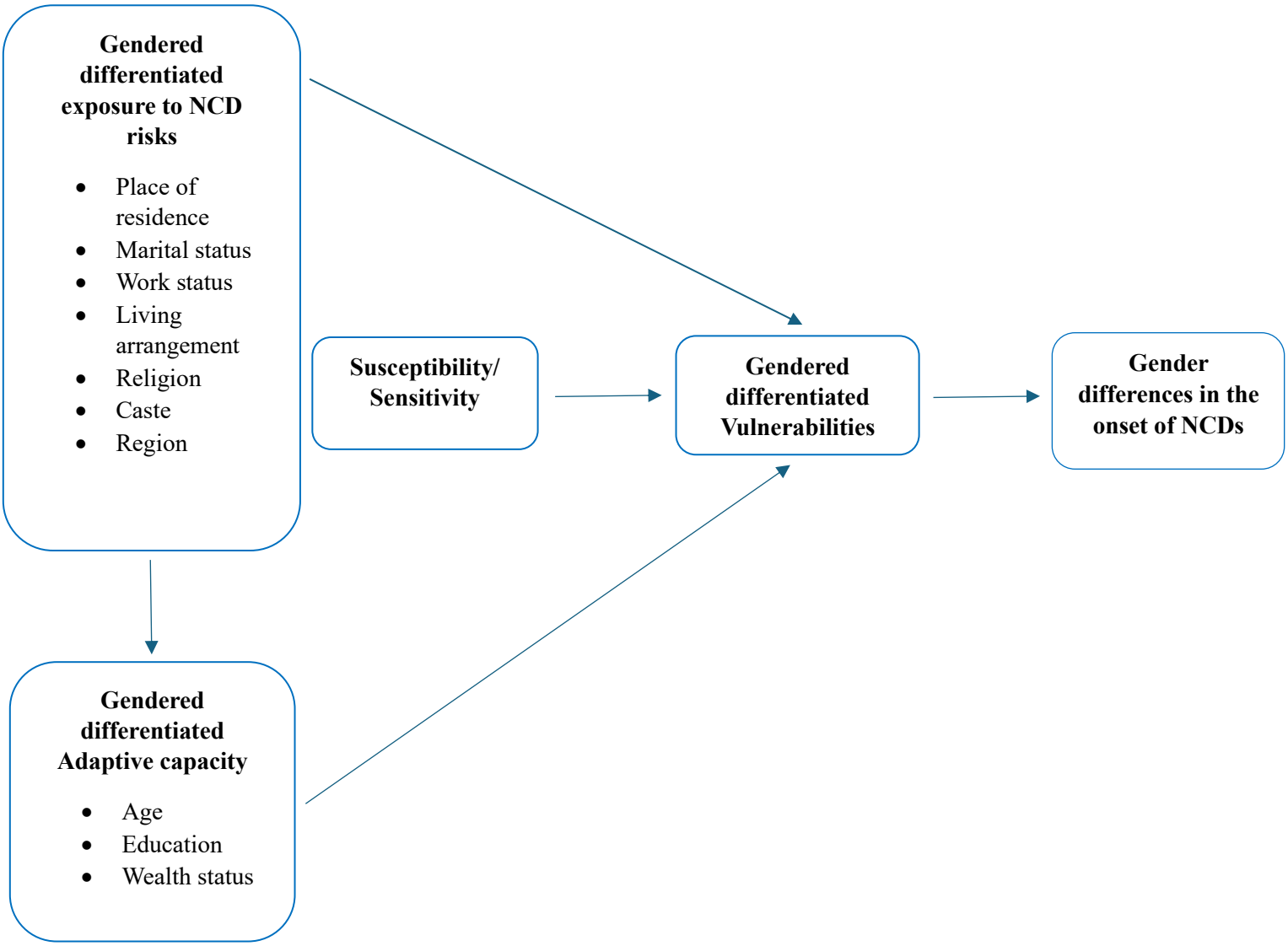


Figure 2: Conceptual framework: Gender differences in exposure and vulnerability to onset of non-communicable diseases

Note: Some exposure and adaptive capacity variables were excluded from the framework to avoid collinearity, while others were not included due to a lack of available data

Statistical Analysis

The analyses were conducted in four stages: First, descriptive statistics were estimated to show the sample distribution across the categories of the variables used in this study. Second, the statistical distribution of age at onset of NCDs was determined for each gender by calculating the mean age at onset. Note that the information on the onset of diseases available after age 45 years in the survey, thus data contains right-censored observations,

Third, Kaplan-Meier survival functions were used to estimate the probability of surviving an individual into the next age cohort without the onset of any NCDs before the median age of onset of any NCDs in the population. Each Kaplan-Meier estimator plot uses the current age of the respondent (in years) as the measure of time and a binary disease onset variable ("1" denotes the onset of disease in an individual is earlier than the median age at onset of disease in the population; otherwise denoted as "0") as the final event (failure) measure. We use the median age at onset for NCDs in a population as the cut-off to derive our dependent variable.

Kaplan-Meier survival Analysis

The Kaplan-Meier estimate of survival time S(t) is given by:

$$S_{\mathrm{t}} = \prod_{ti=\leq t} \left(1 - \frac{\text{di (no. of individuals with NCDs onset is before media age)}}{ni \text{ (total no. of individuals exposed to risk)}}\right) \quad (1)$$

Fourth, a set of disease-specific Cox proportional hazards regression models was used to estimate the relative risk of onset of NCDs in an individual earlier than the median age at onset of the same in the population by gender after controlling for exposure and adaptive capacity variables.

Cox proportional hazard regression model

Mathematically, the Cox proportional hazard regression is expressed as follows:

$$\text{NCDs onset before media age}_{ipc}\,(t, X) = h_{0\ \text{Gender\_ipc}}(t) \exp(ß_1X_1 + ß_2X_2 \ldots\ldots ß_2X_k) \quad (2)$$

X_i stands for predictor variables, namely socio-economic and demographic characteristics used in the model. The quantity $h_0\ (t)$ is the baseline or an underlying hazard function and corresponds to the probability of the onset of NCDs earlier than the median age at onset when all explanatory variables are zero. The regression coefficients ßs are the proportional changes in the hazards due to changes in the explanatory variables.

For instance, in the case of the Cox proportional hazard regression model by gender, we assume that the hazard of onset of NCDs earlier than the median age at onset at time 't' of men (z) is proportional to the hazard of onset of NCDs earlier than the median age at onset in populations (y) by the same factor ψ at time t. Mathematically, it is expressed as follows:

$$h_z\ (t) = \psi\ h_y\ (t) \quad (3)$$

where h_z and h_y are the hazards (probabilities of onset of NCDs earlier than the median age at onset of the same in the populations) for women and men, and ψ is the hazard coefficient. The hazard coefficient is interpreted as if ψ>0, compared to men, women have a smaller hazard of onset of NCDs before the median age of onset of the same in the population. On the other hand, if ψ <0, the hazard of onset of NCDs before the median age at onset is higher for women than men. Similarly, if ψ=1, there is no difference in the hazard of onset of non-communicable disease earlier than the median age at onset between men and women.

Further, a multivariate decomposition analysis was used to examine the relative contribution of key exposure and adaptive capacity variables to the gender gap in the onset of NCDs among older adults in India.

Multivariate decomposition analysis

In this approach, we used a regression model to decompose the difference between two groups into covariates fitted in the model. The difference in the proportion between two groups can be attributed to the differences in the composition between groups (*differences in characteristics*) and differences in the effects of independent variables (*differences in coefficients*) (Powers et al.,2011). As a result, the observed differences in the onset of NCDs, thus can be additively decomposed into characteristics (or *endowments*) components and a coefficient (or *effects of characteristics*) component.

The dependent variable in a nonlinear model is a linear combination of covariates and regression coefficients:

$$Y = F\,(X\,\beta) = Logit\,(\,Y\,) = X\,\beta \tag{4}$$

where Y is the N x 1 dependent variable vector, X is an N x K matrix of independent variables, and β is a $K\,x$ 1 vector of coefficients. The difference between group A and group B in terms of Y can be decomposed into:

$$Y_{Men} - Y_{Women} = F\,(X_{\,men}\,\beta_{Men}\,) - F\,(X_{\,Women}\,\beta_{Women}\,) \tag{5}$$

The difference in proportion in Y between groups A and B (in this case, group A is men and group B is women) can be decomposed as:

$$Logit\,(Y_{Men}) - Logit\,(Y_{Women}) = F\,(X_{\,men}\,\beta_{Men}\,) - F\,(X_{\,Women}\,\beta_{Women}\,)$$
$$= \{F\,(X_{\,men}\,\beta_{Men}\,) - F\,(X_{\,Women}\,\beta_{Men}\,)\}\;E \;+ \{F\,(X_{\,Women}\,\beta_{Men}\,) - F\,(X_{\,Women}\,\beta_{Women}\,)\}C \tag{6}$$

The component labelled "E "refers to the part of the difference attributable to changes in endowments or characteristics (compositional), usually called the explained component or characteristics effect. The "C "component is the difference attributable to coefficients or behavioural change, which is usually labelled as the unexplained component. The decomposition results of E and C are at the aggregate level. To understand the contribution of

each predictor in the model, we need to divide E and C into portions or percentages of contribution, E_k and C_k ($k = 1,\ldots, k$; in which k is the number of independent variables) (Powers et al., 2011). The code *mvdcmp* was used to perform multivariate decomposition analysis using STATA Version 16.

Results

Descriptive Statistics

The socio-economic and demographic profiles of the older adults are described in Table 1. More than half of the men (60.4 percent) and women (55.4 percent) respondents were above 60 years of age. About one-third of the men (30.2 percent) and two-thirds of the women (59.3 percent) had no formal education. Around 52.8 percent of the men and 23.2 percent of the women were currently working.

Regarding marital status, a significant percentage of older adults were currently married: 86.9 percent of men and 58.3 percent of women were currently married. Conversely, women constituted a greater percentage of widowed individuals, accounting for 39.4 percent. Most of the men and women (around 80 percent) were Hindu, and more than 40 percent belonged to the other backward class.

Table 1. Sample distribution across the socio-economic and demographic characteristics of older adults aged 45 years and above in India, LASI Wave 1,2017-18

Characteristics	**Total population= 30,168 (%)**	**Men =13006 (%)**	**Women =17162 (%)**	**P Value**
Exposure variables				
Place of residence				
Rural	61.7	62.9	60.8	0.062
Urban	38.3	37.1	39.2	
Religion				
Hindu	80.0	80.5	79.7	0.005
Muslim	13.2	12.7	13.6	
Christian	2.8	2.7	2.9	
Others*	4.0	4.1	3.9	
Caste				
Scheduled caste	18.2	17.2	18.9	0.127
Scheduled tribe	5.3	5.7	5.1	
Other backward class	46.5	47.4	45.8	
Others	30.0	29.8	30.2	
Marital status				
Currently married	70.5	86.9	58.3	0.000
Widowed	27.1	10.7	39.4	
Others **	2.4	2.4	2.3	

Living arrangement				
Living alone	4.3	1.8	6.1	
Living with spouse, children, and/or others	69.5	86.2	57.1	
Living with children and/or others	26.2	12.0	36.8	0.000
Working status				
Currently working	35.9	52.8	23.2	
Worked in the past but currently not working	34.5	43.9	27.5	0.000
Never worked	29.6	3.3	49.3	
Region				
Northern	13.4	13.4	13.4	
Central	15.1	16.3	14.2	
Eastern	22.5	23.1	22.0	
North-eastern	2.9	2.9	2.9	0.053
Western	17.9	17.0	18.5	
Southern	28.3	27.4	29.0	
Adaptive capacity variables				
Age-group				
45-49	13.6	10.9	15.6	
50-54	14.1	14.3	13.9	
55-59	14.9	14.4	15.2	0.000
60 and above	57.5	60.4	55.3	
Education level				
No education	46.8	30.2	59.3	
Less than 5 years of schooling	11.7	13.3	10.5	0.000
5-9 years of schooling	21.6	26.5	17.9	
10 and above years	19.9	30.0	12.3	
MPCE Quintile				
Poorest	17.33	17	17.57	
Poorer	20.01	20.01	20.01	
Middle	19.85	19.38	20.2	0.002
Richer	20.97	21.05	20.91	
Richest	21.84	22.56	21.31	

***Note**:* Religion; others*: Sikh, Buddhist/neo-Buddhist, Jain, Jewish, and Parsi/Zoroastrian Marital status; others**: Never married/divorced/separated/live-in-relationship

Age at onset of non-communicable diseases by gender

The mean age at onset of any NCDs was 53.2 years for men and 51.8 years for women (Figure 3). This difference was most pronounced in cancer (56 years in men vs. 50.4 years in women) and arthritis (55.9 years in men vs. 53.1 years in women), while the onset ages for neurological disorders (53.4 years in men vs. 52.9 years in women) and diabetes (52.9 years in men vs 53 years in women) showed no significant gender difference.

Table 2 shows that the mean age at the onset of any NCDs varied by gender across different exposure and adaptive capacity variables such as place of residence, religion, caste, marital status, work status, economic status, education level, and region. Notably, across all exposure and adaptive capacity variables, the mean age at onset of NCDs was found to be earlier among women than men. Supplementary Tables 2 and 3 present the mean age at onset of various NCDs among older adults by gender, across exposure and adaptive capacity variables.

