Cognitive Health of Older Indians: Individual and Geographic Determinants of Female Disadvantage

Introduction

India is experiencing rapid demographic and epidemiologic transitions. The share of persons 65 years and older is projected to increase from 5% of the population in 2011 to 14% by 2050: an increase of approximately 222 million aging persons (UNPD, 2009). The health concerns of these aging individuals are changing such that non-communicable chronic diseases in late life, such as dementia, are becoming increasingly prevalent (Prince et al. 1997; Mahal, Karan, & Engelgau, 2010; Alladi S, Kaul S, Mekala S, 2010; Suh & Shah, 2000; WHO, 2009; Das SK, Bose P, Biswas A, et al, 2007). Poor cognitive function is a risk factor for and may result from these chronic health conditions, yet cognitive health among older developing populations is understudied, particularly in India (Kalaria et al., 2008). Cognitive aging research on Indian populations has focused mainly on dementia and other serious neurodegenerative disorders, using data from limited geographic, single-city settings with small sample sizes (Kalaria et al., 2008; Jotheeswaran et al., 2010). To address limitations in extant studies of cognitive aging in India, we examined the cognitive health of older Indians, using cross-sectional data from the pilot round of the 2010 Longitudinal Aging Study in India (LASI), a study of a representative sample of adults aged 45 years or older and their spouses from four, geographically diverse, Indian states.

Recent studies suggest that the cognitive health of women in developed countries is as good or better than that of men (Langa et al., 2008, 2009), even after adjusting for socioeconomic, medical and behavioral risk factors and demographic characteristics. More specifically, studies of U.S., U.K., and European samples have found that women perform better than men on measures of episodic recall and verbal fluency (Langa, Larson et al., 2009; Hertlitz et al., 1997; De Frias et al., 2006; VanHooren et al., 2007), although on measures of orientation men scored just as well as women (Langa, Llewellyn et al 2009). Some studies argue that women have an inherently higher cognitive aptitude than men for episodic memory and verbal skills whereas men perform better on tasks that involve visuoperceptual and spatial recognition (Lewin et al., 2001; Hertlitz et al., 2002).

By contrast, studies of cognitive function from the developing world find women often perform worse than men (Yao et al., 2009; Zunzunegui et al., 2009; Yount, 2008; Kalaria et al., 2008), even after adjusting for social, economic, and clinical risk factors. Studies in India have found that women ages 55 and older living in India's northern state of Haryana did worse than men after adjusting for age on a Hindi version of the Mini Mental State Exam (H-MMSE) (Ganguli et al., 1996). The authors attributed this female disadvantage in cognitive function to differences in educational attainment but were not able to formally test this hypothesis. Other studies have not found gender differences in cognitive functioning in India. When adjusting for both age and education, Mathuranath, George et al. (2007) found no female disadvantage on the Malayalam Mini Mental State Exam (M-MMSE) and the Malayalam version of Addenbrooke's Cognitive Examination score among a sample (N=488) of older men and women in southern India. In an additional study, Mathuranath, Cherian et al. (2003) also found no gender differences in the unadjusted score of verbal fluency among a sample of 153 men and women. The results from these studies are from single-city populations, so generalizability is limited. However, the studies raise important questions of whether gender differences in cognitive function exist in India like in other developing countries, if such disparities vary geographically, and whether factors like education may account for such gender difference.

Gender disparities in cognitive health may be explained by variation between men and women in factors such as nutrition, education, physical health, access to health services, social engagement, and emotional distress. Several studies have noted that Indian women are not given equal access to food, education, and health services and that this discrimination begins in early childhood (Mishra et al., 2004; Oster, 2009a; Pande, 2003). Under-nutrition, lower education, and poor physical health are all known risk factors of poor cognitive functioning in later life (Luchsinger et al., 2007; Sabia et al., 2009; Zhang et al., 2010; Farias et al., 2011; Cagney and Lauderdale, 2002; Stewart et al., 200; van Hooren et al., 2005; van Boxtel et al., 1998). More traditional gender roles in developing countries may also mean more confinement to the home for women, which restricts social engagement and limits opportunities for work and economic independence (Zunzunegui et al., 2008). Social engagement through work and other organized activities protects cognitive function (Berkman et al., 1993; Seeman et al., 2001; Yeh and Liu, 2003), which therefore may contribute to female disadvantage in cognitive health. Persistent social and economic disadvantage among females can also lead to psychological and emotional distress (McDonough et al., 2001; Reiker and Bird, 2005), depleting cognitive resources and reducing cognitive performance (Gerstorf, Hoppmann, Kadlec, & McArdle, 2009; Gerstorf, Hoppmann, Anstely, & Luszcz, 2009; Macdonald, Hultsch, & Bunce, 2006). Moreover, a prior history of depression has been consistently linked with increased risk of poor cognitive functioning (Chodosh et al., 2007; Dotson, Resnick, & Zonderman, 2008; Lichtenburg et al, 1996; Nebes et al., 2000).

These nutritional, economic, and psychosocial risk factors for poor cognitive function also vary by region in India because of geographic variability in female discrimination. Sen (1992; 2003) noted that northern and western Indian states tend to have more imbalanced gender ratios compared to the eastern and southern Indian states. This gender imbalance could reflect preferential treatment towards sons and male household members, inequity in the investment of household resources (health care, education, and food) across gender, and the restricted social and economic livelihood for women, both in childhood and in older ages as well (Sen, 1992, 2003; Oster, 2009b; Zunzunegui et al., 2009). Mishra et al. (2004) showed that girls in northern India were less likely to be vaccinated and more likely to have poor nutritional health as measured by stunting, compared to girls living in southern India. Son preference is particularly higher in northern India and by extension, so are more implicit and explicit forms of discrimination against women and girls (Das Gupta, 1987; 2005).

