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JINKOOK LEE, REGINA A. SHIH,
KEVIN CARTER FEENEY, AND KENNETH M. LANGA

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RAND LABOR AND POPULATION

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

Jinkook Lee[1], PhD; Regina A. Shih[1], PhD; Kevin Feeney[1], BA, Kenneth M. Langa[2], PhD, MD

1. RAND Corporation
2. University of Michigan, Veterans Affairs Ann Arbor Center for Clinical Management Research

Correspondence:

Jinkook Lee, PhD
RAND Corporation
1776 Main Street, PO Box 2138
Santa Monica, CA 90407
Email: Jinkook@rand.org

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Abstract

India is experiencing a rapid demographic and epidemiologic transition. Among a growing aging population, non-communicable diseases, including dementia, are increasingly prevalent, but our understanding of cognitive health is quite limited. Recent studies suggest that women in developed countries perform as well or better than men on cognitive functioning tests, though research from developing countries shows the opposite. This gender disparity in developing settings may be attributable to that fact that women are traditionally not given equal access to education, health services, economic opportunity, and social engagement. Furthermore, in countries such as India, discrimination against women may play a role in the gender disparity. To address this issue, we examine cognitive function of older Indians, using cross-sectional data from the 2010 pilot round of the Longitudinal Aging Study in India, fielded across Punjab and Rajasthan in the north and Kerala and Karnataka in the south. We found gender disparities in cognitive function and suggest that female cognitive disadvantage could be explained by disparities in education, health and social engagement in southern India. However, female disadvantage persisted in northern states where discrimination against women has been notably acute even after controlling for education and other key risk factors of poor cognitive function.

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 (Alladi et al., 2010; Das, Bose, Biswas et al, 2007; Mahal, Karan, & Engelgau, 2010; Prince,1997; Suh & Shah, 2000; WHO, 2009). Poor cognitive function is a risk factor for dementia and other 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, Williams, & Prince, 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 (Lei et al., 2011; Maurer, 2011; Yao et al., 2009; Yount, 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., 1995). 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. (2003) 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. (2007) 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 across different regions of India, and whether factors like education may account for such gender difference.

Gender disparities in cognition may be explained by variation between men and women in factors such as education, health, 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, Roy, & Retherford, 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 (Cagney &Lauderdale, 2002; Farias et al., 2011; Luchsinger et al., 2007; Sabia et al., 2009; Stewart et al., 2000; van Boxtel et al., 1998; Zhang, 2006). 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 & Liu, 2003), which therefore may contribute to female disadvantage in cognition. Persistent social and economic disadvantage among females can also lead to psychological and emotional distress (McDonough & Walters, 2001; Rieker & 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; 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., 2008). Mishra, Roy, & Retherford (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).

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 a host of risk factors contribute to female disadvantage in cognitive function, and whether gender disparities persist after controlling for these factors associated with cognitive function, such as under-nutrition, education, health and health care utilization, social engagement, emotional distress, and other factors.

Methods

Data

The study sample was drawn from the pilot survey of the Longitudinal Aging Study in India (LASI). LASI was 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 consisted of two main sections: the household interview and the individual interview. The household module asks about household finances, expenditure, consumption, and assets and could have been answered by any knowledgeable household member 18 years of age or older. The household response rate was 88.6%. The individual interview was only for age-eligible household members and their spouses, and could have been answered by a proxy respondent if necessary (we excluded proxy respondents in this analysis). The individual response rate was 91.7%. We further restricted the analysis in this paper to 1451 respondents who were at least 45 years of 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 were 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., 1995); 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, Cherian, et al. 2007, 2009). 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 included the following risk factors to see whether they explained female disadvantage in cognitive function: education, health, social engagement, emotional distress, and geographic residency.

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: We included (1) 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 & Asenso-Okyere, 1998), (2) cardiovascular health based on both self-reports and directly assessed biomarkers, (3) physical functioning based on both self-report and performance measure, as well as (4) self-report of health care utilization and health behaviors to capture variances in health.