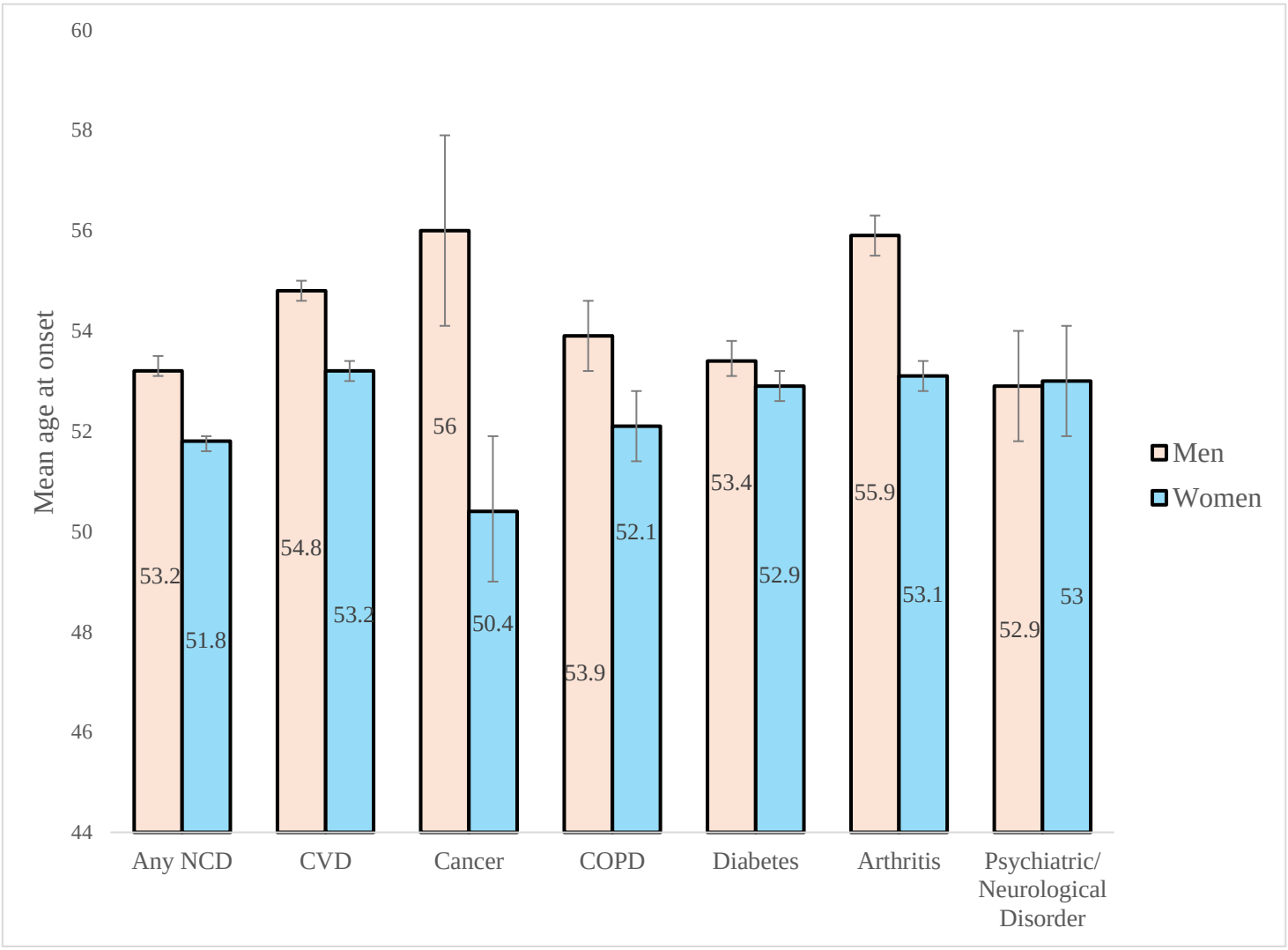


Figure 3: Mean age at onset of non-communicable diseases by gender

Table 2. Mean age at onset of any NCDs of older adults by gender across various exposure and adaptive capacity variables

Characteristics	Men		Women	
Exposure variable	**Mean (SD)**	**P Value**	**Mean (SD)**	**P Value**
Place of residence				
Rural	54.4 (12.2)	<0.001	52.7 (11.9)	<0.001
Urban	51.7 (11.5)		50.5 (11.3)	
Religion				
Hindu	53.2 (12.0)	0.076	51.9 (11.7)	<0.001
Muslim	53.1 (11.3)		50.9 (11.7)	
Christean	53.8 (12.8)		52.4 (12.1)	
Others*	54.1 (12.1)		52.1 (11.6)	
Caste				
Scheduled Caste	53.2(11.7)	0.247	51.9 (11.6)	0.002
Scheduled Tribe	53.8 (12.2)		52.6 (11.8)	
Other backward class	53.3 (11.9)		51.8 (11.6)	
Others	53.1 (12.1)		51.4 (11.8)	
Marital status				
Currently married	52.5 (11.5)	<0.001	48.8 (10.1)	<0.001
Widowed	61.4 (12.7)		56.7(12.3)	
Others**	50.0 (12.7)		48.7 (11.7)	
Living arrangement				
Living alone	56.1 (14.7)	<0.001	57.1(11.5)	<0.001
Living with spouse, children, and/or others	52.5 (11.5)		48.9 (10.1)	
Living with children and/or others	58.6 (13.5)		55.6 (12.6)	
Working status				
Currently working	49.4 (10.2)	<0.001	48.3 (9.5)	<0.001
Ever worked but currently not working	57.8 (12.2)		54.9 (12.4)	
Never worked	55.3 (12.9)		51.7 (11.8)	
Region				
Northern	53.6 (11.7)	<0.001	51.2 (11.5)	<0.001
Central	54.0 (11.7)		51.7 (11.5)	
Eastern	54.2 (12.2)		52.0 (12.2)	
North-eastern	54.0 (12.9)		52.9 (12.2)	
Western	52.8 (11.8)		52.2 (11.4)	
Southern	52.3 (11.9)		51.4 (11.5)	
Adaptive capacity variable				
Age group				
45-49	40.2 (5.8)	<0.001	39.9 (6.2)	<0.001
50-54	44.5 (6.2)		44.2 (6.4)	
55-59	48. 6 (7.3)		48.4 (7.2)	
60 & above	59.1 (10.9)		58.3 (10.7)	
Education Level				
No education	56.3 (12.1)	<0.001	53.9 (11.9)	<0.001
Less than 5 years	54.9 (12.7)		52.3 (11.7)	
5-9 years completed	52.5 (11.8)		48.7 (10.6)	
10 years or more	50.8 (11.2)		47 (9.9)	

MPCE Quintile				
Poorest	54.5 (12.0)	<0.001	52.7 (11.6)	<0.001
Poorer	53.6 (12.0)		52.6 (11.6)	
Middle	53.2 (12.1)		52.1 (12.0)	
Richer	53.1 (12.1)		51.4 (11.6)	
Richest	52.5 (11.6)		50.4 (11.5)	

Note: Religion; others*: Sikh, Buddhist/neo-Buddhist, Jain, Jewish, and Parsi/Zoroastrian Marital status; others**: Never married/divorced/separated/live-in-relationship

Kaplan-Meier survival estimates

Figures 4 and 5 present Kaplan-Meier (K-M) survival curves for at least one NCD and specific categories of NCDs, such as cardiovascular diseases, cancer, chronic obstructive pulmonary diseases, diabetes, arthritis, and neurological/psychiatric disorders, with stratification by gender. The Kaplan-Meier survival curve shows that the probability of "survival," without the onset of any NCDs earlier than the median age at onset in the population, tends to be lower among women than men.

The red curve, (representing women) shifted diagonally downward to the left relative to the blue curve (representing men), suggesting the earlier onset of NCDs among women than men (Figure 4). This pattern was especially pronounced for cancer and arthritis, where the occurrence of these diseases was significantly earlier among women than men (Figure 5).

Supplementary Figure 1 provides a visual representation of the age distribution at the onset of non-communicable diseases across the genders of older adults.

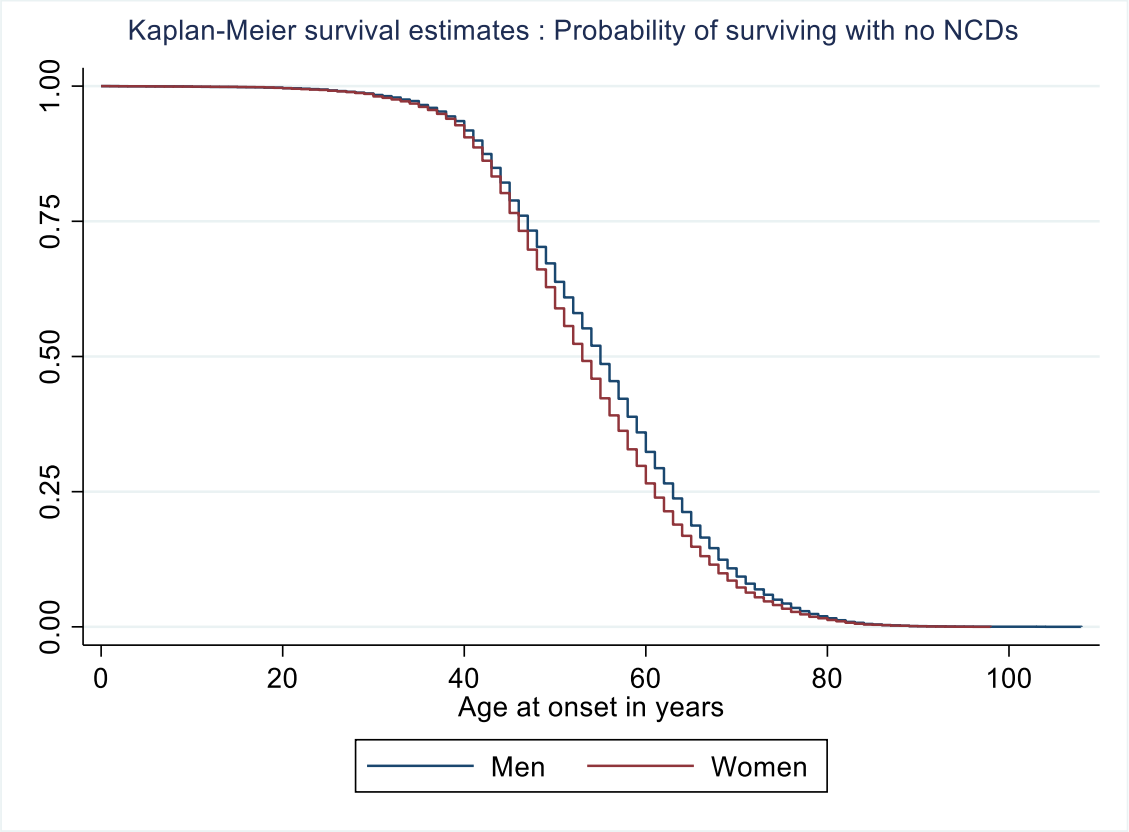
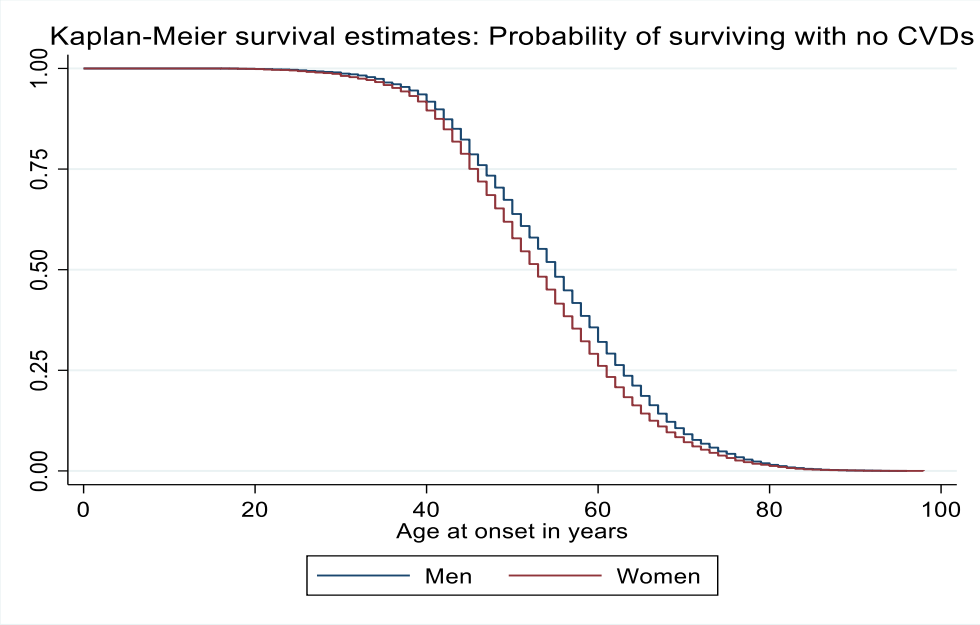
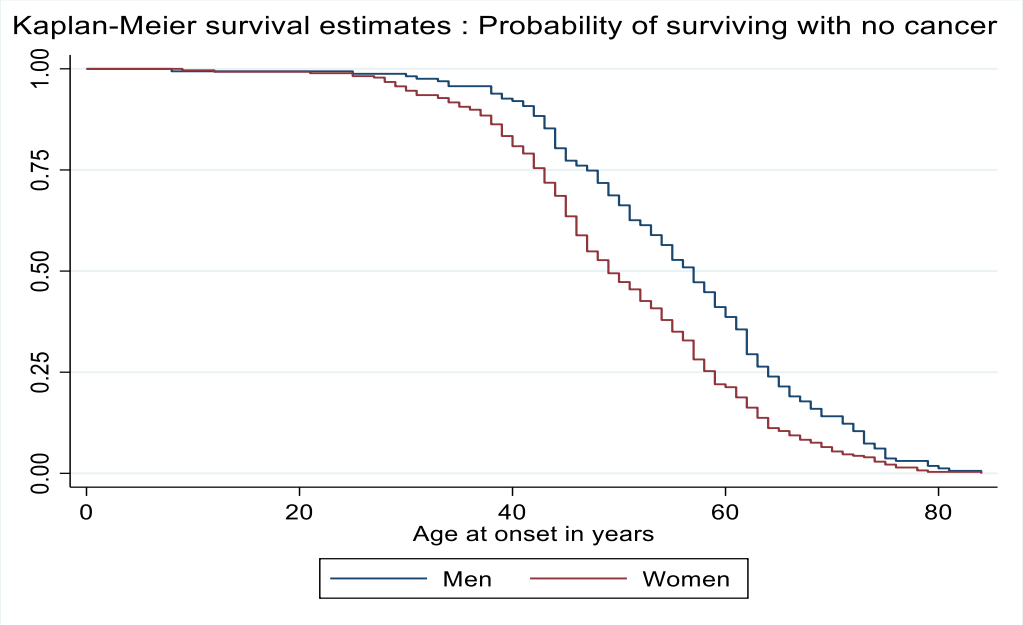
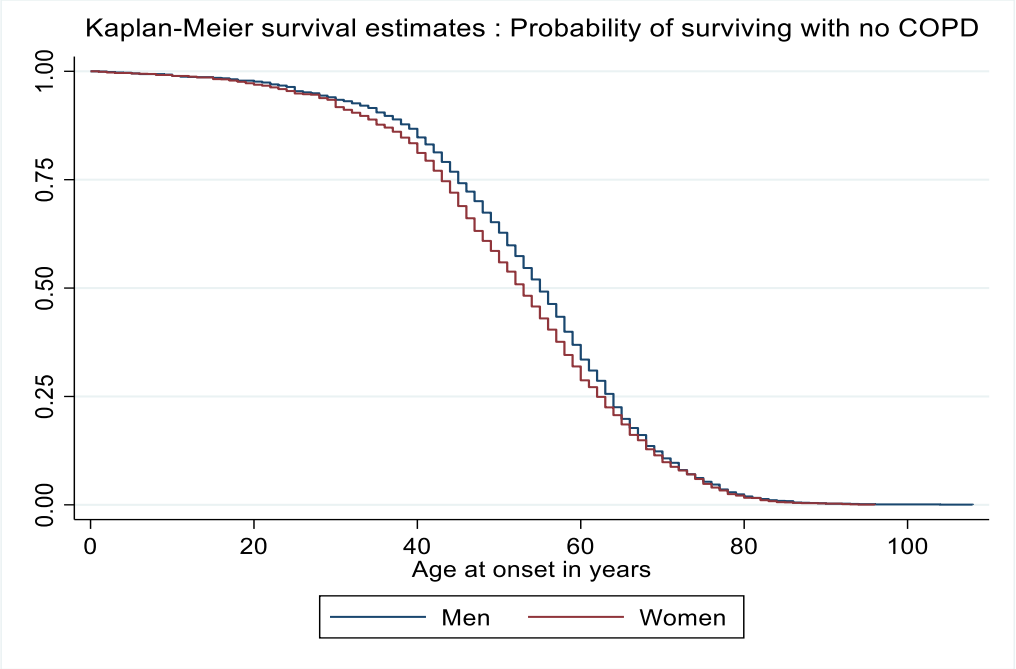
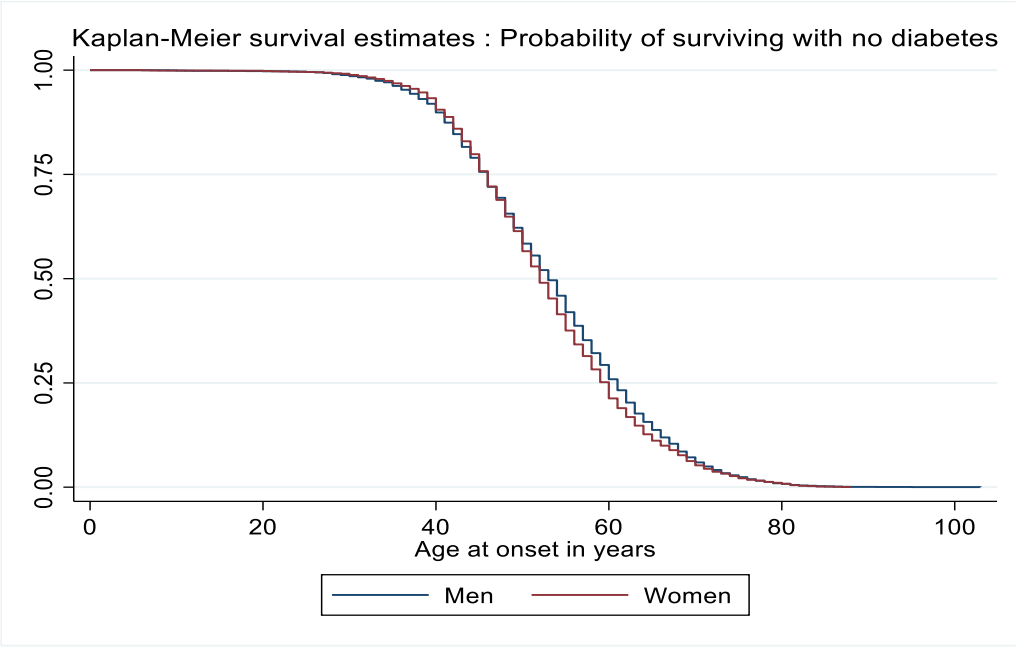