In this paper, we use data from four representative, geographically diverse, Indian states, to study first whether gender disparities in cognitive function exist among older adults in India, and second whether such disparity varies geographically. We hypothesize female disadvantage in cognitive function is more pronounced in northern states than southern states, due to greater female discrimination in the north. We further examine whether gender disparities persist after controlling for factors associated with cognitive function, such as under-nutrition, education, health and health care utilization, social engagement, emotional distress, and other factors, and which of these risk factors contribute to female disadvantage in cognitive function.

Methods

Data

The study sample is drawn from the pilot survey of the Longitudinal Aging Study in India (LASI). LASI is designed to be a panel survey representing persons at least 45 years of age in India and their spouses regardless of age. The LASI survey was fielded in four states: Karnataka, Kerala, Punjab, and Rajasthan. These four states were chosen to capture regional variations as well as socioeconomic and cultural differences across India (Lee et al., 2011). Primary sampling units (PSUs) were stratified across urban and rural districts within each of the four states to capture a variety of socioeconomic conditions. LASI randomly sampled 1546 households from these stratified PSUs, and among them, households with a member at least 45 years old were interviewed. Data were collected from 1,683 individuals during October through December of 2010.

The multidisciplinary survey includes questions about demographic, economic, behavioral, social, physical and mental health characteristics, as well as an extensive set of cognitive functioning tests. The survey questions were translated into the languages common in these states (i.e., Hindi, Malayalam, Kannada, Punjabi), and the interview was done in the language of respondent's choice. The LASI questionnaire consists of two main sections: the household interview and the individual interview. The household module asks about household finances, expenditure, consumption, and assets and can be answered by any knowledgeable household member 18 years of age or older. The household response rate was 88.6%. The individual interview is only for age-eligible household members and their spouses, and can be answered by a proxy respondent if necessary (we exclude proxy respondents in this analysis). The individual response rate was 91.7%. We further restricted the analysis in this paper to 1,486 respondents who are at least 45 years or age; spouses under age 45 were excluded.

Measures

The following cognitive tests were administered to all respondents to measure episodic memory and global cognitive function:

Episodic Memory*:* Two measures of episodic memory, immediate and delayed word recall, were included in the LASI pilot. Respondents were read aloud ten words and asked to recall them when the interviewer finished (immediate). They werere then asked again to recall as many of the same words as they could at the conclusion of the cognitive functioning tests (delayed). Scores on the immediate and delayed word recall ranged from 0 to 10; scores on the combined summary measure for episodic memory were created by summing immediate and delayed recall scores together, yielding a range from 0 to 20. Similar word recall tasks have been validated in low literacy populations in India (e.g., Hindi-Mini Mental State Examination (Ganguli et al., 1996); Malayalam Mini Mental State Examination (Mathuranath et al., 2003)).

Global cognitive function: Respondents were asked: (1) to name the date (year, month, day of the week, date of the month) and prime minister as a measure of orientation, (2) to count backward from 20, and (3) to subtract 7 from 100 and then again from 93 for a total of five iterations (serial 7s). Answers for the dates could be given with reference to the Western calendar, or any religious/vernacular calendar. Date naming as part of a Mini-Mental State Examination scale has been previously validated for the older Indian populations (Ganguli et al., 1995; Mathuranath, 1997). Questions about the prime minister/president have been included in similar studies in industrialized countries like the United States (Langa et al 2008), but not in countries like India. Slightly modified versions of counting backwards and serial 7s have been used in the Mini-Mental State Exams in India as well (Tiwari et al., 2008). A summary score was then created by adding score for naming date, naming prime minister, backward counting, and serial 7s, ranging from 0 to 12.

We include the following risk factors to explain female disadvantage in cognitive function: under-nutrition, education, health and health care utilization, social engagement, emotional distress, and geographic residency.

Under-nutrition: We included two indicators of under-nutrition: food insecurity and underweight based on body mass index (BMI), which has been used in developing country settings (Ferro-Luzzi et al., 1992; Nube et al., 1998). LASI interviewers measured height and weight, and we calculated BMI based on these measures as weight in kilograms divided by height in meters squared. Respondents with a BMI less than 18.5 were classified as underweight. Food insecurity was measured by four questions: whether a respondent reported reducing the size of his/her meals in the last 12 months because there was not enough money in the household, whether s/he was hungry but could not eat in the last 12 months because there was not enough money, whether s/he did not eat for a whole day, and whether s/he lost weight in the last 12 months because there was not enough money to buy food. We considered respondents who reported "yes" to at least one of these questions to be "food insecure."

Education: We included two measures of education: literacy and schooling. Respondents were considered literate if they reported being able to read and write. We categorized education based on whether the respondent did not receive any formal education, attained some or any primary or middle school education, or some high school education or more.

Health and healthcare utilization: As a health measure, we included multiple measures of cardiovascular diseases. We first accounted for self-reported diagnosis by a health professional for heart disease, stroke, diabetes, and hypertension based on the following question: "Has any health professional ever told you that you have [a heart attack, angina, coronary heart disease, congestive heart failure, or any other heart problems; a stroke; high blood sugar or diabetes; high blood pressure or hypertension]?" For developing countries like India, access to health care is limited (Balarajan et al., 2011) and therefore, these self-reported conditions diagnosed by a health professional are few in numbers and could reflect bias from socioeconomic status. Thus, we also counted respondents who had high blood pressure as measured in the biomarker components of LASI as having poor cardiovascular health if they had an average systolic reading above 140 mmHg across two readings or an average diastolic reading above 90 mmHg across two readings.

We also included a binary measure indicating a limitation in activities of daily living (ADL). Respondents were asked about six ADLs (dressing, walking across a room, bathing, eating, getting in and out of bed, and using the toilet). Respondents who reported that they had difficulty with or could not do at least one of the six tasks were considered to have an ADL limitation.

