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Gender differences in the association between cardiovascular diseases and major depressive disorder among older adults in India

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ABSTRACT

Background: Despite the global disease burden associated with the co-occurrence of cardiovascular diseases (CVDs) and depression, depression remains underdiagnosed and undertreated in the CVD population, especially among older adults in India. As such, this study examines (1) the association between single and multiple CVDs and major depressive disorder among older Indians; (2) whether this association is mediated by older adults' self-rated health and functional limitations; and (3) whether these associations vary for older men and women.

Methods: Data come from the 2017–18 wave 1 of the Longitudinal Ageing Study in India. Multivariable logistic regression is used to explore the association between CVDs and major depressive disorder among older men and women. The Karlson–Holm–Breen (KHB) method is used to examine the mediation effects of self-rated health and functional difficulties in the observed associations.

Results: Overall, 5.08% of the older adults had multiple CVDs. Older women (9.71%) had a higher prevalence of major depressive disorder compared to men (7.50%). Multiple CVDs were associated with greater odds of major depressive disorder after adjusting the potential covariates (adjusted odds ratio [AOR]: 1.49; 95% confidence interval [CI]: 1.10–2.00). Older men with multiple CVDs had a greater risk of major depressive disorder (AOR: 1.64; 95% CI: 1.05–2.57) relative to women with CVDs (AOR: 1.39; 95% CI: 0.93–2.08). The association between multiple CVDs and depression was mediated by self-rated health (34.03% for men vs. 34.55% for women), ADL difficulty (22.25% vs. 15.42%), and IADL difficulty (22.90% vs. 19.10%).

Conclusions: One in five older Indians with multiple CVDs reports major depressive disorder, which is three times more common than the prevalence of depressive disorder in older adults without CVDs. This association is attenuated by self-rated health and functional limitations. Moreover, these associations are more pronounced in older men relative to older women. These findings depart from prior inferences that men with CVDs are less psychologically distressed than their female counterparts. Moreover, the findings underscore the importance of gender-specific approaches to interventions and therapeutics for CVD-related mental health.

1. Introduction

Although once afflicted by acute infectious diseases, in recent decades, low- and middle-income countries (LMICs) have witnessed reduced morbidity and mortality associated with infectious conditions and are instead contending with the social, fiscal, and health ramifications of non-communicable diseases (NCDs). NCDs, particularly cardiovascular diseases (CVDs), such as hypertension, heart attack, myocardial infarction (MI), stroke, and coronary heart disease (CHD) because of their protracted nature, often compromise "active" life expectancy and lead to premature mortality [1,2].

According to the WHO (2017) [3], 85% of the 15 million premature deaths due to NCDs occur in LMICs, India being one of them. The increased prevalence of NCDs has resulted in a proportional increase in CVDs, which now account for approximately two-thirds of NCD mortality in India [4]. Age, which is instrumental in the breakdown of cardiovascular function, remains a significant challenger to heart health in both older men and women [5–7]. Twenty percent of the world's population will age 65 or older in this

Abbreviations: CVD, Cardiovascular disease; NCD, Non-communicable disease; CHD, Coronary heart disease; LASI, Longitudinal ageing study in India; CIDI-SF, Short form composite international diagnostic interview; ADL, Activities of daily living; IADL, Instrumental activities of daily living; SRH, Self rated health; OR, Odds ratio; CI, Confidence intervals; BMI, Body mass index; MPCE, Monthly per-capita consumption expenditure; CEB, Census enumeration block; OBC, Other backward class; SC, Scheduled caste; ST, Scheduled tribe.

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current decade, and death from CVDs, the leading cause of mortality worldwide, including in LMICs like India, will likely surge from 16.7 million in 2002 to 23.3 million by 2030 [8,9].

While it is normal to experience diminished cardiovascular functionality with advancing age [10,11], bearing the brunt of CVDs can provoke fear and uncertainty and negative affect, including anger, anxiety, and depression among older adults [8]. Depressive symptoms and major depression are, in fact, common among patients with CVDs [12–14]. For instance, relative to the general population, the prevalence of depression is significantly elevated in patients with CHD [9,10]. Similarly, research has found depression rates to be upward of 48% among those with peripheral arterial disease (PAD) [11]. Studies also reveal similar prevalence rates of depression among those suffering from heart failure [12], and whereas the prevalence of depression among stroke patients is more uneven, this may be related more to the functional disability associated with this type of CVD [9,13].

Aside from being frequent among CVD patients, depression, in and of itself, has been identified as a major and most prevalent mental health illness among older adults [14,15]. Major depressive disorder currently is the second leading cause of disability globally [16], and by 2030, it likely will become the leading cause of it. Notably, the impact on disease burden will continue to surge because depression frequently co-occurs with NCDs, like CVDs. Despite this, depression remains underdiagnosed and undertreated in the CVD population, especially among older adults in LMICs like India. The co-occurrence of CVD and depression, which can be emotionally and fiscally draining [17], is likely to disproportionately damage the quality of life for older adults [18,19], especially in resource constrained LMICs like India.

1.1. Self-rated health and functional limitations as potential mediators

Both biological and behavioral factors are proposed to clarify the association of CVDs with depression. For instance, increased levels of inflammatory biomarkers (e.g., C-reactive protein) that predict CVDs [20] are also an etiological factor for mental health disorders, including major depression [21–24]. While behavioral mechanisms, such as poor nutrition, substance use, obesity, and lack of medication compliance are explored, the focus of such investigations is to track what leads depression and other mental disorders to CVD and not vice-versa. In our study, we zero in on two conceptually relevant and yet otherwise understudied mechanisms that could potentially increase the risk of major depression among those with CVDs.

One such potential mechanism is self-rated health. Self-rated health uncovers the subjective evaluation of one's health and well-being, which could be a powerful indicator for the symbiotic relationship between physiological and psychological health [25–28]. Having positive self-appraisals of one's health, for instance, can uplift a person's mood, inspire self-confidence, reduce stress, and encourage health-promoting behaviors, all of which can protect against mental distress. Alternatively, suffering from chronic conditions, such as a CVD, may induce poor self-appraisals of health, which consequently can be depressogenic. In fact, prior research has suggested that health perceptions matter not simply for individual domains of physical and psychological health but they also may mediate the reciprocal linkage between the two [25,27–29]. Considering this, we test whether the association of CVD with depression is mediated by older adults' self-evaluated health.