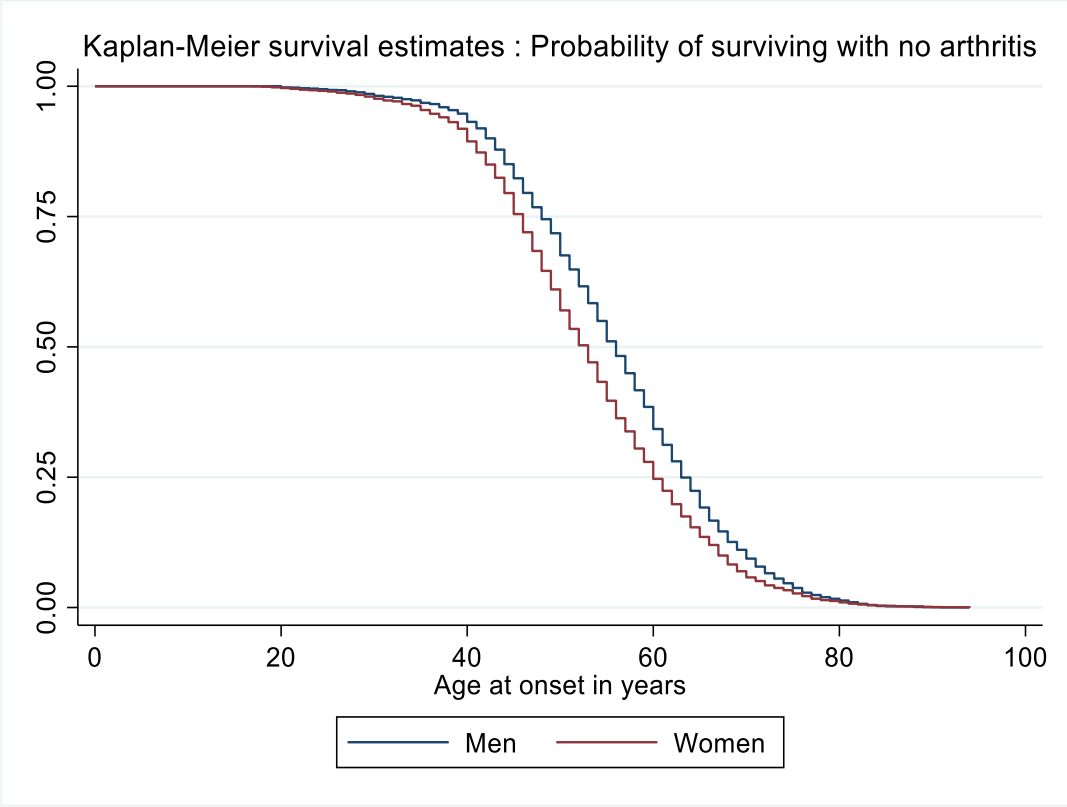
Figure 4: Kaplan-Meier (K-M) survival curves for any NCDs among older adults in India by gender, 2017-18


Kaplan-Meier survival estimates: Probability of surviving with no CVDs
1.00
0.75
0.50
0.25
0.00
0
20
40
60
80
100
Age at onset in years
Men
Women


Kaplan-Meier survival estimates : Probability of surviving with no cancer
1.00
0.75
0.50
0.25
0.00
0
20
40
60
80
Age at onset in years
Men
Women


Kaplan-Meier survival estimates : Probability of surviving with no COPD
1.00
0.75
0.50
0.25
0.00
0
20
40
60
80
100
Age at onset in years
Men
Women


Kaplan-Meier survival estimates : Probability of surviving with no diabetes
1.00
0.75
0.50
0.25
0.00
0
20
40
60
80
100
Age at onset in years
Men
Women



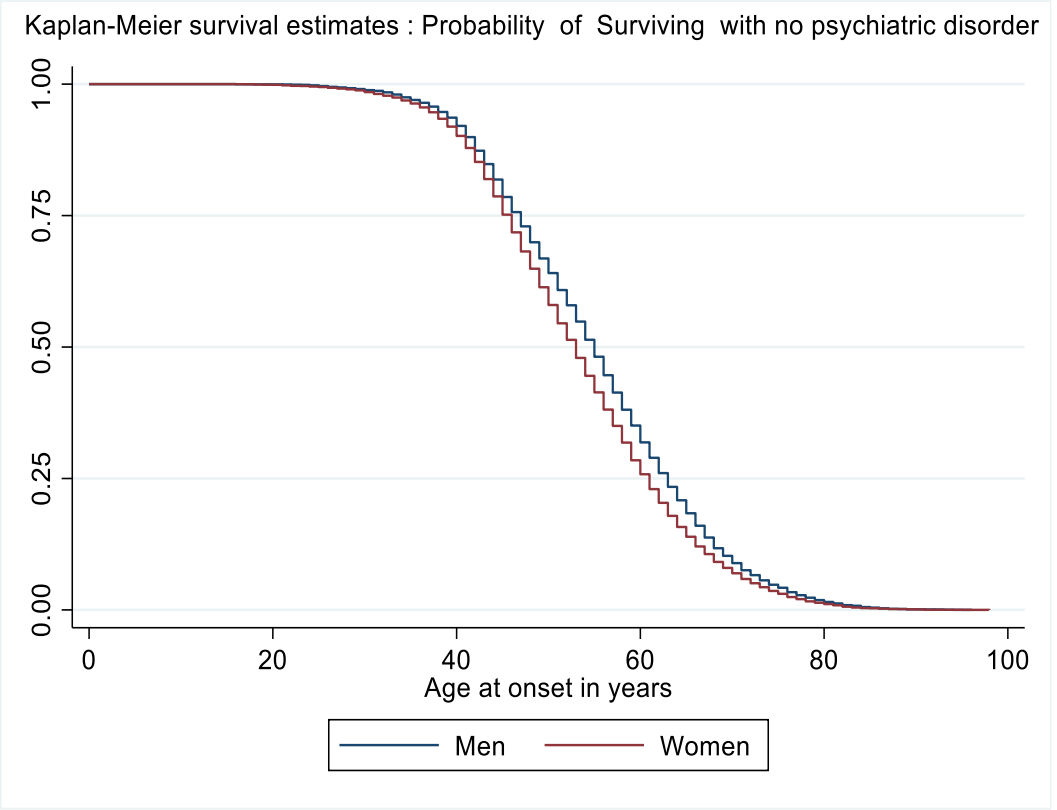


Figure 5: Kaplan-Meier (K-M) survival curves for selected NCDs (CVD, Cancer, COPD, Diabetes, Arthritis, and Psychiatric disorder) among older adults in India by gender, 2017-18

Cox proportional hazard model estimates

We empirically analyse the relationship between gender and the onset of NCDs earlier than the median age at onset. We provide results of Cox proportional hazard regression that examined the gender differences in the onset of NCDs with and without adjusting for the effects of exposure and adaptive capacity variables. The results are presented in Table 3, where Model 1 provides the bivariate associations between the onset of NCDs and gender. In Model 2, we provide the results of the association between the onset of NCDs and gender, adjusting for the effects of exposure and adaptive capacity variables known to influence the onset of NCDs.

The unadjusted results in Model 1 show that the relative risk for the onset of at least one NCD earlier than the median age was significantly higher among women than men (Hazard ratio 1.35; 95% CI 1.30, 1.39).

In Model 2, even after controlling for various exposure and adaptive capacity variables, including place of residence, marital status, work status, religion, caste, region, living arrangement, education level, and economic status, we found consistent results, that is the relative risk for the onset of at least one NCDs earlier than the median age was significantly higher among women (Hazard ratio 2.36; 95% CI 2.26, 2.47). Overall, these results suggest that women continue to have a higher relative risk of early onset of NCDs, even after accounting for different exposure and adaptive capacity variables. This higher relative risk among women may be attributable to unobserved heterogeneity or potential bias from omitted variables, which stems from differential gender-sensitive factors and also unobservable gender-based discriminations.