For healthcare utilization, we included a dichotomous measure for whether a respondent had ever visited a private doctor with an MBBS degree in his or her lifetime.

Social engagement: We included a measure for social activity, as well as labor force participation. LASI asks a comprehensive set of questions about the frequency of participating in the following social activities: organizations, clubs, or societies (e.g., such as tenant groups, farmer's associations), community organizations, and "self-help groups/NGOs/co-operatives/mahila mandal[1] groups", as well as leisure and recreational activities, such as going to the cinema, playing cards or games, attending religious celebrations, or visiting relatives or friends. We created a continuous, single measure of social engagement by summing up the number of times per month respondents reported participating in any type of social activity.

Labor force participation counts respondents who self-reported working at least one hour in the last week or some agricultural work for at least ten days in the last year. Since many older workers work in the informal sector of economy and their work schedule is irregular (Unni, 2002), we also counted respondents as working if they were reported to have some earnings from work in the past 12 months, including self-employment and agricultural work.

Emotional distress: was measured using the 20-item Center of Epidemiologic Studies – Depression Scale (CESD) (Radloff, 1977). We used a continuous measure of CESD ranging from 0 to 60, with higher scores indicating more depressive symptoms. Cronbach's alpha in our sample was 0.907. Missing CESD scores were replaced with gender-specific means in the models, and we adjust for potential bias by introducing a flag indicator for imputed values.

Geographic residency: State affiliation is used to group the respondents geographically. We assign the four states into two categories: northern states, which include Rajasthan and Punjab, and southern states, which include Kerala and Karnataka. Women may face more social and economic disadvantage in northern states than southern states, due to gender discrimination (Sen, 1992; 2003), and thus, we include interaction terms for female and residency in northern states.

[1] Mahila Mandal are women's empowerment groups

Control variables: We also controlled for the following covariates: demographics (sex, age, quadratic age), caste, health behaviors, per capita household consumption, and flags indicating potential disturbance (e.g., any interruptions) during the cognitive tests. We also control for whether or not the interview was given in the respondent's native language.

For castes, we included a categorical variable based on respondents' self-report: scheduled caste, scheduled tribe, other backward class, and all "other" caste or affiliations, including "no caste" affiliation. Scheduled castes and scheduled tribes are particularly disadvantaged due to a historical legacy of inequality. Scheduled tribes are more geographically isolated, highly heterogeneous ethnic minority populations, while scheduled castes can generally be characterized as socially segregated by traditional Hindu society, often excluded from education, public spaces (wells for drinking water, temples, etc), and most other aspects of civil life in India (Subramanian et al., 2008). Many of our respondents are considered by the Government of India to be a member of an OBC (other backwards class). While less marginalized and stigmatized than scheduled castes or tribes, these individuals are nevertheless considered to be of relatively lower social status and also face barriers to economic and educational opportunities (Subramanian et al, 2008).

For health behaviors, we included smoking and physical activity. Respondents were categorized as never smoked, former smoker, or current smoker based on self reported smoking activity including tobacco, cigarettes, bidi, chewing tobacco, or other smokeless tobacco. For physical activity, respondents were asked "how often [they] take part in sports or activities that are vigorous, 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: everyday, more than once a week, once a week, one to three times a month, or hardly ever or never." We grouped respondents into three groups: hardly ever or never; some exercise; and daily exercise. Alcohol consumption was not included in the analysis because of the low prevalence of self-reported drinking (specify exact % by gender).

For economic status, we used per capita household consumption. This measure is a preferred indicator of economic status in low-income and rural settings (Strauss et al., 2010). LASI collected detailed data on household consumption, including both market-purchased and home-produced goods. We use the OECD equivalence scale that differentially weights the consumption burden of household members—the household head is weighted 1, each additional adult is weighted by 0.5 and each child by 0.3—to create a per capita consumption measure. LASI provides imputed data for missing values using a hot deck method, and we control for imputed consumption in the models to adjust for any systematic bias due to missing data for some components of household consumption. We operationalized this variable as dummy tertile indicators in our analysis.

Analysis

We first examine gender differences in the mean scores of the cognitive measures across the entire sample and then by geographic regions. We weight the sample and accounted for survey design in our estimate of standard error. We formally test gender difference in the cognitive measures by fitting unweighted and design-corrected, bivariate OLS regression models and report the F-statistics.

We then examine gender differences in the distributions of risk factors of poor cognitive function. To test gender differences for categorical measures, we conduct a design-corrected chi-square test (StataCorp, 2009), and for continuous measures, we report the F-statistics from unweighted and design-corrected, bivariate OLS regression models.

We further investigate female disadvantage in unweighted and design-corrected, multivariate OLS regression models to examine whether female disadvantage persists after controlling for age and other control variables. Specifically, we estimate the female disadvantage in cognitive function with the following equation:

$$Cog_i = c + \beta F_i + X_i \delta + \varepsilon_i$$

where Cog_i is a measure of individual i's cognitive function, F_i stands for individual i being a female, X_i is a vector of age, age square, and control variables (e.g., disturbance during the cognitive test), c is a constant term, and ε is the error term. The coefficient β for being female (also referred to as the female disadvantage) is the primary object of interest and measures the independent effect of being female on cognitive function.

The interaction between geographic residence (northern versus southern states) and gender is a secondary object of interest in this paper. We hypothesize that there is geographic variation, G_i, in female disadvantage, and introduce interaction term $F_i \times G_i$ to the above equation:

$$Cog_i = c + \beta_1 F_i + \beta_2 G_i + \beta_3 F_i \times G_i + X_i \delta + \varepsilon_i$$

We reported standard errors and t-statistics from the estimation corrected for survey design and potential disturbance during the cognitive testing. We also control for caste affiliation, as scheduled tribes are geographically segregated and may reflect unique cultural attributes not reflective of more traditional Indian culture (Mitra, 2008).