A second possible mechanism connecting CVD and depression is the extent of functional limitations. CVD is associated with higher levels of functional limitations [30]. While functional limitations are expected to increase with age, such an increase is steeper and faster among those with chronic conditions, such as heart disease, hypertension, PVD, and MI [30–34]. Functional limitations, which constrain the ability to execute activities of daily living (ADLs), may compromise independence and one's wherewithal to maintain work and social activities and relationships [35]. These stressors, in turn, could result in mental distress, namely depression. Despite this knowledge, the contribution of functional limitations to the association between multiple CVDs and major depression is not yet adequately assessed among the aging population in India.

1.2. Gender differences in the association between CVDs and depression

Depression is more widespread, in fact, and up to two times higher in women than in their male peers [36,37]. Several biological, genetic, psychological, and social factors have been proposed to explain this disparity [38,39]. While the stress exposure hypothesis suggests that, relative to their male counterparts, women are exposed to a greater number of stressors, the differential vulnerability hypothesis posits that women experience more intense responses to stressful life events [40,41]. Both reflect gendered experiences in families, workplaces, and societies at large. Studies also find that women report a higher mortality associated with CVDs, despite an overall lower incidence of heart illnesses [42,43]. For instance, women are in a more susceptible condition following coronary artery bypass [44], report more disruption in daily chores and activities, and more mental distress following MI [45,46]. Compared to their male peers, women also have a higher recurrence of CVD events, including MI and heart failure [47,48]. In all, despite the lower incidence of most CVDs, women with CVDs endure a much higher risk of depression relative to men [49,50].

Even though women face the greater and often concomitant burden of CVD and depression, they continue to be understudied, underdiagnosed, and undertreated segment of the aging population worldwide [51], and especially so in LMICs, like India. The high burden of CVD and mental distress among women warrants identifying whether the association between these conditions is different for men and women in India. Moreover, whether the association between CVDs and major depression is mediated by self-rated health and functional limitations similarly or differentially by gender remains unknown. This ultimately makes it difficult to identify older adults who may be at higher risk of CVD-related depression.

1.3. Study hypotheses

In sum, in the present study, we hypothesize that a number of CVDs, including hypertension, stroke, and heart disease, are positively associated with major depression among older Indians, after adjusting for several socio-demographic and health-related confounders. These associations, we hypothesize, are mediated by self-rated health and functional limitations. Moreover, we posit that the risk of depressive symptoms is higher among older women with CVDs relative to their older male counterparts.

2. Methods

2.1. Study design and sample

Data come from wave 1 of the Longitudinal Ageing Study in India (LASI) that was collected during 2017–18. The LASI is a nationally representative survey of over 72,000 individuals aged 45 and above across all states and union territories of India. The main objective of the survey was to study the health status and the socioeconomic well-being of older adults in India. The present study is conducted on eligible respondents aged 60 years and above. After removing the missing cases for physical activity, yoga, tobacco use, alcohol consumption, and CVDs, the total sample size for the present study was 30,333 older adults aged 60 years and older (men 14,537 and women 15,796).

2.2. Procedure

LASI adopted a state-of-the-art large-scale survey protocol and field implementation strategies. To reach to the eventual units of observation, the survey adopted a three-stage sampling design in rural areas and a four-stage sampling design in urban areas. In each state and union territory (UT), the first stage involved the selection of primary sampling units (PSUs), that is, sub-districts (Tehsils/Talukas), and the second stage

involved the selection of villages in rural areas and wards in urban areas in the selected PSUs. In rural areas, households were selected from selected villages in the third stage. However, sampling in urban areas involved an additional stage. Specifically, in the third stage, one Census Enumeration Block (CEB) was randomly selected in each urban area. In the fourth stage, households were selected from this CEB. The goal was to select a representative sample at each stage of sample selection. Further, an individual survey schedule was administered to each consenting respondent aged 45 and above and their spouses (irrespective of age) in the sampled households.

The survey protocol used state-of-the-art technology, such as computer-assisted personal interviews (CAPI), at full scale and minimized data recording and entry errors. In addition, LASI includes an individual module on biomarkers and a direct health examination. The overall individual response rate in LASI was 87%, which ranges from 96% in the state of Nagaland to 74% in the UT of Chandigarh. A detailed methodology, with complete information on the survey design and data collection, was published in the survey report [52]. The survey agencies that conducted the field survey for the data collection have collected prior consent from the respondents. The Indian Council of Medical Research (ICMR) extended the necessary guidelines and ethics approval for undertaking the LASI survey.

2.3. Outcome variable

Depression: The outcome variable in the study was major depressive disorder, which was coded as 0 for "no depressive disorder" and 1 for "having depressive disorder." Major depressive disorder among older adults with symptoms of dysphoria was calculated using the CIDI-SF (Short Form Composite International Diagnostic Interview), with a score of three or more indicating major depression on the CIDI-SF scale of 0 to 10. The scale has three screening questions and seven symptom-based questions, and a positive response to three or more symptoms indicates having a depressive disorder. This scale estimates a probable psychiatric diagnosis of major depression, has been validated in field settings and is widely used in population-based health surveys [52]. The criterion of the scale was validated in field settings especially by non-clinicians in general population surveys and widely used in population-based health surveys [53]. Cronbach's alpha indicated that CIDI-SF has acceptable reliability ($\alpha = 0.7$).

2.4. Main explanatory variable

Cardiovascular diseases (CVDs): The main explanatory variable in this study was the presence of one or more CVDs, which include stroke, chronic heart diseases, and hypertension. The diseases were self-reported, as was assessed through the question, "Has any health professional ever diagnosed you with the chronic conditions or diseases such as stroke, hypertension (high blood pressure), or chronic heart disease?" Chronic heart diseases also included coronary heart disease (a heart attack or myocardial infarction), congestive heart failure, or other chronic heart problems.

2.5. Socio-demographic characteristics

Gender was coded as "men" and "women." Age was categorized into three age groups: 60–69 years, 70–79 years, and 80+ years. Level of education was coded as "no formal education," "primary," "secondary," and "higher." Working status was coded as "never worked," "currently not working," "currently working," and "retired." Marital status was recoded as 0 not in union and 1 currently in a marital union. Living arrangements were recoded as living alone, with a spouse, and with others.