Table 3. Estimates from Cox Proportional Hazard Model: Effect of gender on the onset of NCDs with and without adjusting the exposure and adaptive capacity variables

Background characteristics	At least one NCD		CVD		Cancer		COPD		Diabetes		Arthritis		Psychiatric/Neurological disorder	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Gender														
Men®														
Women	1.35***	2.36***	1.48***	2.55***	2.23***	4.40***	0.99***	1.62***	1.06*	1.82***	2.09***	3.53***	1.01	1.55***
	[1.30,1.39]	[2.26,2.47]	[1.42,1.55]	[2.41,2.69]	[1.66,3.00]	[3.07,6.32]	[0.90,1.09]	[1.43,1.83]	[1.01,1.13]	[1.68,1.96]	[1.95,2.25]	[3.24,3.85]	[0.87,1.18]	[1.28,1.89]
Exposure variables														
Place of residence														
Rural Ⓡ														
Urban		1.35***		1.45***		1.27		1.08		1.98***		0.99		1.06[0.89,1.26]
		[1.30,1.40]		[1.39,1.52]		[0.93,1.72]		[0.97,1.20]		[1.85,2.11]		[0.92,1.07]		
Religion														
Hindu Ⓡ														
Muslim		1.41***		1.49***		1.23		1.40***		1.44***		1.43***		1.03
		[1.34,1.48]		[1.41,1.59]		[0.80,1.89]		[1.22,1.61]		[1.32,1.56]		[1.32,1.57]		[0.81,1.32]
Christian		0.90**		0.93		1.73*		0.8		1.07		0.71***		0.78[0.56,1.09]
		[0.84,0.97]		[0.86,1.02]		[1.04,2.88]		[0.64,1.01]		[0.96,1.20]		[0.61,0.83]		[0.56,1.09]
Others		1.05		1.15**		0.38		0.68**		1.16*		0.63***		1.04
		[0.97,1.14]		[1.05,1.26]		[0.14,1.04]		[0.52,0.89]		[1.01,1.33]		[0.51,0.78]		[0.70,1.55]
Caste														
Scheduled Caste Ⓡ														
Scheduled tribe		0.66***		0.65***		0.61		0.57***		0.65***		0.69***		0.72

	[0.61,0.70]	[0.60,0.72]	[0.34,1.12]	[0.47,0.70]	[0.57,0.74]	[0.60,0.79]	[0.52,1.01]
Other backward class	0.84***	0.80***	0.85	0.79***	0.85***	0.89*[	0.96
	[0.80,0.89]	[0.75,0.86]	[0.56,1.30]	[0.69,0.90]	[0.77,0.93]	[0.81,0.98]	[0.76,1.21]
Others	0.82***	0.80***	0.78	0.63***	0.81***	0.9	0.953
	[0.78,0.87]	[0.74,0.85]	[0.50,1.21]	[0.55,0.74]	[0.73,0.89]	[0.81,1.01]	[0.74,1.23]
Marital status							
Currently married ®							
Widowed	1.32***	1.35***	1.22**	1.38***	1.42***	1.33***	1.34***
	[1.28,0.37]	[1.23,1.42]	[0.83,1.56]	[1.25,1.57]	[1.32,1.56]	[1.25,1.43]	[1.18,1.64]
Others	0.72***	0.70***	0.19*	0.8	0.8	0.83	1.35
	[0.62,0.84]	[0.58,0.86]	[0.05,0.81]	[0.50,1.29]	[0.59,1.09]	[0.61,1.13]	[0.70,2.60]
Working Status							
Never worked ®							
Currently working	0.67***	0.58***	0.81**	0.60***	0.41***	0.77***	0.51***
	[0.60,0.75]	[0.49,0.68]	[0.26,0.59]	[0.39,0.84]	[0.30,0.54]	[0.62,0.93]	[1.21,1.88]
Currently not working	0.76***	0.73***	0.99	0.93	0.65***	0.79***	0.93
	[0.72,0.80]	[0.69,0.78]	[0.52,1.17]	[0.81,1.07]	[0.60,0.71]	[0.71,0.87]	[0.74,1.11]
Living arrangement							
Living alone ®							
Living with spouse	1.08	1.08	0.99	1.05	1.48*	1.3	1.05
	[0.92,1.27]	[0.88,1.32]	[0.28,3.52]	[0.65,1.68]	[1.08,2.03]	[0.89,1.70]	[0.51,2.16]
Living with children	1.44***	1.40***	1.81	1.33	1.43***	1.51***	1.55

	[1.28,1.61]	[1.22,1.61]	[0.64,5.10]	[0.98,1.80]	[1.16,1.75]	[1.22,1.88]	[0.96,2.51]
Region							
North ®							
Central	0.76***	0.74***	0.84	0.92	0.76***	0.76***	0.78
	[0.71,0.82]	[0.68,0.80]	[0.48,1.45]	[0.77,1.10]	[0.67,0.87]	[0.66,0.88]	[0.56,1.10]
East	0.90***	0.75***	1.33	0.9	0.91	1.64***	1.25
	[0.85,0.95]	[0.70,0.81]	[0.86,2.05]	[0.77,1.06]	[0.81,1.01]	[1.47,1.84]	[0.95,1.65]
Northeast	0.80***	0.88**	0.48*	0.53***	0.71***	0.52***	0.77
	[0.75,0.87]	[0.80,0.96]	[0.24,0.97]	[0.41,0.67]	[0.61,0.82]	[0.43,0.63]	[0.52,1.13]
West	0.96	0.81***	0.94	0.89	1.17**	1.46***	0.98
	[0.90,1.01]	[0.75,0.87]	[0.58,1.53]	[0.75,1.06]	[1.06,1.30]	[1.29,1.65]	[0.72,1.33]
South	1.20***	0.99	0.91	1.093	1.70***	1.87***	2.03***
	[1.14,1.27]	[0.93,1.06]	[0.58,1.42]	[0.94,1.27]	[1.55,1.86]	[1.68,2.09]	[1.58,2.60]
Adaptive capacity variables							
Education level							
No education ®							
Less than 5 years of schooling	1.35***	1.30***	2.33***	1.49***	1.57***	1.28***	1.14
	[1.27,1.43]	[1.21,1.41]	[1.51,3.59]	[1.28,1.73]	[1.41,1.74]	[1.15,1.43]	[0.87,1.49]
5-9 years of schooling	1.84***	1.96***	2.21***	1.65***	2.23***	1.53***	1.79***
	[1.76,1.93]	[1.85,2.07]	[1.50,3.25]	[1.45,1.87]	[2.05,2.42]	[1.40,1.67]	[1.46,2.19]
10 & above years of schooling	2.17***	2.33***	2.57***	1.41***	2.97***	1.47***	1.40**
	[2.06,2.29]	[2.19,2.49]	[1.66,3.99]	[1.21,1.65]	[2.72,3.25]	[1.3201.64]	[1.10,1.79]

MPCE Quintile							
Poorest Ⓡ							
Poorer	1.12***	1.08*	1.35	1.20*	1.20***	1.07	1.12
	[1.06,1.19]	[1.01,1.17]	[0.83,2.209]	[1.02,1.40]	[1.08,1.33]	[0.96,1.19]	[0.85,1.47]
Middle	1.21*h**	1.23***	1.17	1.28**	1.29***	1.04	1.29
	[1.14,1.28]	[1.14,1.32]	[0.70,1.94]	[1.09,1.50]	[1.16,1.43]	[0.93,1.16]	[0.99,1.68]
Richer	1.34***	1.36***	1.62*	1.34***	1.50***	1.25***	1.44**
	[1.26,1.42]	[1.26,1.46]	[1.00,2.62]	[1.14,1.57]	[1.36,1.67]	[1.12,1.39]	[1.11,1.87]
Richest	1.48***	1.50***	1.93**	1.49***	1.74***	1.38***	1.71***
	[1.39,1.56]	[1.40,1.62]	[1.19,3.13]	[1.27,1.75]	[1.57,1.92]	[1.24,1.55]	[1.32,2.22]

Note: **Dependent variable**: "1" denotes the onset of a specific disease earlier than the median age for the onset of specific diseases in the population; "0" denotes otherwise.

Time variable: Current age of the respondent

In the previous table (Table 3), we examined the association between the onset of NCDs and gender, adjusting for the effects of various exposure and adaptive capacity variables, and found a significant and strong influence of gender on the onset of NCDs. Now, in Table 4, we empirically analyse the gender differences in vulnerability to the onset of NCDs about specific exposure and adaptive capacity variables. The result demonstrates that, although men and women may be exposed to similar exposure and have comparable levels of adaptive capacity, there are significant gender differences in the vulnerability to the early onset of NCDs. The result indicates that among various exposure variables, the impact of marital status on the age at onset of NCDs differs for men and women. Widowhood increases the relative risk of early onset of NCDs than the median age at onset for both men and women (with the reference group being currently married). However, this risk is significantly higher for widowed women (Hazard ratio 2.12; 95% CI 1.28 to 2.77) than for widowed men (Hazard ratio 1.33; 95% CI 1.25 to 1.43).

The results of the other exposure and adaptive capacity variables are equally important for the discussion. The relative risk of early onset of any NCDs than the median age is higher among the richest groups for both men and women. Notably, the hazard ratio for early onset of any NCD is significantly higher for the richest men than the richest women. Compared to men in poor economic status, those in the poorest economic status had a 1.2 times higher relative risk of early onset of NCDs before the median age (Hazard ratio 1.20 [95% CI 1.02 to 1.39]). This risk increased to 1.5 times (Hazard ratio 1.49 [95% CI 1.11 to 1.69]) for those in the middle economic status, 1.6 times (Hazard ratio 1.59 [95% CI 1.19 to 1.61]) for those in the richer economic status, and 1.7 times (Hazard ratio 1.70 [95% CI 1.43 to 1.81]) for those in the richest economic status. For women, compared to those in poor economic status, the relative risk of early onset of NCDs before the median age was 1.2 times higher (Hazard ratio 1.15 [95% CI 1.04 to 1.26]) among those in the poorest economic status. This risk increased to 1.2 times (Hazard ratio 1.23 [95% CI 1.12 to 1.35]), 1.4 times (Hazard ratio 1.41 [95% CI 1.28 to 1.54]), and 1.5 times (Hazard ratio 1.54 [95% CI 1.41 to 1.69]) for those in the middle, richer and richest economic status, respectively.

The results also illustrate that despite having the same level of adaptive capacity through education, there is a contrasting pattern among men's and women's vulnerabilities to the early onset of NCDs. For men, compared to those with no education, the relative risk of early onset of any NCDs is 1.5 times higher (Hazard ratio 1.47 [95% CI 1.36 to 1.58]) among those with less than 5 years of schooling. This relative risk increased to 2.1 times (Hazard ratio 2.06 [95% CI 1.94 to 2.18]) among those with 5–9 years of schooling and to 2.2 times (Hazard ratio 2.22 [95% CI 2.07 to 2.38]) among those with 10 or more years of schooling. However, the results revealed a contrasting pattern for women. The hazard of early onset of any non-communicable diseases earlier than the median age at onset was low for non-educated women, increased for middle-educated women who have <5 years of schooling (Hazard ratio 1.20 [95% CI 1.09 to 1.32]) and then declined for women with 5–9 years of schooling (Hazard ratio 1.12 [95% CI 1.50 to1.32]) and ≥10 years of schooling (Hazard ratio 1.03 [95% CI 0.91 to 1.24]). The same trend is also evident in the onset of cardiovascular diseases, chronic obstructive pulmonary diseases, and diabetes among women. Supplementary Figure 2 further illustrates the gendered,

heterogeneous relationships between education and the onset of NCDs, as well as between wealth status and the onset of NCDs.

Table 4. Cox proportional hazards regression model predicting the onset of NCDs after adjusting for the effects of exposure and adaptive capacity variables separately for men and women

Background characteristics	At least one NCDs		CVD		Cancer		COPD		Diabetes		Arthritis		Psychiatric/Neurological disorder	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Exposure variables														
Place of residence														
Rural Ⓡ														
Urban	1.47* [1.38,1.56]	1.26 [1.19,1.32]	1.58 [1.47,1.70]	1.36** [1,21,1.52]	1.37 [0.78,2.39]	1.23 [0.85,1.79]	1.43 [0.84,2.43]	1.21 [0.85,1.73]	2.12* [1.92,2.35]	1.92 [1.74,2.11]	2.1** [1.91,2.31]	1.86* [1.70,2.04]	1.13 [0.88,1.44]	1.22 [0.78,1.37]
Religion														
Hindu Ⓡ														
Muslim	1.22* [1.12,1.32]	1.55 [1.45,1.65]	1.18* [1.06,1.31]	1.71 [1.59,1.84]	1.32 [0.61,2.87]	1.21 [0.72,2.04]	1.18 [0.55,2.53]	1.19 [0.72,1.98]	1.25** [1.09,1.43]	1.66* [1.47,1.87]	1.22 [1.07,1.39]	1.61 [1.44,1.81]	0.79 [0.53,1.16]	1.31 [0.95,1.80]
Christian	0.88* [0.78,0.99]	0.92 [0.84,1.01]	0.96 [0.84,1.11]	0.93 [0.83,1.04]	1.78 [0.64,4.94]	1.72 [0.95,3.12]	1.39 [0.50,3.87]	1.55 [0.86,2.79]	1.02 [0.84,1.23]	1.20* [1.02,1.40]	1.05 [0.88,1.26]	1.12 [0.97,1.30]	0.75 [0.46,1.24]	0.785 [0.50,1.24]
Others	1.11 [0.98,1.26]	1.01 [0.91,1.11]	1.25* [1.08,1.44]	1.09 [0.98,1.23]	1.65 [1.23,1.77]	0.58 [0.21,1.62]	1.4 [1.21,1.56]	0.6 [0.24,1.52]	1.23 [0.99,1.52]	1.09 [0.89,1.34]	1.30* [1.07,1.59]	1.05 [0.87,1.27]	1.01 [0.56,1.76]	1.09 [0.63,1.89]
Caste														
Scheduled Caste Ⓡ														
Scheduled tribe	0.79 [0.70,0.88]	0.58 [0.53,0.64]	0.77 [0.69,0.89]	0.59 [0.53,0.66]	0.81 [0.26,2.54]	0.55 [0.27,1.13]	0.8 [0.28,2.29]	0.51 [0.26,1.01]	0.78* [0.63,0.96]	0.53 [0.43,0.64]	0.77* [0.63,0.94]	0.56* [0.47,0.67]	0.73 [0.46,1.18]	0.73 [0.45,1.18]
Other backward class	0.85 [0.78,0.92]	0.83 [0.78,0.88]	0.77 [0.70,0.86]	0.81 [0.75,0.88]	0.97 [0.42,2.23]	0.81 [0.50,1.31]	0.82 [0.38,1.77]	0.55 [0.29,1,11]	0.91 [0.79,1.06]	0.78 [0.68,0.90]	0.91 [0.79,1.05]	0.78 [0.69,0.88]	0.77 [0.55,1.06]	1.21 [0.87,1.69]
Others	0.87*	0.78	0.85	0.75*	0.91	0.73	0.79	0.65	0.85*	0.72	0.87	0.74*	0.88	1.01