We then examine whether gender disparities (β_1) and geographic differences in gender disparities (β_3) persist after simultaneously controlling for the risk factors associated with cognitive function, such as under-nutrition, education, health and health care utilization, social engagement, and emotional distress. All models correct for sample design and we report robust standard errors of the regression coefficients to account for heteroskedasticity.

Finally, we assess specifically which of the five factors outlined above (e.g., under-nutrition, education, health and health care utilization, social engagement, and emotional distress) accounts for the main effect of female disadvantage and geographic-specific female disadvantage in cognitive function. The central question we ask is which risk factor accounts for the female disadvantage. We formally test differences in female disadvantage between two models using an estimate of the simultaneous covariance matrix for regression parameter estimates and report F–statistics from an adjusted Wald test (StataCorp, 2009).

Results

Sample Characteristics: Table 1 shows the characteristics of our sample. Significant inter-state variations are observed, reflecting different patterns in economic development and population growth. While women's representation in the survey does not vary significantly across states, there is an uneven age distribution. Kerala and Rajasthan have greater proportions of elderly; 32% and 31% of the population, respectively, are 65 years old or older. Most of our sample are members of an OBC or some "other/none" caste category. However, scheduled tribes and schedule castes are disproportionately represented across states: 32% of the Rajasthan sample identifies as a scheduled tribe, while the highest proportion of scheduled castes, 30%, is found in Punjab. The two northern states have relatively lower educational attainment – almost 80% of respondents in Rajasthan report having no schooling of any kind, and nearly 60% in Punjab are similarly uneducated. Punjab also has the highest proportion of respondents who did not identify as a scheduled caste or tribe. In Kerala, less than 10% report receiving no schooling. Both southern states and the more economically developed state of Punjab in the north have higher median consumption than the poorer state of Rajasthan.

Gender difference in cognitive function: Table 2 presents the mean scores for men and women across all states on each composite cognitive domain (episodic memory and global cognitive function), as well as the individual tests comprising each summary measure. Overall, women in the sample did significantly worse than men on both the composite measures of cognitive function and individual components of these tests. This was also true within each region; that is, women in the north did worse than men in the north, and women in the south did worse than men in the south. The F-statistics show the gender differences are stronger in the north than in the south, particularly for episodic memory. Mean scores for women in the north were also lower than mean scores for southern Indian women.

Gender differences in risk factors of cognitive function: Table 3 presents gender differences in risk factors of cognitive function. We found distribution across gender to be asymmetric for BMI, literacy, education, ADL difficulties, social activities, work status, and emotional distress, but did not find gender difference in food insecurity, cardiovascular disease, and health care utilization across the pooled sample. For BMI, a greater proportion of men (30.3%) were underweight than women (23.6%). Women tended to be illiterate, receive no education, have an ADL limitation, have less frequent social activities, be less likely to work, and have poorer emotional health than men.

These gender disparities in risk factors show different patterns across geographic regions. Gender differences in ADL difficulty and social engagement were significant in the north but not in the south. Northern Indian women had higher prevalence of disability as measured by ADLs, while in the south there was no statistically significant difference, though both men and women reported more difficulty than in the north. Women in the north were much less likely to socialize than men, which was not true in south. Education, literacy, BMI and work status all favored men in both regions, however, more men and women were likely to be underweight, less educated, and more likely to work in the North than in the South.

Geographic differences in female disadvantages: Table 4 presents two regression models of episodic memory: the first shows age-adjusted, female disadvantage and geographic differences in total word recall; the second presents female disadvantage and geographic differences after controlling for the all risk factors of cognitive function. The first models shows women perform worse than men after adjusting for age; and women in the northern states do especially worse. On average, women score one fifth of a standard deviation lower than men, but women in the north score one third of a standard deviation lower. We find some attenuation in the main effect for women in the adjusted model and we fully account for the geographic disparity: the interaction between northern state residency and female gender is no longer significant. Higher income, education, northern state affiliation, and some exercise all benefited episodic memory, while difficulty with ADLs, poor emotional health (CESD), low BMI (underweight), smoking were detrimental to episodic memory scores.

Table 5 presents two regression models for global cognitive function summary score. The first model is adjusts only for age, caste, and geographic residence. The second fully adjusts for the same risk factors to cognitive health as Table 4. Like episodic memory, women also perform worse on this composite measure of cognitive functioning, and women in the north perform especially worse than women in the south, much more than seen with the total word recall measure: women in the north perform on average at one standard deviation lower than men in the south. Unlike models in Table 4, both men and women in northern states perform worse than those in southern states. In the second model, we regressed global cognitive function summary score on a full set of covariates, which accounted for the main effect of female disadvantage, but women in northern India continue to have lower scores. Literacy, education, health care utilization, cardiovascular disease, social activity, work status, and formerly smoking all contributed to higher scores on the summary measure. Underweight and ADL limitation were associated with lower performance on the cognitive tests for global functioning.

What contributes to female disadvantage in cognitive function? Table 6 presents female disadvantages estimated by OLS regression models of total word recall. Model A estimates female disadvantage controlling only for age (linear and quadratic), and Model B estimates the regional effects and their interaction with gender, after controlling for age and caste. From this Model B, we separately introduce each of the five sets of risk factors of cognitive function to ascertain which accounts for female disadvantage, controlling for the same covariates as Model B: (1) under-nutrition; (2) education; (3) health and health care utilization; (4) social engagement; and (5) emotional distress (Models C1 – C5). In each case, we compare female disadvantage in total word recall within this subset of variables to the female disadvantage observed in Model B by calculating the difference in the estimates and testing whether the difference is statistically significant from zero.