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." 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; 18.5 $\leq$ BMI < 25 is normal weight; 25 $\leq$ BMI < 30 is overweight; BMI of 30 or over is obese.

For cardiovascular health, we created a binary variable, accounting 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.

For physical functioning, we included a binary measure indicating a limitation in activities of daily living (ADL) and a performance measure of grip strength. 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. Grip strength is an indicator of hand muscle strength (Crimmins et al., 2008) and has been proven to be a strong predictor of disability and mortality (Snih et al., 2002). Grip strength was measured twice, using Smedley hand dynamometer, and we used the average value of dominant hand.

For health care 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. While this variable is limited, as it does not discriminate the extent of health care use nor the use of other health care providers, we are bound to what is available from the data source. 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.

<u>Social engagement</u>: We included social activity and labor force participation measures. 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. We also control for urban versus rural residency and which state respondents reside to capture other geographic variations.

[1] Mahila Mandal are women's empowerment groups

Control variables: We also controlled for the following covariates: demographics (sex, age, quadratic age, caste), 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 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:

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

where Cog_i is a measure of individual i's cognitive function; F_i stands for individual i being a female; $F_i \times G_i$ refers to the interaction between geographic residence (north) and gender, capturing female disadvantage in north; 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_1 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, and the coefficient β_2 captures additional female disadvantage experienced only by women residing in north.

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 age, caste affiliation (as scheduled tribes are geographically segregated and may reflect unique cultural attributes not reflective of more traditional Indian culture (Mitra, 2008), residing in rural versus urban area, and states where respondents resided.

We then examine whether gender disparities (β_1) and geographic differences in gender disparities (β_2) persist after simultaneously controlling for the risk factors associated with cognitive function, such as education, health, 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 four factors outlined above (e.g., education, health, 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 33% 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: 35% of the Rajasthan sample identifies as a scheduled tribe, while the highest proportion of scheduled castes, 33%, 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 about 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. Southern states, Karnataka and Kerala, 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, both for episodic memory and global cognitive function. 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 the distributions across gender to be asymmetric for literacy, schooling, cardiovascular health, ADL difficulties, smoking, physical activities, social activities, work status, and emotional distress, but did not find gender differences in food insecurity and health care utilization across the pooled sample. For BMI, a greater proportion of men (31%) were underweight than women (23%). Women were more likely 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 showed 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 more emotionally distressed than men, but gender difference in emotional distress was not statistically significant in South. Education, literacy, physical activities, social activities 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 model showed that women performed worse than men after adjusting for age; and women in the northern states performed especially worse. On average, women scored 0.67 (out of 20 points) lower than men, but women in the north scored 1.5 lower. We fully accounted for the main coefficient for female, once we controlled for the risk factors, although the interaction between northern state residency and female gender remained significant. Women in northern states scored 0.8 points lower after controlling for all risk factors. Higher education, stronger grip strength, and some exercise were positively associated with better episodic memory, while being underweight, having difficulty with ADLs, current smokers, and those who were emotionally more distressed had worse episodic memory. The residents of Punjab had better memory scores than the residents of Karnataka, while the residents of Kerala did worse than those of Karnataka.

Table 5 presents two regression models for global cognitive function summary score. The first model adjusted only for age, caste, and geographic residence. The second fully adjusted for the same risk factors to cognitive health as Table 4. Like episodic memory, women also performed worse on this composite measure of cognitive functioning, and women in the North performed worse than women in the South. Once we regressed global cognitive function summary score on a full set of covariates, we were again able to account for the main effect of female disadvantage, but women in northern India continued to have lower scores. These results are consistent with what we found in episodic memory. Literacy, education, stronger grip strength, smoking cessation, social activities, and labor force participation all contributed to higher scores on the summary measure of global cognitive functioning. Being scheduled caste and tribe, rural residence, and ADL limitation were associated with lower performance on the cognitive tests for global functioning. The residents of Karnataka performed worse than those in Rajasthan and Kerala. While having cardiovascular disease had the opposite association than expected with cognitive functioning, our measure of health care utilization is limited, and the extent of un-diagnosed diseases is widespread due to lack of access to health care utilization. Further studies are needed to shed a light on this unexpected finding.