	[0.8,0.94]	[0.73,0.84]	[0.76,0.94]	[0.69,0.82]	[0.38,2.11]	[0.43,1.23]	[0.36,1.74]	[0.40,1.07]	[0.723,0.99]	[0.63,0.83]	[0.75,1.01]	[0.65,0.85]	[0.62,1.24]	[0.73,1.51]
Marital status														
Currently married ®														
Widowed	1.33***	2.12***	1.35***	1.55***	0.17*	0.39	0.19	0.46	0.32***	0.42***	0.42***	0.43***	1.11**	1.61*
	[1.25,1.43]	[1.28,2.77]	[1.25,1.49]	[1.28,1.62]	[0.03,0.93]	[0.09,1.67]	[0.04,1.04]	[0.11,1.93]	[0.19,0.51]	[0.29,0.62]	[0.27,0.66]	[0.30,0.62]	[0.06,1.24]	[0.18,1.95]
Others	1.26***	1.66***	0.93	0.66***	0.18	0.31	0.39	0.3	0.75	0.83	0.82	0.86	1.24	1.47
	[0.74,1.46]	[0.54,1.80]	[0.66,1.32]	[0.52,0.84]	[0.02,1.16]	[0.04,1.22]	[0.06,1.43]	[0.042,2.14]	[0.46,1.230]	[0.54,1.27]	[0.51,1.32]	[0.57,1.29]	[0.63,1.31]	[0.46,1.78]
Work Status														
Never worked ®														
Currently working	0.93***	0.55***	1.86***	1.49***	0.89	1.86**	1.04	1.87**	2.17***	1.15*	0.94***	0.13*	0.82	1.822***
	[0.67,1.04]		[1.55,2.24]	[1.39,1.59]	[0.31,2.50]	[1.25,2.76]	[0.37,2.92]	[1.27,2.74]	[1.65,2.85]	[1.03,1.29]	[0.53,1.47]	[1.01,1.26]	[0.51,1.31]	[1.40,2.37]
Currently not working	0.71***	0.87***	0.71***	0.83***	0.28*	0.96	0.31*	1.01	0.77	0.77***	0.71**	0.78***	0.54*	1.01
	[0.61,0.83]	[0.82,0.92]	[0.59,0.86]	[0.78,0.90]	[0.09,0.87]	[0.62,1.49]	[0.10,0.95]	[0.70,1.53]	[0.58,1.01]	[0.69,0.86]	[0.56,0.91]	[0.71,0.87]	[0.33,0.87]	[0.76,1.33]
Living arrangement														
Living alone ®														
Living with spouse	0.99	1.12	0.99	1.09	0.17**	0.38	0.16**	0.78	1.11	1.52	1.19	1.63*	0.76	1.4
	[0.76,1.31]	[0.90,1.35]	[0.70,1.40]	[0.85,1.39]	[0.04,0.63]	[0.59,0.57]	[0.05,0.58]	[0.71,1.14]	[0.68,1.82]	[0.98,2.36]	[0.74,1.91]	[1.07,2.49]	[0.26,2.17]	[0.52,3.72]
Living with children	1.1	1.53	1	1.49*	0.42	0.51	0.3	0.69*	1.02	1.46**	1.06	1.54	1.08	1.97**
	[0.87,1.40]	[1.35,1.75]	[0.76,1.38]	[1.27,1.74]	[0.09,0.52]	[0.86,46.3]	[0.07,1.3]	[0.06,0.10]	[0.66,1.60]	[1.13,1.89]	[0.71,1.58]	[1.21,1.96]	[0.47,2.46]	[1.08,3.59]
Region														
North ®														

Central	0.76**	0.77*	0.72	0.75	0.406	1.1	0.41	0.9	0.81*	0.74**	0.83*	0.70***	0.7	0.89
	[0.68,0.84]	[0.70,0.84]	[0.63,0.82]	[0.68,0.83]	[0.130,1.270]	[0.58,2.07]	[0.15,1.15]	[0.49,1.66]	[0.66,0.99]	[0.61,0.90]	[0.69,1.00]	[0.59,0.84]	[0.43,1.15]	[0.5,1.542]
East	0.90*	0.90*	0.77*	0.74	1.011	1.54	0.82	1.3	0.95	0.88	0.97	0.85*	1.19	1.34
	[0.82,0.98]	[0.83,0.967]	[0.68,0.87]	[0.67,0.81]	[0.466,2.190]	[0.90,2.63]	[0.39,1.70]	[0.79,2.16]	[0.80,1.13]	[0.75,1.03]	[0.83,1.14]	[0.73,0.99]	[0.80,1.75]	[0.91,1.98]
Northeast	0.86**	0.76*	0.96	0.81*	0.64	0.37*	0.62	0.44	0.73**	0.72**	0.73**	0.68***	0.72	0.78
	[0.76,0.96	[0.69,0.84]	[0.83,1.10]	[0.72,0.90]	[0.213,1.925]	[0.14,0.93]	[0.22,1.73]	[0.20,1.01]	[0.58,0.91]	[0.58,0.89]	[0.59,0.90]	[0.56,0.83]	[0.42,1.26]	[0.45,1.35]
West	1.04	0.89*	0.93	0.74*	[0.449,2.329]	0.92	0.82	0.84	1.31**	1.06	1.32***	1.05	0.88	1.06
	[0.94,1.14]	[0.83,0.96]	[0.82,1.05]	[0.67,0.81]	1.023	[0.50,1.68]	[0.22,1.09]	[0.48,1.48]	[1.12,1.54]	[0.91,1.23]	[1.14,1.54]	[0.91,1.21]	[0.56,1.38]	[0.70,1.62]
South	1.34	1.11*	1.21*	0.86*	0.54	1.12	0.49	0.97	1.89***	1.59***	1.85***	1.58***	2.02***	2.01***
	[1.23,1.46]	[1.03,1.18]	[1.09,1.34]	[0.80,0.94]	[0.230,1.270]	[0.65,1.92]	[0.22,1.09]	[0.48,1.48]	[1.63,2.182]	[1.39,1.82]	[1.62,2.13]	[1.39,1.78]	[1.42,2.88]	[1.42,2.86]
Adaptive capacity variables														
Education level														
No education ®														
Less than 5 years of schooling	1.47***	1.20***	1.60*	1.44***	1.2	2.90***	1.51	2.86***	1.50***	1.65***	1.47***	1.7***	0.89	1.44*
	[1.36,1.58]	[1.09,1.32]	[1.02,1.32]	[1.31,1.58]	[0.44,3.28]	[1.80,4.68]	[0.61,3.73]	[1.81,4.53]	[1.26,1.81]	[1.42,1.91]	[1.23,1.76]	[1.49,1.95]	[0.58,1.35]	[1.01,2.04]
5-9 years of schooling	2.06***	1.12***	1.74***	1.21***	2.15*	2.20***	1.98	2.28***	2.29***	1.31***	2.26***	2.28***	1.75***	1.89***
	[1.94,2.18]	[1.50,1.32]	[1.57,1.92]	[1.06,1.38]	[1.01,4.54]	[1.39,3.50]	[0.96,4.11]	[1.47,3.55]	[1.97,2.67]	[1.06,1.60]	[1.97,2.61]	[2.05,2.54]	[1.31,2.35]	[1.43,2.50]
10 & above years of schooling	2.22***	1.03***	2.40***	1.06***	2.31*	2.63***	2.42*	2.19***	3.40***	1.13***	3.32***	2.66***	1.35	1.53*
	[2.07,2.38]	[0.91,1.24]	[2.16,2.66]	[0.77,1.37]	[1.04,5.14]	[1.53,4.51]	[1.13,2.70]	[1.60, 2.24]	[2.92,3.95]	[0.40,1.22]	[2.88,3.82]	[2.35,3.00]	[0.96,1.88]	[1.07,2.21]
MPCE_ quintile														
Poorest ®														

Poorer	1.20**	1.15**	1.11	1.2	1.18	1.43	1.04	1.34	1.46***	1.04	1.40***	1.06	1.17	1.08
	[1.02,1.39]	[1.04,1.26]	[0.98,1.25]	[0.97,1.21]	[0.44,3.17]	[0.82,2.52]	[0.40,2.71]	[0.78,1.41]	[1.23,1.74]	[0.90,1.22]	[1.19,1.65]	[0.92,1.22]	[0.79,1.73]	[0.73,1.58]
Middle	1.49***	1.23***	1.23***	1.32***	1.36	1.16	1.41	1.25	1.42***	1.19*	1.39***	1.21**	1.36	1.21
	[1.11,1.69]	[1.12,1.35]	[1.09,1.39]	[1.11,1.53]	[0.52,3.53]	[0.61,2.01]	[0.58,3.43]	[0.71,2.18]	[1.19,1.69]	[1.03,1.382]	[1.18,1.63]	[1.06,1.39]	[0.94,1.99]	[0.83,1.77]
Richer	1.59***	1.41***	1.37***	1.40***	2.05	1.49	1.89	1.43	1.75***	1.34***	1.69***	1.37***	1.33	1.56*
	[1.19,1.61]	[1.28,1.54]	[1.22,1.54]	[1.22,1.47]	[0.83,5.02]	[0.84,2.63]	[0.81,2.24]	[0.83,2.48]	[1.48,2.07]	[1.16,1.55]	[1.44,1.97]	[1.20,1.57]	[0.91,1.94]	[1.08,2.23]
Richest	1.70***	1.54***	1.53***	1.58***	1.94	1.96*	1.88	1.88*	2.04***	1.59***	1.96***	1.60***	1.39	2.03***
	[1.43,1.81]	[1.41,1.69]	[1.36,1.72]	[1.46,1.63]	[0.77,4.89]	[1.12,3.45]	[0.79,2.11]	[1.09,2.02]	[1.73,2.41]	[1.38,1.84]	[1.68,2.29]	[1.39,1.83]	[0.94,2.04]	[1.42,2.90]

Note: Dependent variable: "1" denotes the onset of a specific disease earlier than the median age for the onset of specific diseases in the population; "0" denotes otherwise.

Time variable: Current age of the respondent

Mechanisms of gender heterogeneous patterns of onset of NCDs

Decomposition analysis

Figure 6 illustrates the results of the multivariate decomposition analysis, revealing the relative proportional contributions of key exposure and adaptive capacity variables to the gap in the onset of NCDs between men and women in India. The key exposure and adaptive capacity variables explain around 52.4% of the overall gender differences in the onset of NCDs.

Among the key exposure variables, differences in work status (26.8 % contribution) and marital status (4.2% contribution) among men and women contributed the most to explaining the gender gap in the onset of NCDs. Additionally, among the adaptive capacity variables, the heterogeneity in age distribution contributes 17.1% to the gender gap proportion of people experiencing the onset of NCDs before the median age. To further investigate the contribution made by marital status, work status and age to the gender differences in the onset of NCDs, we plotted the distribution of male and female populations by marital status, work status, and age. The result presented in Figure 7 illustrates the stark differences in the distribution of work status, age, and marital differences by gender in the sample. This probably explains that differential marital, work status and age-group-wise distribution of men and women are the underlying mechanisms of the gendered heterogeneous pattern in the onset of NCDs.

The residual effects show that significant parts of the gender differences in the onset of NCDs remain unexplained. However, this can be attributable to the third component that we have highlighted in our analytical framework, i.e., the *sensitivity effect*. Although we incorporated a broad set of socio-economic and demographic factors as exposure and adaptive capacities variables in our analysis, many other factors, such as biological and genetic factors, likely play a key role, which we have not included in our study, thus observed in the residual and can be attributed to the *sensitivity effect*. Supplementary Table S4 gives complete details of the decomposition analysis.

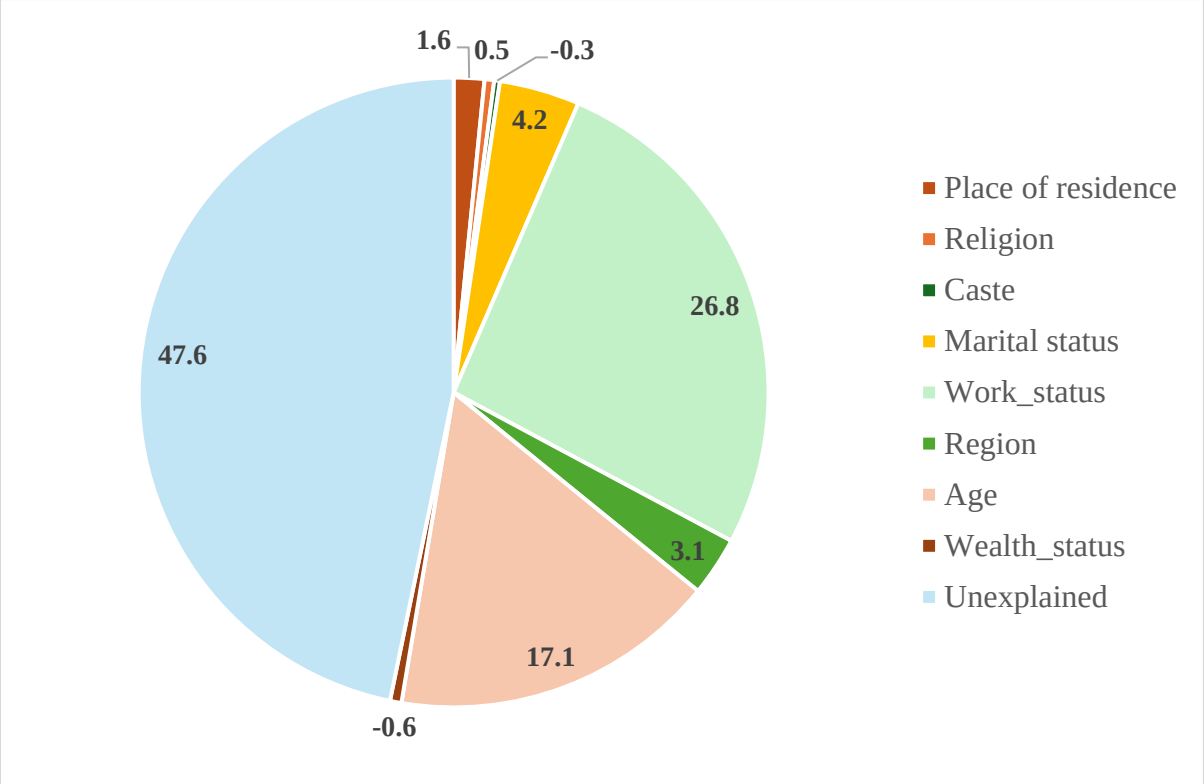
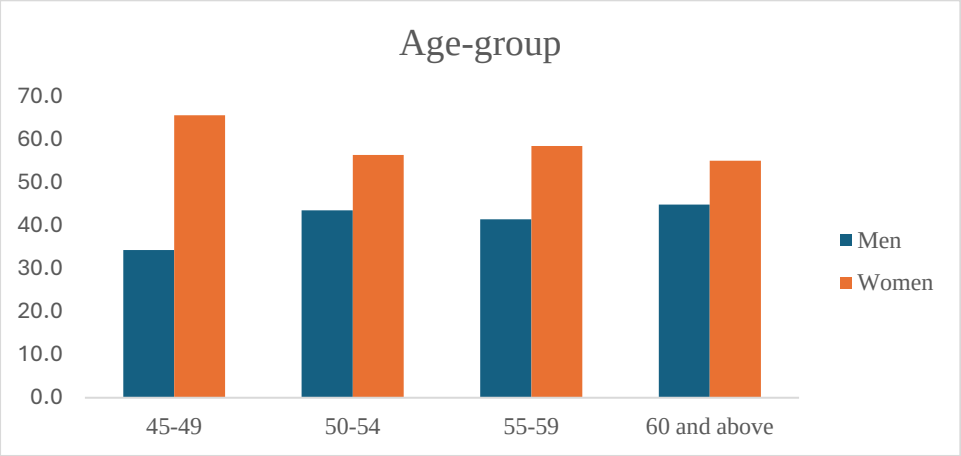