Comparing the regression coefficients for female of Model C with Model B, we observe reduced female disadvantages when we controlled for education and emotional distress. Adjusting for education reduced the main effect of female disadvantage in episodic memory by 40%. We do not see any statistically significant changes in regression coefficients for female when we controlled for under-nutrition and social engagement. When we control for health and health care utilization, we see an increase in regression coefficients for female. Adjusting for health and health behaviors increased the main-effect female disadvantage significantly by 50%. However, the same set of health variables significantly attenuated the disadvantage of northern females by about 25%. Model D, the fully adjusted model (the same as Table 4), shows that the geographic difference in female disadvantage in episodic memory is no longer significant, once other risk factors of poor cognitive function and per capita consumption is controlled for, but the main effects for female disadvantage still persists after controlling for the risk factors.

Similarly, Table 7 presents regression coefficients for female and female and region interaction estimated by OLS regression models of global cognitive function. Model A estimates female disadvantage controlling only for age (linear and quadratic), and Model B estimates the regional effects and their interaction with gender, after controlling for age and caste. We then adjust for each set of risk factors of poor cognitive function in Models C1 – C5, and finally control for all risk factors and other covariates in Model D. Education and literacy are the only factors that singularly account for the gender disparity in this measure of global cognitive functioning, reducing the estimate on female disadvantage by over 55%. No other risk factors explain female disadvantage in global cognitive functioning. Once adjusting for all covariates, we further reduce the female disadvantage by an additional 20%. The geographic-specific female disadvantage is not accounted for by any risk factor or combination of them.

Discussion

Using pilot data from the Longitudinal Aging Study in India (LASI), we examined cognitive functioning for men and women ages 45 years or older, representative of four Indian states: Punjab and Rajasthan in the north and Kerala and Karnataka in the south. We found significant gender disparity in cognitive function. Our results were consistent with a growing literature on cognitive health in developing countries that show women do worse than men on a variety of performance measures (Zunzunegui et al., 2009; Taboonpong et al., 2008). These results contrast specifically to what is observed in industrialized countries, where women outperform men (Langa et al., 2008, 2009).

We also found gender disparity in cognitive functioning was more pronounced in the northern Indian states than in the southern states. We hypothesized these patterns exist because women are traditionally not entitled to many of the same social, economic, and medical resources as men. Research has shown this discrimination to be particularly acute in northern India (Mishra et al., 2008; Sen, 1992; Sen 1993). In our study, women in the north were much more likely to have difficulty with activities of daily life and less likely to engage in social activities than men, and such gender difference is more pronounced in the north than the south. The gender gap in labor force participation was also larger in the north than the south.

Several risk factors we examined in this study (e.g., age, nutritional health, disability, smoking, emotional distress, socioeconomic status) contribute to cognitive functioning, but only education and emotional distress accounted for the female disadvantage. Education was the single factor with the strongest relationship to female disadvantage, and our results suggest that about 40 to 55 percent of the disparity between men and women could be attributable to differential investment in education. Education, however, does not alone fully explain the specific disadvantage that women face in the north. Emotional health, on the other hand, accounted for only modest variance of female disadvantage in episodic memory, but not significantly explaining female disadvantage in global cognitive function. It is also notable that once health and health behaviors are controlled, female disadvantages were even more pronounced.

Moreover, female disadvantage persisted even after controlling for all risk factors and other covariates. For episodic memory, the main effects of female disadvantage persisted, after controlling for all risk factors and covariates, but the interaction term suggesting geographic difference in female disadvantage was no longer significant. For global cognitive functioning, the main effect of female disadvantage was no longer significant, but its interaction with geographic region remained significant after controlling for all risk factors and covariates.

Health and health behaviors were the only factor to significantly reduce the region-gender interaction, but increased the main effect of female disadvantage. This was statistically significant for only episodic recall, though the global cognitive functioning displays a similar pattern. The ADL morbidity is not statistically different between men and women in the south as it is among respondents in the north. Once we adjust for this covariate, we see the interaction between female and region losses significance, while the main effect of female disadvantage exacerbated.

Emotional distress also explained some of female disadvantage in cognition, but only in the model for episodic memory. We did not observe similarly significant results in the model for global cognitive functioning. While the size of the estimate of emotional distress is small, the poor psychological health experienced by women may “use up” the cognitive resources required for memory tasks (Gerstorf, Hoppmann, Kadlec, & McArdle, 2009; Gerstorf, Hoppmann, Anstely, & Luszcz, 2009 ; Macdonald, Hultsch, & Bunce, 2006).

Prior studies from India have focused on single city observations in the north (Ganguli et al., 2008) and the south (Mathuranath, et al. 2007). In the north, women were found to have worse age-adjusted cognitive functioning than men. Although the authors could not test what accounted for the difference, our results were consistent with their hypothesis that education can significantly reduce the disparity. Our results contrast somewhat from studies of cognitive function in southern India, where no female disadvantage was found after adjusting for age and education. While education did not completely explain the female disadvantage for southern women, it explained a large proportion of female disadvantage in cognitive function.

Our results may differ from these previous studies primarily because of the outcomes assessed. Both Ganguli and Mathuranath used a composite measure of cognitive health – adapted versions of the Mini Mental State Exam (MMSE). The MMSE includes both word recall and the global cognitive functioning summary measure into a combined score, along with additional tests of categorical fluency and visuospatial and constructional praxis that were not fielded in the LASI pilot.

Although we cannot study all dimensions of cognitive function, our study makes an important contribution to the emerging literature on cognitive function in India. While prior findings were limited to geographically confined small samples, our study brings further insight to geographic difference in cognitive function and its potential effect on gender disparity with a relatively large sample. Another strength is our ability to analyze and adjust for a rich set of risk factors. To the best of our knowledge, only a limited set of covariates has been used when examining gender disparity in India. In this study, we control for key risk factors of cognitive function, including under-nutrition, education, health and health behaviors, social engagement, and emotional distress, as well as other control variables. These allow us to explore and test our hypothesis regarding what might have contributed to female disadvantage in cognitive function in India.