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), caste, and geographic residence. For Model B, we separately introduce each of the four set of risk factors of cognitive function to ascertain which accounts for female disadvantage, controlling for the same covariates as Model A: (1) health ; (2) education; (3) social engagement; and (4) emotional distress (Models B1 – B4). 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 being female of Model B with Model A, we observed 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 58%, and adjusting for emotional distress reduced the main effect of female disadvantage by 12%. We did not see any statistically significant changes in regression coefficients for female when we controlled for health and social engagement. When we controlled for health, the regression coefficients for female were no longer significant, but our test statistic did not indicate significant differences between two coefficients from Model A and B. Model C, the fully adjusted model (the same as Table 4), showed that the geographic difference in female disadvantage in episodic memory is persistently significant, even after all risk factors of poor cognitive function and per capita consumption were controlled for, although the main effects for female disadvantage was no longer significant.

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), caste, and residence. We then adjusted for each set of risk factors of poor cognitive function in Models B1 – B4, and finally controlled for all risk factors and other covariates in Model C. Health, education, and social engagement accounted for the gender disparity in this measure of global cognitive functioning. The inclusion of education reduced the estimate of female disadvantage by 53%; and the inclusion of health variables and social engagement variables reduced the estimates on female disadvantage by 27% and 17%, respectively. Emotional distress did not explain female disadvantage in global cognitive functioning. Once adjusting for all covariates, the main effect of female disadvantage was no longer significant. 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 among a sample of 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 disparities in cognitive function. Our results were consistent with a growing literature on cognitive health in developing countries that showed that women performed worse than men on a variety of cognitive measures (Lei et al., 2011; Maurer, 2011; Taboonpong et al., 2008; Yount, 2008). These results contrast with what is observed in industrialized countries, where women typically outperform men (Langa et al., 2008, 2009).

We also found that the 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. Other research has also shown this discrimination to be particularly acute in northern India (Mishra et al., 2004; Sen, 1992, 2003). In our study, women in the North were much more likely to have difficulty with activities of daily life and less likely to get education than men in the North.

Risk factors we examined in this study (i.e., education, health, social engagement, and emotional health) contributed to cognitive functioning, and together fully accounted for the female disadvantage in cognition, both in episodic memory and global cognitive functioning. But, these risk factors did not account for additional female disadvantage in northern states, suggesting there are other forms of disadvantage and discrimination unaccounted for this analysis impacting women's cognitive health. As previously proposed, education was the factor with the strongest relationship to female disadvantage, and our results suggest that about 53 to 58 percent of the disparity between men and women could be attributable to education.

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).

On the other hand, health and social engagement explained female disadvantage in global cognitive function, but not in episodic memory. As noted earlier, due to data limitations, we were not able to adequately capture health care utilization in our analysis. Social engagement may have more direct influence on global cognitive function, as some of the items (e.g., naming of prime minister) can be learned from interacting with friends and other social activities.

Prior studies from India have focused on single city observations in the North (Ganguli et al., 1996) and the South (Mathuranath, George et al., 2003; Mathuranath, Cherian, et al. 2007, 2009). 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 also support the findings from previous studies of cognitive function in southern India, where no female disadvantage was found after adjusting for age and education. Once we account for education, emotional distress, and other risk factors, the female disadvantage in cognitive function is no longer significant for southern women.

Our study makes an important contribution to the emerging literature on cognitive function in India and developing countries in general. While prior findings on Indian adults 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 disparities in India. In this study, we controlled 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 also 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 on discrimination by gender. 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 assessed over a lifetime, and may not adequately capture disparity on the extent of health care utilization.