2.6. Behavioral characteristics

Following the previous studies [54–56], survey questions based on participation in social activities were assessed to generate the "community involvement" variable. The activities included eating out of the house, going to the park or beach, visiting relatives or friends, attending cultural performances, shows, or cinema, and attending community, political, or organization group meetings. These activities were included and recoded as 0 "yes" and 1 "no" (0 = at least once in a month, 1 = rarely or never). Physical activity status was categorized as yes (every day, more than once a week, once a week, one to three times in a month) and no (hardly ever or never). The question through which physical activity was assessed was "How often do you take part in sports or vigorous activities, such as running or jogging, swimming, going to a health center or gym, cycling, or digging with a spade or shovel, heavy lifting, chopping, farm work, fast bicycling, cycling with loads"? Similarly, participation in yoga was assessed through the question, "How often do you engage in activities such as yoga, meditation, asana, pranayama, or similar kinds?" The responses were recoded into 0 (at least 1–3 times a month) and 1 (hardly ever or never). Further, tobacco use and alcohol consumption were recoded as "no" and "yes," respectively, both representing the ever-present use of tobacco and alcohol.

2.7. Mediating factors

Self-rated health was coded as "good," which includes very good, good, and fair, whereas "poor includes poor and very poor. Activities of daily living (ADL) are assessed through the normal daily self-care activities (such as movement in bed, changing position from sitting to standing, feeding, bathing, dressing, grooming, personal hygiene, etc.). Instrumental ADLs (IADL), while not essential for survival, ensure independent living and, as such, allow people to age in place. Respondents were asked if they were having any difficulties that were expected to last more than three months, such as preparing a hot meal, shopping for groceries, making a telephone call, taking medications, doing work around the house or garden, managing money (such as paying bills and keeping track of expenses), and getting around or finding an address in unfamiliar places. The difficulty in both ADL and IADL was recoded into 0 no and 1 yes (difficulty in any of the respected activities).

2.8. Household characteristics

The monthly per-capita consumption expenditure (MPCE) quintile was assessed using household consumption data. Sets of 11 and 29 questions on the expenditures on food and non-food items, respectively, were used to canvass the sample households. Food and non-food expenditures have been standardized for the 30-day reference period. The MPCE is computed and used as the summary measure of consumption [52]. The variable was then divided into five quintiles, i.e., from poorest to richest. Religion was recoded as Hindu, Muslim, and Other. Caste was recoded as Scheduled Caste/ Scheduled Tribe (SC/ST), Other Backward Class (OBC), and others. The place of residence was coded as urban or rural. The regions were coded as North, Central, East, Northeast, West, and South.

2.9. Statistical analysis

In this study, descriptive statistics and bivariate analysis have been performed to assess the prevalence of major depression along with explanatory variables. A Chi2 test has been conducted to evaluate the significance level of the outcome variable, i.e., major depressive disorder, in association with explanatory variables. A proportion test was conducted to further examine the significance of the gender differences in depressive disorder across the explanatory variables. Further, multivariable binary logistic regression analysis was used to fulfill the objective of the study. The multivariable analysis provides unadjusted and adjusted estimates for the total sample as well as separately for men and women.

In terms of examining the confounding percentage of self-rated health and functional limitations in the observed associations of number of CVDs and depression across male and female samples, the total effect was divided into direct effects and indirect effects using Karlson–Holm–Breen (KHB) method [53,57]. The confounding percentage (the indirect effect divided by the total effect) is interpreted as the percentage of the association explained by the mediator variable. The mediated percentage was only

considered significant when the total and indirect effects were significant. Moreover, the KHB method allows researchers to include other confounding variables (as concomitants) into the models without the scale identification issue to control the decomposition of any potential confounding factors. The KHB method is implemented by a user-written *khb* command in Stata, which applies the decomposition properties of linear models to the logit model.

The results are presented in the form of an odds ratio (OR) with a 95% confidence interval (CI). Individual weights were used to make the estimates nationally representative. For all the analyses, STATA version 15 has been used.

3. Results

Table 1 represents the gender-wise sociodemographic profile of older adults aged 60 and above. In the study sample, 52.75% of the older adults were women, 59.41% were in the age group of 60–69 years, and 56.51% had no formal education. More than one-third of the older adults were not currently working. At the time of the interview, 81.19% of men and 44.49% of women were currently married, and 2.45% of men and 8.62% of women were living alone. About 6% of men and 4% of women in the study were not involved in community activities, 41.55% of men and 22.6% of women were physically active, and 16.77% of men and 11.32% of women practiced yoga. Further, 8.67% of the older adults (7.49% men and 9.68% women) had major depression assessed by the CIDI-SF scale in the study. Nearly 26% of men and 34% of women had a single morbidity, whereas multiple morbidities were reported by 5.2% of men and 4.8% of women.

Fig. 1 depicts the percentage distribution of CVDs in the current study. A total of 3.29% and 2.23% of older men and women were diagnosed with stroke; 5.81% and 4.64% were diagnosed with heart disease; and 27.95% and 37.10% of older men and women were hypertensive. Overall, 5.33% and 4.86% of older male and female participants, respectively, had multiple CVDs.

Table 2 presents the bivariate association of major depression with different background variables. Older adults with multiple CVDs (13.01%) and a single CVD (10.13%) had a positive association with major depression. Older women (9.71%) had a higher prevalence of major depression as compared to older men (7.50%). It was also found that older adults who had no formal education (9.56%) and who had never worked (7.59%) had a higher prevalence of major depression and were found to be statistically significant. Older adults who were not in a marital union (10.13%), living alone (13.51%), and not involved in community activities (10.1%) had a higher prevalence of major depression.

Table 3 represents the logistic regression estimates for major depression among older adults. In the overall sample, the unadjusted analysis showed that older adults with multiple CVDs (UOR: 1.80; 95% CI: 1.32–2.46) and single CVDs (UOR: 1.36; 95% CI: 1.18–1.64) were, respectively, 80% and 36% significantly more likely to suffer from major depression in comparison to the older adults without CVD. After adjusting for potential covariates, a similar and significant positive relationship between CVD and major depression was found in older adults. In the subsample of older men, the older adults with multiple CVDs and single CVD were 1.56 and 1.46 times more likely to suffer from major depression, even after controlling potential covariates in the study. The subsample of older women showed a positive but insignificant association between multiple CVDs and major depression even after adjusting selected study covariates.