However, the cross sectional design of this study limits our ability to establish causality. Poor cognitive health may lead to decreased social participation and physical morbidity, as well as increased emotional distress. Studies have shown the relationships between these factors to be bidirectional. Furthermore, while geographic differences in gender discrimination have been hypothesized, we are not able to directly examine gender discrimination due to lack of data. Similarly, we do not measure access to food or health services as a child due to a lack of data, and our measure of health service utilization was over a lifetime, not adequately capturing disparity on the intensive margin of health care utilization.

Conclusions and Implications

We found that women in India have poorer cognitive function than men, and this disparity is particularly acute in north. The extent to which factors like education and emotional distress account for the overall and region-specific gender disparity differed across models of cognitive domains, but education is the strongest contributor, accounting for 40 to 55 percent of the gender disparity. Gender disparity, however, persisted even after controlling for education and other key risk factors of poor cognitive function.

The findings presented have important implications for the health of aging individuals in India and in developing countries. Education can reduce the burden of poor cognitive function among older adults, and greater access to education among girls and women has the potential to reduce gender disparities. Therefore, policy directed towards educating girls may improve cognitive health and alleviate the health disparities observed later in life.

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Table 1. Sample characteristics: Age 45 +

		unweighted N					weighted %						
			Southern		Northern			Southern		Northern			
		ALL	karnataka	kerala	punjab	rajasthan	ALL	karnataka	kerala	punjab	rajasthan	F-stat	*
All		1486	337	418	368	363		100%	100%	100%	100%		
gender	men	722	166	185	185	186	50.45%	50.14%	44.82%	50.22%	51.45%		
	women	764	171	233	183	177	49.55%	49.86%	55.18%	49.78%	48.55%	2.33	
age	45 - 54	651	163	154	170	164	38.84%	48.30%	36.79%	46.36%	45.22%		
	55 - 64	434	109	131	111	83	31.74%	32.40%	31.41%	30.09%	22.79%		
	65 - 74	259	51	84	50	74	19.42%	15.16%	19.80%	13.51%	20.36%		
	75+	142	14	49	37	42	10.01%	4.15%	12.00%	10.04%	11.63%	2.65	**
caste	scheduled caste	235	56	33	111	35	13.68%	16.47%	7.35%	29.95%	9.72%		
	scheduled tribe	145	30	0	0	115	12.52%	8.89%	0.00%	0.00%	32.13%		
	other backward class	523	198	179	43	103	39.04%	58.88%	42.91%	11.64%	28.17%		
	Other/none	582	53	206	214	109	34.76%	15.76%	49.74%	58.41%	29.98%	10.88	**
education	no schooling	681	149	31	219	282	47.22%	43.93%	7.45%	59.36%	78.11%		
	primary/ms schooling	524	128	251	99	46	34.53%	37.93%	60.83%	27.00%	12.57%		
	hs or more	280	60	135	50	35	18.25%	18.14%	31.72%	13.63%	9.31%	34.69	**
per capita consumption (Rps)	median		--	--	--	--	41300	55250	42387	48093	28091		
	mean		--	--	--	--	54929	69537	58080	58680	36560		
	sd		--	--	--	--	42524	48529	42545	37803	29212		
	at bottom tercile	492	62	139	86	205	34.76%	18.96%	32.93%	23.38%	57.07%		
	at middle	444	121	129	136	58	31.76%	37.15%	31.55%	36.94%	26.90%		
	at top tercile	530	142	145	146	97	33.47%	43.89%	35.52%	39.68%	16.03%		
	total	1466	325	413	368	360	100.00%	100.00%	100.00%	100.00%	100.00%	7.13	***

* p<0.05; ** p<0.01; *** p<0.001
Note: F-stat test across states.

Table 2. Gender differences in cognitive functioning

Gender differences	Mean (std error)	score range	ALL				Northern states				Southern states			
			men	women	F-stat	*	men	women	F-stat	*	men	women	F-stat	*
episodic memory	Immediate	0 to 10	5.26 (0.103)	4.63 (0.101)	37.78	***	5.47 (0.195)	4.62 (0.205)	22.81	***	5.09 (0.088)	4.63 (0.087)	12.16	**
	Delayed	0 to 10	3.91 (0.083)	3.42 (0.083)	27.03	***	3.68 (0.109)	3.06 (0.130)	20.68	***	4.11 (0.124)	3.70 (0.107)	6.75	*
	total word recall	0 to 20	9.19 (0.159)	8.06 (0.172)	38.57	***	9.17 (0.279)	7.68 (0.320)	28.04	***	9.20 (0.171)	8.34 (0.180)	9.99	**
Global cognitive function	date naming	0 to 4	2.93 (0.080)	2.30 (0.082)	64.23	***	2.76 (0.095)	1.91 (0.106)	67.00	***	3.08 (0.125)	2.60 (0.114)	15.67	***
	naming prime minister	0 to 1	0.52 (0.026)	0.32 (0.019)	58.31	***	0.38 (0.035)	0.21 (0.022)	33.13	***	0.65 (0.035)	0.40 (0.027)	37.59	***
	backward count from 20	0 to 2	1.15 (0.051)	0.85 (0.049)	53.24	***	0.84 (0.077)	0.41 (0.052)	41.06	***	1.42 (0.058)	1.17 (0.072)	38.72	***
	serial 7s	0 to 5	1.92 (0.104)	1.19 (0.067)	71.74	***	1.55 (0.151)	0.53 (0.096)	71.22	***	2.25 (0.137)	1.70 (0.074)	20.83	***
	global summary score	0 to 12	6.51 (0.209)	4.67 (0.174)	115.55	***	5.49 (0.297)	3.06 (0.222)	99.97	***	7.39 (0.278)	5.89 (0.223)	47.70	***