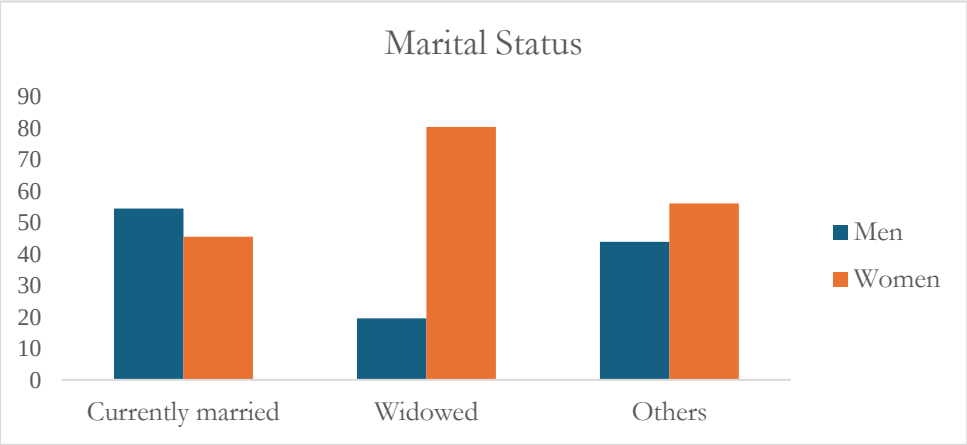
Figure 6: Percentage contribution of select explanatory factors to the gender gap in the onset of NCDs among older adults

Note: Education was excluded from the decomposition analysis due to the high degree of multicollinearity between education and other explanatory variables, which can distort the results. Additionally, education exhibits a strong non-linear relationship with the onset of non-communicable diseases due to self-reporting biases that are difficult to account for. Consequently, both the percentage contribution and the statistical significance of education are insignificant.

(A)



(B)



(C)

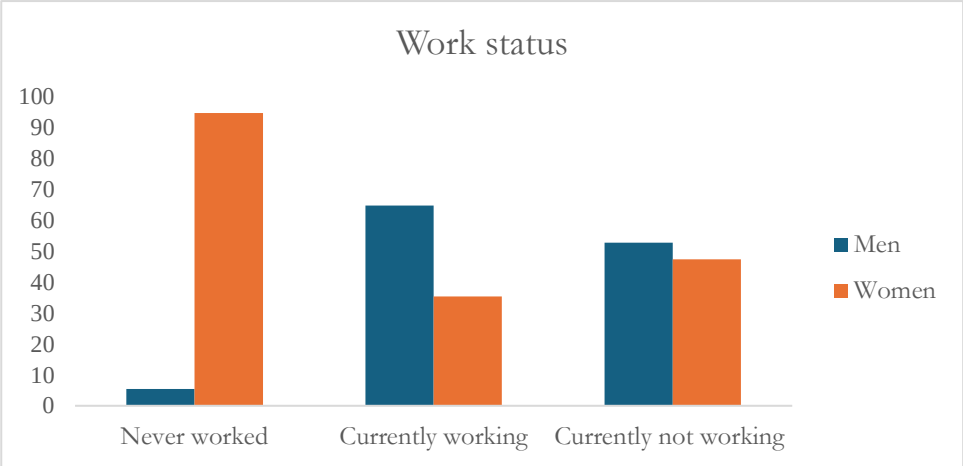


Figure 7**:** key mechanisms explaining the gendered heterogeneous pattern of the onset of NCDs

Discussion

In this study, we examined the gendered pattern of the onset of NCDs among older adults in India. Further, we explored the mechanisms behind the gendered pattern of the onset of NCDs by using two hypotheses: 'differential exposure' and 'differential vulnerability.' Although a significant body of research documented the gender differences across various health measures by age spectrum and in different contexts, the influence of gender-sensitive roles in the onset of NCDs has received limited attention, particularly in India. The age at onset of NCDs is a crucial indicator for assessing the extent to which the increased life expectancy equates to a healthy life expectancy.

The findings from this study indicate that the age at onset of NCDs is sensitive to gender roles. Compared to men, women have a higher relative risk of early onset of NCDs than the median age at onset in the population, even after adjusting for various exposure and adaptive capacity variables, including place of residence, marital status, work status, religion, caste, region, living arrangement, education level, and economic status. Once exposure and adaptive capacity variables are controlled separately for men and women, we observe a statistically higher relative risk of early onset of NCDs among widowed women than widowed men. Because of the uniquely vulnerable position of women in India (Kashyap & Behrman,2020; Weitzman 2020; Coffey et al.,2022), widowhood creates additional layers of disadvantage (Lamb,2000; Chen, 2000; Hossain et al.,2023), leading to a higher relative risk of early onset of NCDs among women. Further, the findings from the decomposition analysis highlight that among the key exposure and adaptive capacity variables, work status, age, and marital differences by gender in the sample contribute maximum in explaining the higher relative risk of early onset of NCDs among women. An assessment of the distribution of the men and women sample across the marital status shows a greater occurrence of widowhood for women than men. Furthermore, unlike men, a notable proportion of women are not participating in the workforce. Additionally, the age distribution of the sample reveals a greater percentage of women in all age groups than men, possibly due to higher expectancies in females at higher ages. The contrasting distribution of men and women samples across the characteristics of marital status, age, and work status of men and women could potentially provide a viable explanation for the gender-sensitive pattern in the onset of NCDs.

In line with previous research, our findings also suggest that widowhood and unemployment are significant life events that can trigger persistent stress, which is strongly associated with negative health consequences, particularly cardiovascular disease (Fremont & Bird, 1999). The higher prevalence of widowhood and unemployment among women may exacerbate chronic stress, further increasing their risk of early onset of NCDs. Additionally, the higher percentage of women compared to men across all age groups underscores their increased vulnerability to early-life social disadvantages, which contributes to a higher risk of early onset of NCDs, as the occurrence of chronic diseases in later life is closely related to life course adversities (Ben-Shlomo & Kuh, 2002).

- *The role of marital status in explaining the gender differences in the onset of NCDs*

Marital status is a significant determinant of health, influencing the onset and progression of chronic diseases through mechanisms such as social support, economic stability, and health behaviours. Existing evidence suggests that marriage fosters social ties and extensive social engagement, making it a valuable norm that provides a support system for coping with adversities and daily hassles. Conversely, widowhood is one of the most stressful events a person can experience, often leading to both acute and chronic stress due to declining living standards, disrupted social networks, loss of social support and feelings of loneliness (Marks & Lambert, 1998; Thurston & Kubzansky, 2006) which may contribute to negative health outcome (Hossain et al.,2021) particularly cardiovascular events (Fagundes et al., 2019).

In India, a country with rigid gender norms and traditional kinship systems (Dreze & Srinivasan,1997 & Gwatkin et al.,2007), women face unique vulnerabilities associated with the stigma of widowhood (Lamb, 2000; Chen 2000, Azeez et al.,2023). Traditionally, in Indian culture, the social position of the woman is attached to the husband's socio-economic situation; therefore, losing a husband early pushes woman into a precarious phase characterized by severe poverty, and a lack of social support (Dasgupta,2017, Mohindra, et al.,2012), and the inability to remarry. Existing evidence suggests that the societal stigma and poor socio-economic status associated with widowhood significantly correlate with negative health outcomes (Perkins et al.,2016), particularly for women.

- *The role of work status in explaining the gender differences in the onset of NCDs*

The higher prevalence of unemployment among women also plays a significant role in the gendered heterogeneous pattern in the onset of NCDs. The economic hardships associated with unemployment are often linked to chronic stress, which can, in turn, increase the likelihood of developing chronic diseases at an earlier age (Fremont & Bird, 1999). Furthermore, employment often provides a social network and regular interaction with others. Unemployed women may experience social isolation, leading to feelings of loneliness, which can elevate the levels of stress and anxiety and increase the risk of chronic diseases. Previous studies suggested that there is a positive association between unemployment and systolic blood pressure, blood glucose, and total cholesterol (Kozieł et al., 2010). It has also been suggested that the biological mechanism connecting unemployment and ill health involves the process of inflammation, which is also a common cause of cardiovascular diseases (Hintikka et al., 2009).

Working women often gain more exposure to information about illnesses and healthcare through their workplaces, which boosts their understanding of health-related issues. This increased awareness helps them recognize symptoms more effectively, understand the importance of timely medical care, and communicate their health concerns clearly to healthcare providers, thereby reducing their risk of developing NCDs at an earlier stage.

Employment, especially in active occupations, contributes to higher levels of physical activity. Regular physical activity reduces the risk of many NCDs, including cardiovascular diseases and diabetes. Women who are not working may have fewer opportunities for physical activity,

leading to sedentary lifestyles that contribute to the early onset of chronic diseases (Church et al.,2010; Reiner et al.,2013 & Dishman et al.,2021).

- *The role of age-wise distribution of men and women in explaining the gender differences in the onset of NCDs*

The contrasting age-wise distribution of men and women in the sample could potentially provide a viable explanation for the gendered heterogeneous pattern in the onset of NCDs. The current study reveals a significantly higher percentage of women than men in the higher age groups, highlighting their increased vulnerability to early-life social disadvantages, which leads to a higher risk of developing chronic diseases at an earlier age.

The occurrence of chronic diseases in the later stages of life is closely related to life course adversities (Ben-Shlomo & Kuh, 2002, Elder & Janet Giele,2009). Evidence suggests that childhood socio-economic status is associated with chronic conditions in adults (Kuh & Shlomo, 2004; McEniry, 2013). Due to early life social disadvantages, women are more likely to accumulate socio-economic adversities throughout their lives, leading to adverse health outcomes (Artazcoz et al., 2004; Doyal, 2004; Alvarado et al., 2008). Vikram et al. (2023) also found that psychosocial and reproductive stressors associated with child marriage contribute to the development of early chronic diseases among women. Additionally, they identified early motherhood as an important risk factor for these conditions.

In India, where societal norms are deeply embedded in the cultural framework, women often face social disadvantages from childhood, cumulatively impacting their health and increasing the risk of early onset of NCDs. Vikram et al. (2023) found that child marriage places women on a negative health trajectory, increasing their risk of chronic diseases in India. Child marriage is a stressful transition that forces young girls into adult roles, leading to the development of secondary stressors that extend beyond reproductive challenge (Vikram ,2021). These women face a higher risk of violence, lack of empowerment over critical life decisions, social isolation due to patrilocal exogamy, and lower marital quality, all of which contribute to psychosocial stress. The early onset of NCDs among women is likely a result of these accumulated disadvantages over the course of their lives.

The results also show that, despite having similar levels of adaptive capacity through education and wealth status, men and women exhibit contrasting patterns of vulnerability to the early onset of NCDs. For both men and women, the relative risk of early onset of any NCD than the median age is higher among the richest groups. However, the relative risk for the early onset of any NCD is significantly higher for the richest men than for the richest women. Additionally, among men, there is a positive linear association between education and the onset of NCDs. In contrast, for women, an increase in education level is associated with a reduced relative risk of early onset of NCDs. This gender heterogeneous pattern in the association between education, wealth status, and the onset of NCDs may be attributed to self-reporting biases. Compared to those in lower-income groups, individuals in the richest quintile are more likely to report diseases accurately due to better access to diagnosis and greater health knowledge (Sommers et al.,2012; Aguila et al.,2015). Similarly, higher education is viewed as social capital that

enhances the reporting of illnesses and healthcare-seeking behavior, thereby improving overall health outcomes (Barik et al.,2018). However, the benefits of education and economic status in terms of social capital are not equally distributed between men and women. Unquantifiable cultural factors, often prevent women from fully benefiting from educational and economic advancements in the form of better healthcare and health outcomes. A study by Kundu et al. (2024) supports this finding that the observed gendered heterogeneous pattern in the association of education and NCDs is deceptive due to self-reporting bias in morbidity. This study found that although education is a key agency factor for women, structural discrimination in institutions such as the labour market and marriage and also unquantifiable cultural factors prevent them from reaping educational dividends in the form of good health care and outcomes.

Limitations

The current study is not without limitations. First, the present study considered self-reported chronic diseases ever diagnosed by a health care provider as only limited biometric information was accessible for a few specific conditions. The self-reported disease prevalence is subject to recall bias and is influenced by respondents' level of knowledge and willingness to report their health condition.