Conclusions and Implications

We found that women in India have lower cognitive function than men, and this disparity is particularly acute in northern India. The extent to which factors like education, health, social engagement, 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 53 – 58 percent of the gender disparity. Once we controlled for all risk factors, the main effect of female disadvantage was no longer significant. However, female disadvantage persisted in northern states even after controlling for education and other key risk factors of poor cognitive function.

Further study is needed to explain the persistent female disadvantage in cognition in northern India. Previous studies noted that discrimination against women is particularly pervasive in northern India (Sen, 1992, 2003). How discrimination against women in India throughout the life course may affect cognitive health, and the causal pathways by which discrimination has its negative effects, are important areas for future research.

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 Across States

		unweighted N					weighted %						
		all	karnataka	kerala	punjab	rajasthan	all	karnataka	kerala	punjab	rajasthan	F-stat	*
		1,451	315	413	365	358	100.00%	21.73%	28.40%	25.17%	24.70%		
gender	men	696	151	183	182	180	48.69%	47.59%	44.87%	51.43%	51.46%	2.23	
	women	755	164	230	183	178	51.31%	52.41%	55.13%	48.57%	48.54%		
age	45 - 54	617	146	148	168	155	43.31%	46.72%	36.04%	46.82%	43.96%	2.79	**
	55 - 64	426	105	130	109	82	29.44%	33.70%	31.81%	30.21%	23.16%		
	65 - 74	252	48	84	46	74	17.93%	15.42%	20.18%	12.70%	20.93%		
	75+	140	13	48	37	42	9.31%	4.16%	11.97%	10.27%	11.95%		
literacy	yes	746	165	363	143	75	49.11%	52.71%	88.25%	39.30%	20.54%	47.55	***
	no	704	150	49	222	283	50.89%	47.29%	11.75%	60.70%	79.46%		
education	no schooling	665	135	30	220	280	48.04%	42.59%	7.28%	60.12%	78.65%	35.61	***
	primary/ms	513	123	249	97	44	34.06%	38.99%	61.13%	26.67%	12.18%		
	hs or more	272	57	133	48	34	17.90%	18.41%	31.59%	13.21%	9.17%		
caste	scheduled caste	242	53	31	123	35	14.49%	16.67%	7.04%	33.48%	9.85%	12.38	***
	scheduled tribe	152	27	0	0	125	13.87%	8.57%	0.00%	0.00%	35.40%		
	other backward class	510	188	177	43	102	39.29%	59.79%	42.93%	11.75%	28.32%		
	other	546	47	205	199	95	32.34%	14.98%	50.04%	54.77%	26.43%		
per capita consumption (Rps)	median						41500	55700	42607	48093	28091		
	mean						55696	72431	58929	58934	35979		
	sd						45103	52501	45327	38803	28278		
	at bottom tercile	483	55	139	86	203	34.99%	17.92%	33.41%	23.58%	57.30%	7.24	***
	at middle	469	114	125	135	95	32.37%	37.30%	31.01%	36.97%	26.71%		
	at top tercile	480	136	143	144	57	32.64%	44.78%	35.58%	39.45%	15.99%		

Notes: * $p<0.05$; ** $p<0.01$; *** $p<0.001$. Consumption tertile calculated on all-India basis. The cutoff for the middle tertile is 31672 Rps and the cut off for the top tertile is 57796 Rps. The cut off values, means, medians, and standard deviations are reported with income top-coded at the 95 percentile following imputation.