* p<0.05; ** p<0.01; *** p<0.001

Table 3 Gender differences in risk factors of cognitive functioning

		ALL					Northern				Southern			
		all	men	women	F-stat	*	Men	Women	F-stat	*	Men	women	F-stat	*
food insecurity	not enough food	3.66%	3.61%	3.71%	0.01		3.45%	4.37%	0.42		3.76%	3.22%	0.20	
	enough food	96.34%	96.39%	96.29%			96.55%	95.63%			96.24%	96.78%		
BMI	bmi < 18.5	26.86%	30.34%	23.58%	10.46	***	37.79%	26.77%	5.40	**	23.95%	21.29%	5.59	**
	18.5 ≤ bmi < 25.0	50.74%	53.66%	47.99%			48.12%	46.76%			58.41%	48.88%		
	25 ≤ bmi < 30	16.73%	13.63%	19.66%			11.14%	17.76%			15.76%	21.03%		
	30 ≤ bmi	5.66%	2.38%	8.76%			2.95%	8.71%			1.88%	8.80%		
literacy	yes	48.99%	57.71%	40.63%	36.29	***	35.51%	17.20%	17.77	***	76.91%	58.14%	34.27	***
	no	51.01%	42.29%	59.37%			64.49%	82.80%			23.09%	41.86%		
education	no schooling	48.15%	40.32%	55.65%	18.57	***	63.19%	82.25%	14.99	***	20.55%	35.79%	14.28	***
	primary/ms	33.90%	37.37%	30.57%			22.03%	11.50%			50.64%	44.81%		
	hs or more	17.95%	22.31%	13.78%			14.78%	6.25%			28.81%	19.40%		
cardiovascular diseases	any	52.27%	50.19%	54.14%	1.95		50.82%	54.57%	0.97		49.64%	53.83%	1.02	
	diagnosed diabetes	8.77%	8.32%	9.20%	0.29		3.56%	5.47%	1.34		12.45%	11.99%	0.03	
	diagnosed or measured hypertension	48.38%	46.44%	50.17%	1.63		49.23%	52.34%	0.69		44.01%	48.56%	1.11	
	diagnosed heart diseases	3.72%	4.30%	3.17%	1.23		0.94%	1.45%	0.32		7.20%	4.45%	2.62	
	diagnosed stroke	0.86%	1.07%	0.66%	0.46		0.72%	0.00%	2.16		1.38%	1.15%	0.05	
disability	ADL difficulty	13.95%	11.46%	16.36%	5.35	*	5.53%	12.36%	11.41	***	16.59%	19.30%	0.63	
health care utilization	ever visited MBBS	57.77%	57.48%	58.06%	0.05		40.08%	42.30%	0.34		72.55%	69.85%	0.56	
	never visited	42.23%	42.52%	41.94%			59.92%	57.70%			27.45%	30.15%		
social activities	frequency per month	1.80	1.96	1.64	4.66	*	1.23	0.97	6.47	*	2.59	2.14	3.38	
	0 activities/month	47.81%	45.01%	50.48%	2.70		64.12%	68.97%	1.00		28.47%	36.64%	3.12	
	1 to 2 activities/month	32.96%	32.80%	33.11%			23.00%	20.52%			41.29%	42.53%		
	3 or more activities/month	19.24%	22.18%	16.41%			12.88%	10.51%			30.24%	20.83%		
work status	working	46.54%	69.86%	24.24%	215.21	***	76.06%	25.64%	155.22	***	64.52%	23.19%	81.61	***
	not working	53.46%	30.14%	75.76%			23.94%	74.36%			35.48%	76.81%		
CESD	mean score	12.50	11.97	12.97	5.34	*	12.29	13.642	3.86		11.69	12.48	1.45	

Table 4 OLS Results for episodic memory

		Base Model				Fully Adjusted Model			
		β	se	t		β	se	t	
Female		-0.735	0.210	-3.50	***	-0.604	0.276	-2.19	*
Age		0.172	0.076	2.24	*	0.171	0.069	2.47	*
Age (quadratic)		-0.002	0.001	-3.66	***	-0.002	0.001	-3.54	***
Region (base: south)	North	0.259	0.355	0.73		0.879	0.345	2.54	*
	North x female	-0.751	0.321	-2.34	*	-0.516	0.342	-1.51	
Caste (base: other/none)	scheduled caste	-1.122	0.361	-3.11	**	-0.074	0.372	-0.20	
	scheduled tribe	-1.795	0.543	-3.30	**	-0.501	0.671	-0.75	
	other backward class	-0.098	0.272	-0.36		0.368	0.247	1.49	
Food insecurity (base: enough food)	not enough food					-0.132	0.727	-0.18	
BMI	underweight					-0.683	0.257	-2.66	*
Literacy (base: illiterate)	literate					0.364	0.404	0.90	
Education (base: none)	primary/ms					0.956	0.452	2.11	*
	hs or more					1.714	0.547	3.13	**
Cardiovascular diseases (base: no disease)	yes					-0.206	0.195	-1.06	
ADL disability (base: no disability)	yes					-0.698	0.291	-2.39	*
Health care utilization (base: never visited)	ever visited MBBS					0.299	0.201	1.48	
Smoking (base: never smoker)	current					-0.882	0.240	-3.67	***
	former					-0.221	0.482	-0.46	
Exercise (base: no exercise)	some					1.097	0.369	2.98	**
	daily					0.024	0.338	0.07	
Social activities	per month					-0.002	0.057	-0.04	
Work status (base: not working)	working					-0.064	0.217	-0.30	
Emotional distress	CESD Score					-0.030	0.014	-2.15	*
Per capita consumption (base: lowest tertile)	mid					0.280	0.245	1.14	
	high					0.600	0.285	2.11	*
Intercept		6.463	2.376	2.72	**	4.101	2.233	1.84	
N		1408				1271			
F-stat		19.99			***	9.22			***
R-square		0.2304				0.3184			

Notes:

(1) For categorical variables, the F-statistics is from a sampling-design corrected chi square statistics. For continuous variables, the F statistics from the difference in mean CESD score and mean social participation are from bivariate regression.