Second, the question on onset was asked only to those who self-reported being diagnosed with the conditions. Those who were unaware of their condition but had been diagnosed with a condition using a biomarker were not asked any questions on the onset of the disease. We know that a significant portion of people in developing nations like India (especially in rural areas) do not receive adequate medical attention on time and are left undiagnosed at the actual age of disease origin, so the age of onset measure may be underreported.

Furthermore, the study's cross-sectional design makes it impossible to establish the causal relationships.

Conclusion

The onset of non-communicable disease is a key measure for not only health care management but also a critical component that can predict the quality of human capital and economic outcomes. Although gender disparity in health is well established, this study demonstrates the relevance of examining gendered patterns in the onset of NCDs by highlighting the underlying social mechanisms contributing to the gender-sensitive pattern in the onset of NCDs. This study provides novel evidence of linkages between local gender norms and the early onset of NCDs for Indian women. Importantly, the findings suggest that despite potential biological advantages in survival rates, women are not necessarily leading healthier lives. Societal norms and gender stereotypes play a substantial role in contributing to the early onset of NCDs among women in India. Therefore, a reduction in discriminatory gender norms could potentially narrow the gap in the early onset of NCDs between men and women.

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Competing interests
The authors declare no competing interests.

Ethical approval
Not required

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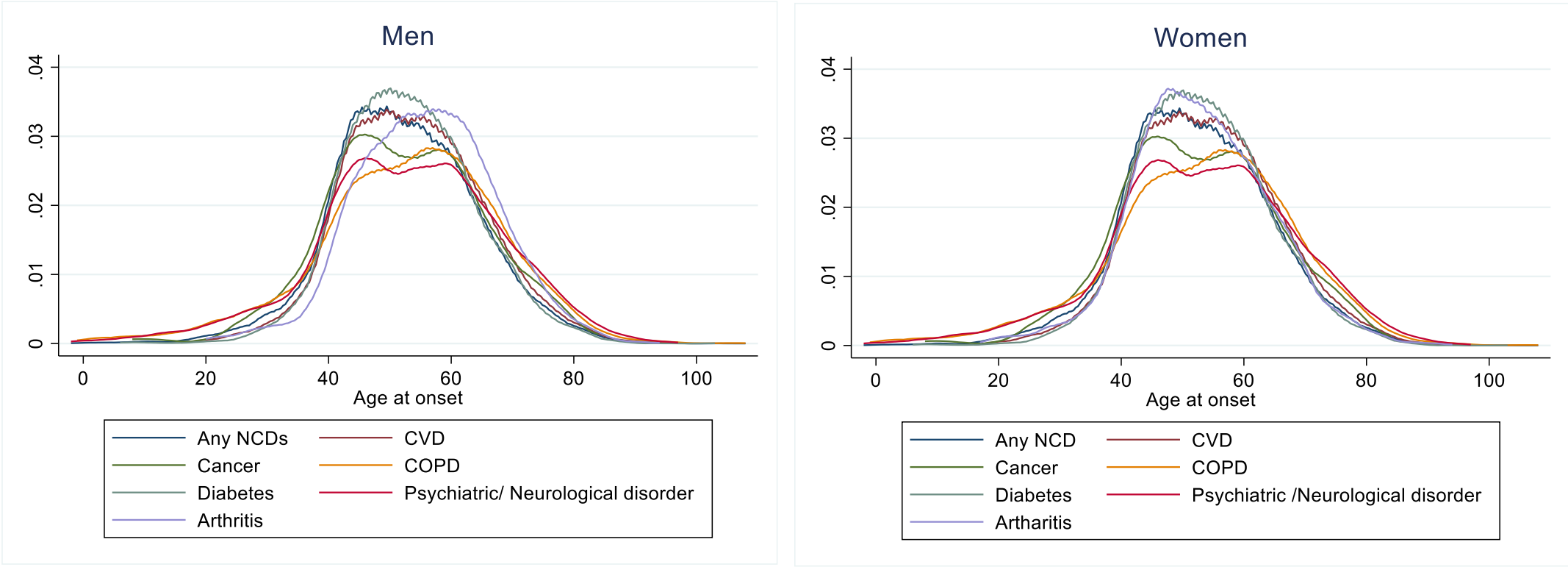
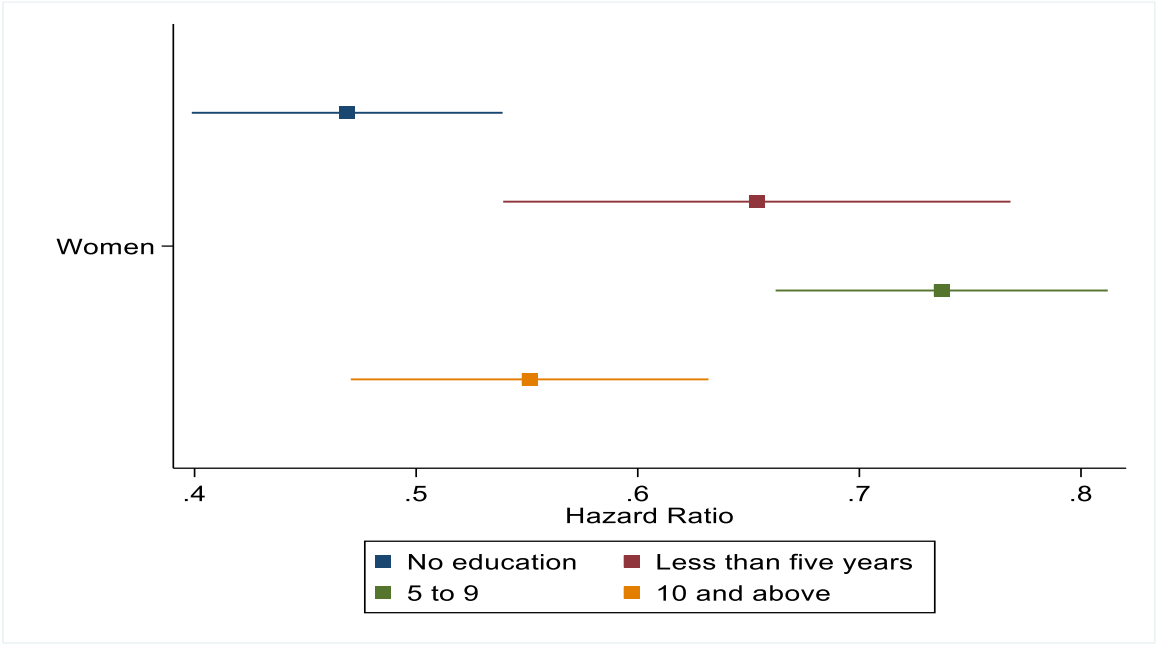
Supplementary Table S1: Definition of variables/measures and their recoding

Variables	Definition/measures and recoding
Dependent variable	
Onset of non-communicable diseases	The age of disease onset was derived from a direct question in the survey: "When were you first diagnosed (by health professionals) with the specific chronic disease in years or age?". Six medically diagnosed self-reported non-communicable diseases such as CVD, cancer, chronic obstructive pulmonary disease, diabetes, arthritis, and neurological / psychiatric disorder were used in this study.
Predictor variables	
Gender	Gender was categorised as "Men" and "Women". Men was used as the reference category.
Exposure variables	
Place of Residence	Place of residence was categorised as – "Rural" and "Urban". Rural was used as the reference category.
Religion	Religion was categorised as Hindu, Muslim, Christian and others. Hindu was used as the reference category.
Caste	Caste was categorised as "Scheduled caste", "Scheduled tribe", "OBC" and Others. Scheduled caste used as a reference category.
Living-arrangement	Living arrangement was categorised as "living alone", "living with a spouse and children", and "living with children and others". Living alone was used as a reference category.
Working status	Working status was categorised as "never worked", "ever worked but currently not working" and "currently working". Never worked used as a reference category.
Region	Region was categorised as "North", "Central", "East", "West", "North-east" and "South". North region used as a reference category.
Adaptive capacity variables	
Age-group	Age-group was categorised into four groups- 45-49,50-54,55-59,60 and above.
Level of education	Level of education of the respondent was categorised as; "No education", "less than 5 years of schooling", "5-9 years of schooling", "10 and above years of schooling". No education was used as reference category.
Monthly-per-capita-expenditure (MPCE Quintile	MPCE quintile was categorised into four groups: "Poorest", "Poorer", "Middle", "Richer", and "Richest". Poorest quintile was used as reference category.

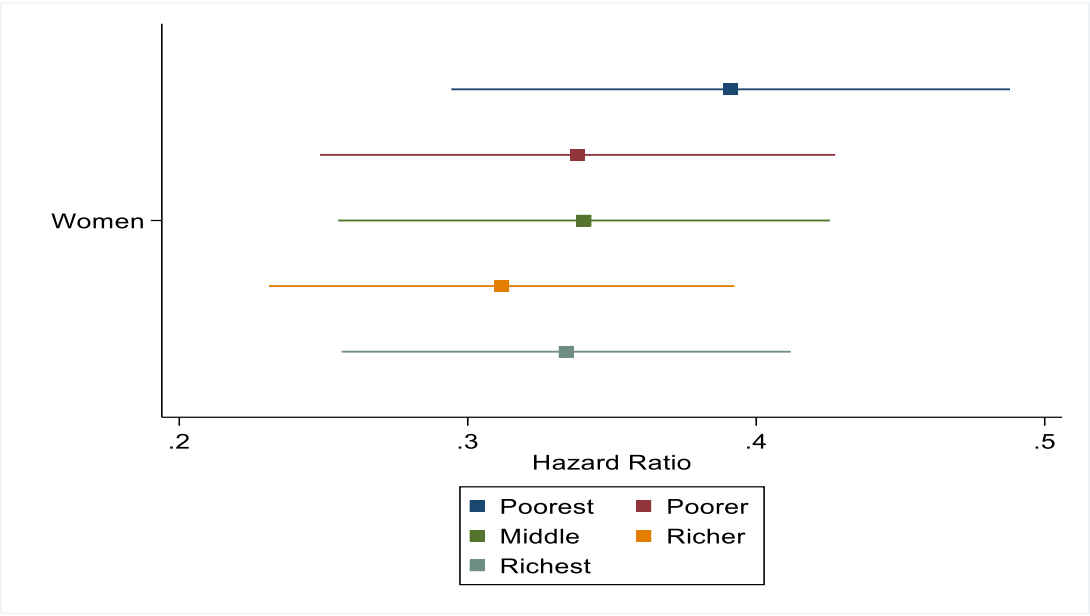


Supplementary Figure S1: Kernel Density Plot for age at onset of at least one NCD, CVDs, Cancer, COPD, Diabetes, Arthritis, and Psychological/Neurological disorder

(A) Education Level



(B) Wealth Status



Supplementary Figure S2: Heterogeneous effects of education and wealth status on the gender-sensitive patterns in the onset of non-communicable diseases

Supplementary Table S2: Mean age at onset (years) of cardiovascular disease, cancer, and chronic obstructive pulmonary diseases across various exposure and adaptive capacity variables

Characteristics	Cardiovascular disease				Cancer				COPD			
	Men		Women		Men		Women		Men		Women	
	Mean (SD)	P value	Mean (SD)	P value	Mean (SD)	P Value	Mean (SD)	P Value	Mean (SD)	P Value	Mean (SD)	P Value
Exposure variables												
Residence												
Rural	56.1 (11.7)	<0.001	54.1 (11.3)	<0.001	56.1 (11.3)	0.899	49.8 (13.2)	0.322	55.0 (14.5)	<0.001	53.1 (14.9)	<0.001
Urban	53.3 (10.8)		52.0 (10.9)		55.9 (13.7)		51.2 (10.7)		51.8 (14.3)		50.7 (14.8)	
Religion												
Hindu	54.7 (11.3)	0.504	53.3 (11.2)	<0.001	55.9 (11.6)	0.269	50.0 (12.1)		53.9 (14.6)	0.392	52.1 (14.7)	0.372
Muslim	55.3 (10.6)		52.1 (11.1)		54.0 (14.3)		48.9 (14.1)		54.0 (14.4)		52.1 (16.1)	
Christean	54.9 (12.6)		54.0 (11.7)		55.3 (15.2)		51.8 (11.2)	0.191	56.2 (14.2)		51.7 (15.3)	
Others	55.3 (11.8)		52.9 (11.5)		64.0 (8.2)		56 (8.7)		53(13.9)		55.4 (14.1)	
Caste												
Scheduled Caste	54.2 (11.2)	0.246	52.9 (11.3)	0.234	54.5 (12.3)	0.199	50.1 (9.9)	0.049	53.6 (13.5)	0.942	51.9 (14.0)	0.059
Scheduled Tribe	54.7 (11.9)		53.3 (11.3)		53.1 (12.8)		49.9 (14.8)		54.3 (15.3)		53.8 (15.6)	
Other backward class	55.0 (11.3)		53.4 (11.1)		54.6 (10.5)		48.0 (11.8)		54.1 (14.1)		51.3 (14.8)	
Others	54.9 (11.4)		52.9 (11.4)		58.3 (13.2)		52.8 (12.3)		53.9 (15.4)		53.2 (15.3)	
Marital status												
Currently married	62.9 (11.3)	<0.001	57.9 (11.7)	<0.001	66.3 (14.8)	<0.001	55.9 (13.0)	<0.001	60.6 (16.1)	<0.001	57.6 (15.0)	<0.001
Widowed	52.5 (11.9)		49.9 (9.7)		38.3 (26.3)		47.4 (10.7)		50.1 (14.9)		48.0 (13.4)	
Others (Never married/divorced/separated/deserted/live-in-relationship)	54.0 (10.9)		50.3 (10.6)		55.5 (11.2)		53 (10.9)		53.2 (13.9)		48.2 (13.9)	
Living arrangement												
Living alone	57.1 (12.7)	<0.001	58.3 (11.0)	<0.001	38.5 (20.7)	<0.001	58.0 (9.0)	<0.001	58.7 (16.0)	<0.001	56.2 (14.5)	<0.001
Living with spouse, children, and/or others	53.9 (10.9)		50.0 (9.7)		55.7 (11.2)		47.4 (10.6)		53.3 (13.9)		48.0 (13.4)	
Living with children and/or others	60.5 (12.4)		56.9 (11.9)		64.1 (14.7)		55.5 (13.1)		58.5 (16.3)		56.9 (15.2)	
Working status												