Table 4a and Table 4b present the results of the mediation analysis for older men and women, respectively. In the subsamples of both genders, the number of CVDs, including single CVD and multiple CVDs, had an indirect effect on major depression through selected potential mediators. However, mediating percentages varied across both genders. The association between multiple CVDs and major depression was mediated through self-rated health (mediating percentage: 34.03 for men vs. 34.55 for women), ADL difficulty (22.25 vs. 15.42), and IADL difficulty (22.90 vs. 19.10).

Table 1
Socio-economic profile of older adults (n = 30,333).

Variables	Total, n (%)	Men, n (%)	Women, n (%)
Number of CVDs			
No	19,011 (64.86)	9616 (68.87)	9395 (61.27)
Single	9840 (30.15)	4128 (25.93)	5712 (33.93)
Multiple	1482 (4.99)	793 (5.2)	689 (4.8)
Depression			
No	28,191 (91.36)	13,614 (92.51)	14,577 (90.32)
Yes	2142 (8.64)	923 (7.49)	1219 (9.68)
Gender			
Men	14,537 (47.25)		
Women	15,796 (52.75)		
Age (in years)			
60–69	18,503 (59.41)	8713 (58.93)	9790 (59.84)
70–79	8743 (29.87)	4359 (30.42)	4384 (29.38)
80+	3087 (10.72)	1465 (10.65)	1622 (10.77)
Level of education			
No formal education	16,219 (56.51)	5237 (38.64)	10,982 (72.53)
Primary	5652 (17.61)	3253 (22.63)	2399 (13.11)
Secondary	5919 (18.05)	4110 (25.69)	1809 (11.2)
Higher	2543 (7.83)	1937 (13.05)	606 (3.16)
Work status			
Never worked	8465 (26.46)	711 (3.75)	7754 (46.81)
Currently not working	10,462 (35.64)	5681 (39.69)	4781 (32.01)
Currently working	8804 (30.55)	5913 (43.12)	2891 (19.3)
Retired	2602 (7.34)	2232 (13.44)	370 (1.88)
Marital status			
Currently married	19,343 (61.84)	11,982 (81.19)	7361 (44.49)
Widowed	10,209 (36.04)	2172 (16.42)	8037 (53.62)
Others	781 (2.12)	383 (2.38)	398 (1.89)
Living arrangement			
Alone	1568 (5.7)	347 (2.45)	1221 (8.62)
With spouse	5902 (19.77)	3501 (24.66)	2401 (15.39)
With others	22,863 (74.53)	10,689 (72.89)	12,174 (75.99)
Community involvement			
No	28,230 (95.22)	13,256 (93.96)	14,974 (96.35)
Yes	2103 (4.78)	1281 (6.04)	822 (3.65)
Physical activity			
No	20,922 (68.44)	8765 (58.45)	12,157 (77.4)
Yes	9411 (31.56)	5772 (41.55)	3639 (22.6)
Yoga			
No	25,691 (86.11)	11,921 (83.23)	13,770 (88.68)
Yes	4642 (13.89)	2616 (16.77)	2026 (11.32)
Tobacco use			
No	18,484 (59.77)	6316 (39.83)	12,168 (77.63)
Yes	11,849 (40.23)	8221 (60.17)	3628 (22.37)
Alcohol consumption			
No	28,330 (94.58)	12,805 (89.93)	15,525 (98.74)
Yes	2003 (5.42)	1732 (10.07)	271 (1.26)
SRH			
Good	23,333 (75.77)	11,500 (77.78)	11,833 (73.97)
Poor	7000 (24.23)	3037 (22.22)	3963 (26.03)
ADL difficulty			
No	24,134 (77.26)	12,031 (79.98)	12,103 (74.82)
Yes	6199 (22.74)	2506 (20.02)	3693 (25.18)
IADL difficulty			
No	17,153 (52.44)	9560 (62.05)	7593 (43.84)
Yes	13,180 (47.56)	4977 (37.95)	8203 (56.16)
MPCE quintile			
Poorest	6216 (21.8)	2905 (20.91)	3311 (22.6)
Poorer	6255 (21.76)	2966 (21.69)	3289 (21.82)
Middle	6193 (20.7)	2948 (20.97)	3245 (20.45)
Richer	5971 (19.29)	2893 (19.47)	3078 (19.12)
Richest	5698 (16.46)	2825 (16.96)	2873 (16.01)
Religion			
Hindu	22,244 (82.75)	10,679 (82.88)	11,565 (82.63)
Muslim	3588 (10.71)	1733 (10.85)	1855 (10.59)
Christian	3026 (2.89)	1411 (2.57)	1615 (3.18)
Others	1475 (3.65)	714 (3.71)	761 (3.6)
Caste			
SC	4953 (18.98)	2365 (19.05)	2588 (18.91)
ST	4975 (8.08)	2355 (7.74)	2620 (8.39)
OBC	11,487 (45.21)	5572 (45.58)	5915 (44.88)
Others	8918 (27.73)	4245 (27.62)	4673 (27.83)
Place of residence			
Urban	10,326 (29.03)	4816 (27.27)	5510 (30.6)
Rural	20,007 (70.97)	9721 (72.73)	10,286 (69.4)

Table 1 (*continued*)

Variables	Total, n (%)	Men, n (%)	Women, n (%)
Region			
North	5611 (12.74)	2690 (12.52)	2921 (12.94)
Central	4100 (20.98)	2073 (22.7)	2027 (19.44)
East	5603 (23.88)	2776 (24.87)	2827 (22.99)
Northeast	3619 (2.99)	1726 (2.94)	1893 (3.03)
South	7293 (22.22)	3401 (20.67)	3892 (23.6)
West	4107 (17.2)	1871 (16.31)	2236 (17.99)

n: Unweighted counts; %: Weighted percentage; CVDs: Cardiovascular Diseases; SRH: Self-rated Health; ADL: Activities of daily living; IADL: Instrumental activities of daily living; MPCE: Monthly per capita consumption expenditure.