(2) * p<0.05; ** p<0.01; *** p<0.001

Table 5 OLS Results for Global Cognitive Function

		Base Model				Fully Adjusted Model			
		β	se	t		β	se	t	
Female		-1.497	0.231	-6.46	***	-0.356	0.287	-1.24	
Age		0.127	0.103	1.24		0.044	0.081	0.55	
Age (quadratic)		-0.002	0.001	-1.93		-0.001	0.001	-0.91	
Region (base: south)	north	-1.578	0.483	-3.27	**	0.432	0.323	1.34	
	north x female	-1.007	0.298	-3.37	**	-0.765	0.310	-2.47	*
Caste (base: other/none)	scheduled caste	-2.848	0.402	-7.09	***	-0.711	0.291	-2.45	
	scheduled tribe	-4.377	0.407	-10.74	***	-1.523	0.338	-4.51	
	other backward class	-1.277	0.315	-4.06	***	-0.383	0.208	-1.84	
Food insecurity (base: enough food)	not enough food					-0.196	0.448	-0.44	
BMI	underweight					-0.636	0.230	-2.76	**
Literacy (base: illiterate)	yes					2.399	0.407	5.90	***
Education (base: none)	primary/ms					2.060	0.433	4.76	***
	hs or more					3.604	0.432	8.35	***
Cardiovascular diseases (base: no disease)	Yes					0.455	0.187	2.43	*
ADL disability (base: no disability)	Yes					-0.563	0.211	-2.67	*
Health care utilization (base: never visited)	ever visited MBBS					0.422	0.207	2.03	*
Smoking (base: never smoker)	current					0.185	0.273	0.68	
	Former					1.427	0.331	4.31	***
Exercise (base: no exercise)	some					-0.096	0.220	-0.44	
	daily					0.024	0.274	0.09	
Social activities	per month					0.098	0.035	2.77	**
Work status (base: not working)	working					0.460	0.170	2.71	**
Emotional distress	CESD Score					-0.011	0.017	-0.68	
Per capita consumption (base: lowest tertile)	mid					-0.399	0.231	-1.72	
	high					-0.002	0.251	-0.01	
Intercept		6.855	3.160	2.17	*	2.559	2.524	1.01	
N		1390				1255			
F-stat		48.89			***	51.03			***
R-square		0.2838				0.5965			

Notes:
(1) For categorical variables, the F-statistics is from a sampling-design corrected chi square statistics. For continuous variables, the F statistics from the difference in mean CESD score and mean social participation are from bivariate regression.
(2) * p<0.05; ** p<0.01; *** p<0.001

Table 6. What contributes to the female disadvantage in episodic memory?

Parameter coefficients (standard errors)	Female (base: male)	North (base: south)	Female x North	Differences in female disadvantage coefficients	Differences in female x north coefficients
Model A	-1.090 ***				
Controls: Age	(0.161)				
Model B	-0.735 ***	0.259	-0.751 *		
Controls: Age, caste	(0.210)	(0.355)	(0.321)		
Model C				Model C vs. Model B	Model C vs. Model B
(1) Under-nutrition: underweight, food insecurity	-0.774 ***	0.339	-0.767 *	-0.039	-0.016
	(0.212)	(0.366)	(0.328)		
(2) education: literacy, schooling	-0.436 *	0.924 **	-0.656 *	0.299 ***	0.095
	(0.185)	(0.305)	(0.316)		
(3) health: cardiovascular health, ADL, ever visited MBBS, health behaviors (smoking, exercise)	-1.090 ***	.035	-.432	- 0.355 *	0.235 *
	(0.268)	(.398)	(.347)		
(4) social engagement: social activities, work status	-0.762 **	0.346	-0.761 *	-0.027	-0.011
	(0.208)	(0.361)	(0.323)		
(5) emotional distress: CESD	-0.657 ***	0.255	-0.752	0.078 **	-0.001
	(0.208)	(0.367)	(0.325)		
Model D				Model D vs. Model B	Model D vs. Model B
Controlling for all covariates, including per capita consumption	-0.604 *	0.879 *	-0.516		
	(0.276)	(0.345)	(0.342)	0.131	0.235

*p<.05; **p<.01; ***p<.001

Table 7. What contributes to the female disadvantage in global cognitive function?

Parameter coefficients (standard errors)	Female (base: male)		North (base: south)		Female x North		Differences in female coefficients		Differences in female x north coefficients
Model A	-1.868	***							
Controls: Age	(0.162)								
Model B	-1.497	***	-1.578	**	-1.007	**			
Controls: Age, caste	(0.231)		(0.483)		(0.298)				
Model C							Model C vs. Model B		Model C vs. Model B
(1) Under-nutrition: underweight, food insecurity	-1.661	***	-1.597	***	-0.959	**	-0.164		0.048
	(0.187)		(0.387)		(0.277)				
(2) education: literacy, schooling	-0.655	***	0.442		-0.692	*	0.842	***	0.315
	(0.218		(0.324)		(0.285)				
(3) health: cardiovascular health, ADL, ever visited MBBS, health behaviors	-1.660	***	-1.660	***	-.840	**	-0.164		0.381
	(0 .251)		(0.411)		(0 .311)				
(4) social engagement: social activities, work status	-1.310	***	-1.355	**	-0.983	**	0.187		0.024
	(0.273)		(0.431)		(0.298)				
(5) emotional distress: CESD	-1.470	***	-1.549	*	-0.964	*	0.027		0.043
	(0.221)		(0.485)		(0.288)				
Model D							Model D vs. Model B		Model D vs. Model B
Controlling for all covariates	-0.356		0.432		-0.765	*	1.141	***	0.242
	(0.287)		(0.323)		(0.310)				

*p<.05; **p<.01; ***p<.001