Currently working	50.4 (9.7)	<0.001	49.2 (9.2)	<0.001	49 (9.4)	<0.001	45.1 (9.9)	<0.001	49.3 (13.0)	<0.001	46.2 (11.8)	<0.001
Ever worked but currently not working	59.3 (11.2)		56.2 (11.8)		61.8 (10.6)		55 (14.0)		58.3 (14.5)		55.6 (13.9)	
Never worked	56.9 (11.9)		53.2 (11.2)		52 (17.4)		50.2 (11.0)		52.6 (13.4)		52.3 (15.9)	
Region												
Northern	54.9 (11.2)	<0.001	52.2 (11.2)	<0.001	57.9 (12.0)	0.719	51.1 (11.3)	0.008	54.8 (13.4)	0.021	53.0 (14.7)	0.076
Central	54.3 (11.5)		52.6 (10.8)		54.4 (7.7)		44.3 (12.3)		55.2 (12.5)		52.4 (15.0)	
Eastern	56.6 (11.2)		53.9 (11.4)		55.2 (12.5)		46.9 (13.3)		53.5 (15.9)		52.9 (15.5)	
North-eastern	54.9 (12.5)		53.5 (12.0)		53.8 (14.6)		54.2 (10.6)		56.6 (14.8)		54 (15.4)	
Western	54.3 (10.9)		53.7 (10.9)		57.6 (11.8)		52.9 (10.7)		52.2 (14.8)		52.8 (14.1)	
Southern	54.1 (11.1)		53.3 (11.1)		54.6 (13.5)		51.6 (12.2)		53.1 (15.0)		50.7 (14.9)	
Adaptive capacity variable												
Age group												
45-49	40.9 (4.9)	<0.001	40.7 (5.1)	<0.001	42.3 (4.6)	<0.001	39.5 (7.7)	<0.001	37.2 (8.8)	<0.001	37.6 (8.8)	<0.001
50-54	45.2 (5.4)		50 (5.8)		45.5 (5.4)		42.9 (7.6)		42.7 (8.3)		42.4 (9.1)	
55-59	49.6 (6.0)		49.3 (6.2)		49.3 (10.1)		47.4 (7.3)		47.6 (9.7)		45.2 (10.8)	
60 & above	60.6 (9.8)		59.5 (9.9)		61.7 (10.7)		58.1 (11.2)		59 .4(13.3)		58.8 (13.6)	
Education Level												
No education	57.6 (11.6)	<0.001	55.3 (11.3)	<0.001	59.7 (12.1)	0.223	51.8 (14.0)	0.425	56.8 (13.2)	<0.001	54.9 (14.7)	<0.001
Less than 5 years	57.1 (11.9)		54.3 (11.1)		55.3 (13.5)		49.1 (9.9)		54.2 (15.6)		51.3 (15.3)	
5-9 years completed	54.6 (11.1)		50.1 (10.4)		54.8 (13.5)		49.6 (11.0)		53.2 (13.8)		48.1 (13.2)	
10 years or more	52.4 (10.7)		48.5 (9.6)		54.9 (10.5)		49.1 (9.9)		49.3 (15.7)		44.0 (14.4)	
MPCE Quintile												
Poorest	55.8 (11.6)	<0.001	53.8 (11.1)	<0.001	53.4 (8.2)	0.069	50.5 (10.8)	0.832	55.1 (14.2)	0.287	52.8 (14.4)	0.472
Poorer	55.3 (10.9)		54.1 (10.9)		54.5 (12.3)		46.7 (13.4)		54.2 (14.4)		53.0 (15.0)	
Middle	54.7 (11.3)		53.4 (11.5)		51.0 (14.6)		50.4 (12.5)		52.8 (14.9)		52.6 (15.7)	
Richer	54.8 (11.9)		53.0 (11.2)		56.2 (13.6)		50.6 (12.5)		53.7 (14.3)		51.3 (15.1)	
Richest	54.0 (11.1)		52.0 (11.2)		58.9 (10.8)		51.4 (11.7)		54.3 (14.6)		51.6 (14.3)	

Supplementary Table S3: Mean age at onset (years) of Diabetes, Arthritis, and Psychiatric /Neurological disorder across various exposure and adaptive capacity variables

Characteristics	Diabetes				Arthritis				Psychological/Neurological disorder			
	Men		Women		Men		Women		Men		Women	
	Mean (SD)	P value	Mean (SD)	P value	Mean (SD)	P Value	Mean (SD)	P Value	Mean (SD)	P Value	Mean (SD)	P Value
Exposure variables												
Residence												
Rural	54.8 (10.9)	<0.001	54.2 (10.4)	<0.001	55.9 (11.2)	0.848	53.5 (11.2)	0.004	53.6 (14.4)	0.13	53.4 (15.3)	0.472
Urban	52.4 (10.7)		52.0 (10.1)		56.0 (10.8)		52.6 (10.9)		51.8 (15.1)		52.6 (14.1)	
Religion												
Hindu	53.4 (10.8)	0.994	53.1 (10.2)	0.036	55.9 (11.6)	0.072	50.0 (12.1)	<0.001	53.9 (14.6)	0.238	52.1 (14.7)	0.985
Muslim	53.5 (10.5)		51.9 (10.3)		54.0 (14.3)		48.9 (14.1)		54.0 (14.4)		52.1 (16.1)	
Christean	53.5 (11.5)		53.3 (10.5)		55.3 (15.2)		51.8 (11.2)		56.2 (14.2)		51.7 (15.3)	
Others	53.6 (10.8)		53.4 (10.6)		64.0 (8.2)		56.0 (8.7)		53.0(13.9)		55.3 (14.1)	
Caste												
Scheduled Caste	53.4 (10.5)	0.239	52.4 (10.1)	0.296	54.5 (12.3)	0.898	50.1(10.0)		53.6 (13.5)	0.658	51.9 (14.0)	0.768
Scheduled Tribe	54.1 (10.8)		53.1 (9.9)		53.1 (12.8)		49.9(14.8)		54.3 (15.3)		53.8 (15.6)	
Other backward class	53.1 (10.8)		52.8 (10.3)		54.6 (10.5)		48.0 (11.8)	0.542	54.1 (14.1)		51.3 (14.8)	
Others	53.7 (11.1)		53.2 (10.4)		58.3 (13.2)		52.8 (12.3)		53.9 (15.4)		53.2 (15.3)	
Marital status												
Currently married	52.8 (10.6)	<0.001	50.7 (8.9)	<0.001	55.2 (10.8)	<0.001	50.0 (9.6)	<0.001	52.2 (14.0)	<0.001	48.9 (11.6)	<0.001
Widowed	61.7 (11.1)		57.1 (11.1)		63.3 (10.9)		58.2 (11.4)		63.6 (14.4)		59.1 (15.4)	
Others (Never married/divorced/separated/deserted/live-in-relationship)	52.2 (10.3)		50.2 (11.0)		53.2(10.5)		50.6 (9.9)		45.8 (16.7)		42.7 (18.7)	
Living arrangement												
Living alone	56.1 (10.9)	<0.01	57.9 (10.3)	<0.001	62.8 (12.3)	<0.001	58.6 (10.4)	<0.001	53 (17.6)	0.034	56.3 (14.5)	<0.001
Living with spouse, children, and/or others	52.8 (10.6)		50.7 (8.9)		55.2 (10.8)		50.0 (9.6)		52.3 (13.9)		49.1 (11.5)	

Living with children and/or others	59.2 (11.6)		56.1 (11.4)		60.1 (11.7)		57.2 (11.6)		56.5 (17.8)		57.3 (16.9)	
Working status												
Currently working	49.4 (9.0)	<0.001	49.2 (8.3)		51.6 (9.9)		49.5 (8.7)		47.4 (13.0)		46.4 (10.7)	<0.001
Ever worked but currently not working	57.6 (11.0)		55.7 (11.0)	<0.001	61.1 (10.1)	<0.001	56.3 (11.6)	<0.001	57.6 (13.8)	<0.001	56.5 (14.7)	
Never worked	55.9 (11.5)		52.7 (10.1)		58.0 (11.7)		53.0 (11.2)		54.1 (18.9)		53.7 (15.5)	
Region												
Northern	53.1 (10.6)	<0.001	52.6 (10.4)	0.065	55.4 (10.8)	0.190	52.1 (10.9)	<0.001	52.4 (15.9)	0.339	52.0 (13.7)	0.213
Central	54.3 (10.2)		53.2 (10.6)		55.9 (10.2)		52.2 (10.3)		54.8 (14.3)		54 (15.4)	
Eastern	55 (10.6)		53.4 (10.9)		55.2 (11.6)		52.5 (11.8)		54.2 (13.9)		55.7 (15.8)	
North-eastern	54.7 (11.7)		53.9 (10.6)		54.8 (12.8)		53.6 (11.5)		55.3 (14.9)		51.8 (11.8)	
Western	52.9 (11.4)		53.5 (10.2)		56.5 (11.1)		54.2 (10.8)		50.4 (13.5)		51.0 (16.0)	
Southern	52.8 (10.7)		52.5 (9.9)		56.4 (10.8)		53.6 (10.9)		52.2 (14.9)		52.9 (14.7)	
Adaptive capacity variable												
Age group												
45-49	41.13 (4.4)	<0.001	41.3 (4.6)	<0.001	40.9 (5.4)	<0.001	40.8 (5.4)	<0.001	37.7 (8.2)	<0.001	37.9 (9.1)	<0.001
50-54	45.5 (4.9)		45.6 (5.0)		45.8 (5.4)		45.3 (5.6)		42.3 (9.1)		41.9 (8.2)	
55-59	48.8 (6.4)		49.2 (6.1)		50.4 (5.6)		50.0 (5.7)		48.0 (10.2)		46.3 (10.1)	
60 & above	58.8 (10.0)		58.6 (9.3)		61.4 (9.1)		59.7 (9.8)		60.4 (12.7)		61.5 (12.2)	
Education Level												
No education	56.3 (11.6)	<0.001	55.0 (10.7)	<0.001	57.2 (10.7)	<0.001	54.7 (11.3)	<0.001	57.6 (13.4)	<0.001	55.5 (15.2)	<0.001
Less than 5 years	55.5 (11.4)		54.3 (9.9)		56.9 (11.6)		53.5 (10.9)		55.6 (12.5)		49.5 (15.1)	
5-9 years completed	53.2 (10.4)		51.1 (9.7)		54.5 (11.2)		50.5 (10.1)		47.7 (15.7)		50.3 (12.7)	
10 years or more	52.1 (10.4)		49.5 (8.8)		54.8 (10.9)		49.4 (9.8)		51.5 (14.0)		47.2 (13.1)	
MPCE Quintile												
Poorest	55.0 (10.6)	0.004	53.8 (10.3)	0.007	56.3 (11.1)	0.596	52.8 (10.7)	<0.001	54.3 (16.1)	0.552	54.2 (14.4)	0.153
Poorer	53.1 (10.6)		53.1 (10.0)		55.7 (11.0)		53.8 (11.4)		51.6 (15.3)		55.2 (15.8)	
Middle	53.8 (11.0)		53.4 (10.4)		56.5 (11.2)		53.9 (11.3)		52.0 (14.7)		53.6 (15.7)	
Richer	53.5 (11.3)		52.8 (9.9)		55.7 (11.2)		53.0 (11.1)		53.0 (14.4)		52.0 (15.0)	

Richest	52.8 (10.6)		52.1 (10.5)		55.6 (10.9)		52.2 (10.8)		53.8 (13.5)		51.4 (13.5)	

Supplementary Table S4: Multivariate logistic regression decomposition estimates for gender differentials in the onset of non-communicable diseases among older adults in India, 2017–2018

Variables	Due to differences in characteristics				
	Coefficient	SE	P value	Percentage contribution	
Exposure effect					
Place of Residence					
Rural					1.6
Urban	0.00094	0.00006	0.000	1.6	
Religion					
Hindu					0.5
Muslim	0.00026	0.00003	0.000	0.5	
Christean	0.00008	0.00002	0.001	0.1	
Other	-0.00006	0.00002	0.001	-0.1	
Caste					
Scheduled Caste					-0.3
Scheduled Tribe	-0.00014	0.00002	0.000	-0.2	
Other backward class	0.00000	0.00003	0.884	0.0	
Others	-0.00002	0.00000	0.000	0.0	
Marital status					
Currently married					4.2
Widowed	0.00245	0.00138	0.076	4.2	
Others	0.00000	0.00002	0.826	0.0	
Work status					
Currently working					26.8
Never worked	0.02253	0.00247	0.000	38.5	
Currently not working	-0.00686	0.00062	0.000	-11.7	
Region					
North					3.1
Central	0.00059	0.00009	0.000	1.000	
East	0.00006	0.00004	0.188	0.100	
North-east	0.00041	0.00007	0.000	0.700	
West	-0.00003	0.00005	0.484	-0.060	
South	0.00080	0.00012	0.000	1.360	
Adaptive capacity effect					
Age group					
45-49					
50-54	0.00020	0.00003	0.000	0.3	17.1
55-59	-0.00055	0.00008	0.000	-0.9	
60-64	-0.00079	0.00004	0.000	-1.3	
65-69	0.00346	0.00013	0.000	5.9	
70 & above	0.00769	0.00021	0.000	13.1	
MPCE_ quintile					
Poorest					

Poor	0.00006	0.00002	0.004	0.1	-0.6
Middle	0.00004	0.00001	0.000	0.1	
Richer	-0.00027	0.00003	0.000	-0.5	
Richest	-0.00027	0.00002	0.000	-0.5	
% explained	0.03055	0.00254	0.000	**52.4**	
% unexplained (residual) Sensitivity effect				**47.6**	