4. Discussion

The present study utilizes wave 1 of the nationally representative data from LASI to explore the association between multiple CVDs and the risk of major depression in older men and women in India. Additionally, we assess whether the association between CVDs and major depression is mediated by self-rated health and functional limitations. We find that nearly 38% of older adults have at least one CVD, and 5% have two or more CVDs. Further, older people with multiple CVDs have a higher prevalence of major depression compared to those with no CVD (7.65% vs. 13.01%), and these estimates are comparable for men and women. We found an unexpected pattern in the association of CVDs and depression across genders. Estimates from logistic regression analysis revealed a positive and statistically significant association between multiple CVDs and major depression for older men; though positively directed, this association was not statistically meaningful for older women, even after controlling potential covariates. On the meditors front, our data yield the expected pattern where both self-rated health and functional limitations significantly mediate the association between multiple CVDs and major depression for both older men and women.

Findings in our study mirror those in prior studies that show the linkage between CVDs and poor mental health in older adults [58–60]. According to epidemiological research, the prevalence of depression is three times higher among those with CVD than in the general population [61]. It is reasonable to assume that a diagnosis or the incidence of acute medical events triggers strong psychological reactions [62]. This may be due to the unexpected and untimely nature of an illness, the severity of the illness, the length of morbidity, restricted mobility, a lack of social support, or/and the financial strain of medical expenses, all of which can manifest into mental distress [63].

In our study, we found self-rated health and functional limitations to mediate the link between CVDs and major depression, and this emerged both in older men and women. Prior evidence shows that among older persons with multiple chronic diseases, self-rated health is crucial [64,65], as individuals with unfavorable self-appraisals of their health may be more susceptible to psychological distress [66]. The magnitude of the mediation effect of self-rated health in the association was almost similar in both older men and women. Epidemiological evidence suggests that self-assessments of health, even when measured using a single item or question, are strongly associated with morbidity, mortality, and health care utilization [67–69]. Subjective health is a powerful indicator of the often synergistic connection between the body and the mind; therefore, clinicians should consider it in risk assessment for older adults living with multiple chronic diseases in general and multiple CVDs in particular.

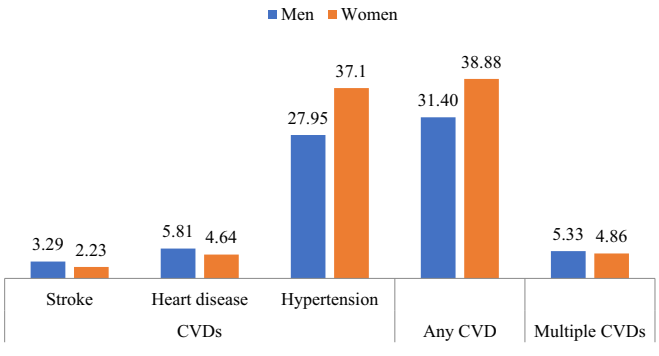

Fig. 1. Percentage distribution of older adults by CVD status.

As hypothesized, our study also found functional disability, including ADL and IADL limitations, to mediate the linkage between CVDs and depression among older Indians. However, the proportion of the association between CVDs and depression mediated by ADL/IADL difficulty was higher among older men relative to older women. This may be because men in India, especially those of older cohorts, typically assume the provider role, where they are in charge of supporting their family. Given this, it stands to reason that when older men are diagnosed with multiple CVDs and functionally constrained, they become more mentally distressed [70]. Further research and interventions focused on CVD should consider employing functional health screenings to potentially disrupt or mitigate functional decline that could render some older adults, especially men, more susceptible to mental distress. This is especially important given the otherwise well-documented finding that a greater proportion of women than men face functional disability in later life [71].

Worth noting, though, is that CVDs and mental distress, especially depression, are bidirectionally related. While the present study investigated the prevalence of major depression among older adults with CVDs, other studies have found the reverse, where older adults with depressive symptoms face an increased risk of multiple CVDs [72–74]. Whether depression is predictive of CHD in the general population yields inconsistent evidence, with some suggesting that the adverse effect of depression on CHD outcomes is restricted to those diagnosed with clinical symptoms of depression or driven by symptom severity [75–77]. Major depression, in consequence, often remains prognostically problematic, which means that if a patient is depressed, he or she is two- to three-times more likely to have another cardiovascular event [78,79].

The association between CVDs and major depression, in our study, is positively and statistically significant for older men, but not older women. Though positively directed, this association is statistically irrelevant for older Indian women, even after accounting for potential covariates. This is contrary to expectation and inconsistent with prior research that shows that women with chronic conditions, particularly CVDs, are at a higher risk of mental distress compared to their male peers. We rely on existing research on gender socialization [80–82] to explain this rather counterintuitive finding. One, and as stated above, multiple chronic conditions, accompanied by functional disability, may be more stigmatizing and emotionally cumbersome for older men given that being sick, frail, and cared for is contrary to what it means to be masculine, resilient, independent, and a provider [83]. Given the centrality of masculinity to men's sense of self-worth [81], for some men with CVDs, that may mean clinging to behaviors associated with masculine behavior [80,82], which may be harmful for mental health. Two, given that women are more actively engaged in child-rearing and the building and sustaining of family social capital [84–86], in times of health crisis, they may be better equipped to garner more emotional and instrumental support from adult children [86], which could motivate positive affect and protect against mental distress. The above speculations deserve to be empirically tested to clarify the differential gender associations between CVDs and depression among older Indians. In particular, future research may be well-advised to consider social support variables in such an inquiry. For instance, in absence of kin, older adults may be encouraged by health care providers to seek care from non-kin [87]; while older women and some older men may follow this suggestion, others, particularly men of older cohorts, may deem this as a sign of weakness [83].

Our research also revealed that being female, lack of a formal education, and SC/ST or OBC group status, which reflect socioeconomic deprivation, increased the prevalence of major depression among older adults. This is in line with earlier cross-sectional as well as longitudinal studies that

Table 2
Bivariate estimates of major depression by background characteristics among older adults, stratified by gender.

Variables	Total, n (%)	Chi-square test *p*-value	Men, n (%)	Women, n (%)	Proportion test p-value
Number of CVDs		<0.001			
No	1519 (7.65)		643 (6.36)	873 (8.96)	<0.001
Single	939 (10.13)		355 (9.33)	581 (10.67)	0.088
Multiple	198 (13.01)		103 (13.46)	96 (12.56)	0.260
Gender		<0.001			
Men	1085 (7.50)				
Women	1572 (9.71)				
Age (in years)		0.207			
60–69	1530 (8.41)		659 (7.62)	869 (9.1)	0.056
70–79	771 (8.42)		297 (6.65)	472 (10.07)	<0.001
80 +	356 (10.79)		146 (9.26)	209 (12.15)	<0.001
Level of education		<0.001			
No formal education	1657 (9.56)		436 (7.7)	1210 (10.44)	0.001
Primary	515 (9.53)		304 (9.14)	212 (10.13)	0.351
Secondary	352 (6.39)		254 (6.73)	101 (5.69)	0.519
Higher	133 (5.56)		108 (5.6)	27 (5.39)	0.957
Work status		<0.001			
Never worked	615 (7.59)		50 (8.96)	558 (7.49)	0.620
Currently not working	1133 (10.33)		520 (8.9)	613 (11.9)	0.003
Currently working	735 (7.87)		393 (6.23)	343 (11.16)	<0.001
Retired	174 (7.74)		139 (7.03)	37 (12.31)	0.229
Marital status		<0.001			
Currently married	1472 (7.77)		859 (7.21)	617 (8.67)	0.068
Widowed	1139 (10.31)		221 (9.15)	908 (10.62)	0.401
Others	46 (7.07)		22 (6.06)	25 (8.22)	0.314
Living arrangement		<0.001			
Alone	238 (13.51)		38 (10.42)	198 (14.3)	0.436
With spouse	519 (8.56)		286 (7.87)	234 (9.56)	0.183
With others	1900 (8.32)		778 (7.28)	1119 (9.22)	<0.001
Community involvement		<0.001			
No	2542 (8.77)		1051 (7.67)	1487 (9.73)	0.101
Yes	94 (6.48)		41 (4.68)	53 (9.14)	0.198
Physical activity		0.007			
No	1874 (8.95)		686 (8)	1182 (9.59)	0.002
Yes	776 (8.02)		413 (6.77)	365 (10.06)	<0.001
Yoga		0.248			
No	2271 (8.62)		881 (7.22)	1384 (9.79)	<0.001
Yes	382 (8.97)		218 (8.84)	165 (9.14)	0.677
Tobacco use		<0.001			
No	1600 (8.42)		438 (6.83)	1155 (9.2)	0.001
Yes	617 (9.43)		334 (8.29)	286 (11.16)	0.043
Alcohol consumption		0.300			
No	2541 (8.77)		997 (7.55)	1538 (9.76)	0.202
Yes	112 (6.75)		105 (7.09)	9 (4.37)	0.038
SRH		<0.001			
Good	1437 (6.19)		613 (5.37)	821 (6.96)	<0.001
Poor	1219 (16.42)		488 (14.94)	728 (17.55)	0.238
ADL difficulty		<0.001			
No	1580 (6.69)		675 (5.75)	904 (7.59)	<0.001
Yes	1076 (15.34)		427 (14.48)	646 (15.95)	0.396
IADL difficulty		<0.001			
No	894 (5.58)		480 (5.27)	415 (5.97)	<0.001
Yes	1759 (12.06)		621 (11.14)	1131 (12.61)	0.617
MPCE quintile		<0.001			
Poorest	592 (8.88)		228 (7.43)	363 (10.08)	<0.001
Poorer	526 (7.92)		189 (5.94)	336 (9.68)	<0.001
Middle	519 (8.17)		238 (7.74)	280 (8.56)	0.791
Richer	519 (8.74)		218 (7.64)	299 (9.72)	0.071
Richest	501 (9.92)		229 (9.11)	272 (10.69)	0.138
Religion		<0.001			
Hindu	2179 (8.6)		927 (7.62)	1249 (9.48)	0.001
Muslim	318 (9.63)		119 (7.4)	198 (11.68)	0.005
Christian	64 (7.22)		12 (3.25)	51 (10.15)	0.001
Others	96 (8.5)		44 (8.09)	52 (8.88)	0.571
Caste		<0.001			
SC	582 (9.99)		272 (9.74)	310 (10.21)	0.024
ST	121 (4.92)		48 (4.21)	74 (5.5)	0.475
OBC	1283 (9.25)		505 (7.54)	775 (10.81)	0.001
Others	671 (7.9)		277 (6.82)	393 (8.87)	0.004
Place of residence		<0.001			
Urban	566 (6.34)		249 (6.21)	316 (6.45)	0.217
Rural	2091 (9.62)		853 (7.99)	1234 (11.15)	<0.001
Region		<0.001			
North	267 (6.8)		127 (6.91)	139 (6.7)	0.467
Central	932 (14.53)		395 (11.87)	535 (17.33)	<0.001

Table 2 (*continued*)

Variables	Total, n (%)	Chi-square test *p*-value	Men, n (%)	Women, n (%)	Proportion test p-value
East	603 (8.28)		269 (7.39)	334 (9.15)	0.089
Northeast	51 (5.63)		20 (4.66)	31 (6.48)	0.052
South	399 (5.82)		154 (5.05)	244 (6.42)	0.020
West	406 (7.69)		136 (5.68)	268 (9.3)	0.007

n: Unweighted counts; %: Weighted percentage; CVDs: Cardiovascular Diseases; SRH: Self-rated Health; ADL: Activities of daily living; IADL: Instrumental activities of daily living; MPCE: Monthly per capita consumption expenditure.

Table 3
Multivariable logistic regression estimates of major depression among older adults, stratified by gender.

	Overall		Men		Women	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Number of CVDs						
None	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Single	1.36*** (1.18–1.57)	1.39*** (1.18–1.64)	1.51*** (1.21–1.89)	1.56*** (1.21–2.02)	1.21* (1.00–1.47)	1.31** (1.07–1.61)
Multiple	1.80*** (1.32–2.46)	1.49** (1.10–2.00)	2.29*** (1.59–3.29)	1.64* (1.05–2.57)	1.46 (0.88–2.42)	1.39 (0.93–2.08)
Age (in years)						
60–69		Ref.		Ref.		Ref.
70–79		0.81* (0.68–0.96)		0.65** (0.50–0.84)		0.90 (0.72–1.11)
80 +		0.85 (0.64–1.13)		0.74 (0.43–1.26)		0.90 (0.66–1.23)
Gender						
Men		Ref.				
Women		1.41** (1.15–1.73)				
Level of education						
No formal education		Ref.		Ref.		Ref.
Primary		1.25 (1.00–1.56)		1.27 (0.90–1.81)		1.28 (0.98–1.67)
Secondary		0.98 (0.78–1.22)		0.99 (0.74–1.33)		0.98 (0.68–1.41)
Higher		0.87 (0.61–1.25)		0.85 (0.55–1.31)		0.77 (0.39–1.52)
Work status						
Never worked		Ref.		Ref.		Ref.
Currently not working		1.64*** (1.34–2.02)		0.98 (0.49–1.93)		1.61*** (1.29–2.01)
Currently working		1.79*** (1.39–2.31)		0.95 (0.49–1.86)		1.87*** (1.39–2.53)
Retired		1.82** (1.25–2.66)		0.90 (0.44–1.85)		2.22* (1.14–4.33)
Marital status						
Currently married		Ref.		Ref.		Ref.
Widowed		1.27* (1.05–1.55)		1.31 (0.91–1.88)		1.31* (1.04–1.65)
Others		0.95 (0.56–1.61)		0.82 (0.37–1.79)		1.05 (0.52–2.13)
Living arrangement						
Alone		Ref.		Ref.		Ref.
With spouse		0.88 (0.62–1.25)		1.34 (0.62–2.86)		0.88 (0.58–1.34)
With others		0.77 (0.57–1.03)		1.24 (0.62–2.51)		0.72* (0.52–0.99)
Community involvement						
No		Ref.		Ref.		Ref.
Yes		0.98 (0.70–1.37)		0.81 (0.49–1.33)		1.13 (0.71–1.79)
Physical activity						
No		Ref.		Ref.		Ref.
Yes		1.06 (0.88–1.27)		0.96 (0.74–1.24)		1.14 (0.89–1.46)
Yoga						
No		Ref.		Ref.		Ref.
Yes		1.18 (0.95–1.46)		1.42* (1.08–1.87)		1.01 (0.73–1.39)
Tobacco use						
No		Ref.		Ref.		Ref.
Yes		1.12 (0.95–1.33)		1.21 (0.92–1.59)		1.11 (0.89–1.39)
Alcohol consumption						
No		Ref.		Ref.		Ref.
Yes		0.86 (0.60–1.24)		0.95 (0.63–1.42)		0.56 (0.26–1.23)
SRH						
Good		Ref.		Ref.		Ref.
Poor		2.42*** (2.05–2.85)		2.43*** (1.85–3.20)		2.43*** (1.99–2.96)
ADL difficulty						
No		Ref.		Ref.		Ref.
Yes		1.71*** (1.42–2.07)		2.11*** (1.44–3.10)		1.54*** (1.25–1.89)
IADL difficulty						
No		Ref.		Ref.		Ref.
Yes		1.72*** (1.43–2.07)		1.60* (1.11–2.31)		1.78*** (1.45–2.20)
MPCE quintile						
Poorest		Ref.		Ref.		Ref.
Poorer		0.93 (0.75–1.14)		0.89 (0.62–1.26)		0.96 (0.74–1.24)
Middle		0.94 (0.73–1.21)		1.12 (0.72–1.75)		0.86 (0.64–1.16)
Richer		1.06 (0.84–1.34)		1.24 (0.85–1.79)		1.00 (0.74–1.33)
Richest		1.22 (0.97–1.54)		1.42 (0.97–2.09)		1.16 (0.87–1.54)

(continued on next page)

Table 3 (*continued*)

	Overall		Men		Women	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Religion						
Hindu		Ref.		Ref.		Ref.
Muslim		1.09 (0.85–1.39)		0.94 (0.66–1.34)		1.17 (0.85–1.62)
Christian		1.59* (1.04–2.43)		0.84 (0.31–2.24)		1.98** (1.22–3.21)
Others		1.14 (0.82–1.57)		0.90 (0.57–1.44)		1.29 (0.82–2.02)
Caste						
SC		Ref.		Ref.		Ref.
ST		0.48*** (0.35–0.67)		0.40*** (0.24–0.69)		0.52** (0.34–0.78)
OBC		1.25* (1.02–1.52)		0.96 (0.69–1.34)		1.41** (1.10–1.81)
Others		1.00 (0.80–1.26)		0.83 (0.58–1.18)		1.10 (0.82–1.48)
Place of residence						
Urban		Ref.		Ref.		Ref.
Rural		1.28* (1.06–1.54)		1.08 (0.82–1.42)		1.35* (1.06–1.74)
Region						
North		Ref.		Ref.		Ref.
Central		2.59*** (2.02–3.33)		2.24*** (1.47–3.40)		2.89*** (2.12–3.93)
East		1.14 (0.90–1.44)		1.05 (0.71–1.54)		1.20 (0.89–1.61)
Northeast		1.00 (0.70–1.41)		1.14 (0.62–2.10)		0.95 (0.62–1.46)
South		0.61*** (0.46–0.81)		0.64 (0.40–1.01)		0.59** (0.42–0.84)
West		1.05 (0.80–1.36)		0.82 (0.52–1.30)		1.17 (0.84–1.62)
Pseudo R2	0.0046	0.1059	0.0088	0.1086	0.0018	0.1098

*if $p < 0.05$; **if $p < 0.01$; ***if $p < 0.001$; OR: Odds Ratio; CI: Confidence Interval; CVDs: Cardiovascular Diseases; SRH: Self-rated Health; ADL: Activities of daily living; IADL: Instrumental activities of daily living; MPCE: Monthly per capita consumption expenditure.

suggest that older women and socioeconomically disadvantaged older adults endure a higher likelihood of suffering from major depressive symptoms [88–92]. We also find, as revealed in other studies [93–96], that the risk of major depression is higher among older adults who are single and living alone. Although statistically not significant, the positive association of higher household consumption quintiles with increased depressive disorder among older adults in India requires further investigation. Our findings, overall, provide a critical context for prior research showing that chronic NCDs, notably CVDs, have become more prevalent among Indian older adults than in the general population, accounting for 28.1% of all deaths and 14.1% of all disability-adjusted life years (DALYs) [97]. Thus, while we focus on illnesses and physical disabilities, we must also be aware of mental health issues, particularly depression, which may become the leading cause of disability worldwide by 2030 [98].

The findings of our study must be interpreted within the context of several limitations. First, the data are cross-sectional, thus precluding any causal claims on the association between CVDs and major depression. It also precludes the use of time-varying factors, so residual confounding remains a concern. Second, CVDs in the study are self-reported, which may indicate recall bias. Though other studies [99] based on large population surveys, such as the English Longitudinal Study of Aging, have found high consistency between self-reported and medical records of incident CVD (accuracy, 77.5%). Third, despite controlling for numerous theoretically relevant covariates, there lingers the possibility that the observed associations among key variables are

Table 4a
Direct and indirect effects of CVD on depressive disorder through self-rated health, ADL/IADL difficulty among men.

Number of CVDs		Total effect	Natural direct effect	Natural indirect effect	Percent effect mediated
	Outcome	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	%
Single CVD	Self-rated health	1.64*** (1.37–1.97)	1.56*** (1.30–1.87)	1.05** (1.01–1.10)	23.59
	ADL difficulty	1.66*** (1.38–2.00)	1.59*** (1.32–1.91)	1.05* (1.01–1.09)	9.17
	IADL difficulty	1.37*** (1.20–1.56)	1.31*** (1.14–1.49)	1.05** (1.01–1.08)	10.63
Multiple CVDs	Self-rated health	2.38*** (1.74–3.26)	1.95*** (1.42–2.68)	1.22*** (1.16–1.28)	34.03
	ADL difficulty	2.46*** (1.80–3.36)	2.01*** (1.47–2.76)	1.22*** (1.16–1.29)	22.25
	IADL difficulty	2.13*** (1.65–2.77)	1.90*** (1.46–2.47)	1.12*** (1.08–1.17)	22.9

Notes: Adjusted OR: OR adjusted for age, level of education, work status, marital status, living arrangements, community involvement, physical activity, yoga, tobacco use, alcohol consumption, MPCE quintiles, religion, caste, place of residence and regions.

Table 4b
Direct and indirect effects of CVD on depressive disorder through self-rated health, ADL/IADL difficulty among women.

Number of CVDs		Total effect	Natural direct effect	Natural indirect effect	Percent effect mediated
	Outcome	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	%
Single CVD	Self-rated health	1.36*** (1.19–1.56)	1.31*** (1.14–1.49)	1.04** (1.01–1.08)	30.60
	ADL difficulty	1.37*** (1.20–1.56)	1.31*** (1.14–1.49)	1.05** (1.01–1.08)	14.97
	IADL difficulty	1.35*** (1.18–1.54)	1.23** (1.08–1.41)	1.10*** (1.06–1.14)	13.89
Multiple CVDs	Self-rated health	2.09*** (1.61–2.71)	1.81*** (1.40–2.36)	1.15*** (1.11–1.20)	34.55
	ADL difficulty	2.13*** (1.65–2.77)	1.90*** (1.46–2.47)	1.12*** (1.08–1.17)	15.42
	IADL difficulty	2.10*** (1.62–2.73)	1.63*** (1.25–2.12)	1.29*** (1.23–1.36)	19.10

Notes: Adjusted OR: OR adjusted for age, level of education, work status, marital status, living arrangements, community involvement, physical activity, yoga, tobacco use, alcohol consumption, MPCE quintiles, religion, caste, place of residence and regions.

the result of unmeasured factors, including but not limited to family history of CVD and depression, personality, and genetic predispositions. Finally, our study is limited to assessing whether the association between CVDs and depression is similarly or differentially distributed between older men and women. Future research should consider extending the present inquiry by evaluating gender specific social, cultural, and psychological mechanisms that may offer more clarity on why the association between chronic conditions like CVDs and mental distress vary for older men and women in India. In fact, we urge future scholarship to go beyond sex and gender to assess the relevance of sexual orientation for the association of NCDs, like CVDs, and resulting psychological distress. Prior research finds sexual orientation (as a stigmatized social status) to be a fundamental cause of health disparities [100,101]. As such, questions such as these are deserving of a separate inquiry, especially within the Indian context, where there is much to be discovered about how sex, gender, and sexual orientation affect experiences related to aging and health.

Notwithstanding these limitations, our study contributes to the existing research on CVD and mental health and does so by focusing on multiple, instead of single, CVDs. Depression related to CVD is a major risk factor that could lead not only to the reoccurrence of a CVD event but also to cardiac death and other non-fatal yet physically and cognitively impairing events [102,103]. The majority of this knowledge pertinent to CVDs and resulting mental health problems is based on samples of older adults in high-income western nations. We focus on CVD-related depression and gender variations in this association among older adults in India. We do so by employing a large and nationally representative sample of older Indians, which affords us more reliable findings with greater statistical power and precision. Further, our work contributes to the existing literature on CVD risk factors and depression by examining the potential pathways of self-rated health and functional disability, and it does so by considering the differential impact of these associations for men and women in their later lives.

5. Conclusion

In sum, the findings reveal that one in five patients who have CVDs is depressed, which is three times higher compared to the prevalence of depression in the non-CVD population. This association is attenuated by self-rated health and functional disability. Further, the presence of CVDs may result in depressive symptoms among older adults and older men in particular, suggesting the need for gender-specific policy interventions focusing on cardiovascular health in late life.

Informed consent

Written informed consent from the parents or guardians and verbal assent from participants were obtained prior to data collection.

Contributors

Conceived and designed the research paper: TM and SA; analysed the data: TM; Contributed agents/materials/analysis tools: MP and SA; Wrote the manuscript: MP, SA and TM; Refined the manuscript: MP, TM and SA. Both the authors read, revised and approved the manuscript.

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Data availability statement

This study used a secondary data available on request at https://www.iipsindia.ac.in/content/lasi-wave-i

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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