Table 2 Gender differences in cognitive functioning

		range	weighted mean (standard error)					Northern States				Southern States			
			all	men	women			men	women			men	women		
			mean	mean	mean	F-stat	*	mean	mean	F-stat	*	mean	mean	F-stat	*
episodic memory	immediate	0 to 10	4.93	5.23	4.64	29.74	***	5.41	4.61	16.86	***	5.07	4.66	10.17	**
	delayed	0 to 10	3.64	3.85	3.43	16.81	***	3.69	3.06	14.74	***	3.99	3.72	2.34	
	total word recall	0 to 20	8.57	9.09	8.08	26.17	***	9.12	7.67	18.70	***	9.06	8.39	5.64	*
mental status	date naming	0 to 4	2.62	2.92	2.32	50.69	***	2.70	1.91	45.95	***	3.13	2.64	15.56	***
	naming prime minister	0 to 1	0.42	0.52	0.32	52.89	***	0.37	0.22	32.70	***	0.66	0.41	36.41	***
	backward count from 20	0 to 2	0.98	1.13	0.84	34.28	***	0.82	0.42	27.47	***	1.42	1.15	23.31	***
	serial 7s	0 to 5	1.57	1.92	1.23	59.24	***	1.50	0.55	55.49	***	2.30	1.76	22.69	***
	mental status summary score	0 to 12	5.60	6.50	4.74	85.74	***	5.37	3.12	68.67	***	7.52	5.98	46.33	***

Notes: * p<0.05; ** p<0.01; *** p<0.001

Table 3 Gender differences in risk factors of cognitive functioning

		All States					North				South			
		all	men	women	F-stat	*	men	women	F-stat	*	men	women	F-stat	*
literacy	yes	49.11%	57.45	41.19	30.36	***	34.53	17.25	18.05	***	78.48	59.17	27.94	***
	no	50.89%	42.55	58.81			65.47	82.75			21.52	40.83		
education	no schooling	48.04%	40.65	55.05	14.15	***	64.70	82.03	14.70	***	18.58	34.79	12.55	***
	primary/ms	34.06%	37.33	30.96			21.15	11.59			52.17	45.51		
	hs or more	17.90%	22.02	13.99			14.15	6.38			29.25	19.70		
food insecurity	not enough food	3.32%	2.92	3.70	0.59		3.46	4.66	0.70		2.42	2.98	0.15	
	enough food	96.68%	97.08	96.30			96.54	95.34			97.58	97.02		
BMI	bmi < 18.5	26.74%	30.57	23.11	10.07	***	37.62	27.66	4.13	*	24.36	19.82	6.82	***
	18.5 ≤ bmi < 25.0	51.20%	53.57	48.95			48.34	46.46			58.17	50.75		
	25 ≤ bmi < 30	16.47%	13.51	19.27			11.06	16.98			15.67	20.93		
	30 ≤ bmi	5.59%	2.35	8.67			2.98	8.90			1.80	8.50		
health	cardiovascular	49.17%	46.41	51.77	2.41		46.02	50.04	0.49		46.77	53.07	2.20	
	ADL difficulty	13.59%	11.24	15.85	5.87	*	5.71	12.12	8.68	**	16.32	18.59	0.40	
health care utilization	ever visited MBBS	57.48%	57.57	57.40	0.25		40.27	41.69	1.25		73.48	69.19	2.02	
smoking	Current smoker	16.88%	29.09	5.23	88.40	***	21.56	2.64	30.99	***	36.02	7.18	75.09	***
	Past smoker	4.74%	7.87	1.75			3.60	0.58			11.80	2.63		
	Not smoking	78.38%	63.04	93.01			74.83	96.79			52.18	90.19		
physical activities	daily	21.56%	29.39	14.09	55.99	***	28.84	11.28	23.11	***	29.90	16.19	33.90	***
	some	11.81%	15.97	7.85			17.71%	9.65			14.36	6.50		
	no	66.63%	54.64	78.06			53.45%	79.07			55.74	77.30		
social activities	frequency per month	1.76	1.80	1.73	2.42		1.19	1.00	0.47		2.36	2.28	4.44	*
	0 - 1 times	47.89%	46.14	49.54	1.40		65.32	68.16	0.58		28.51	35.55	1.77	
	1 - 3 times	33.10%	32.69	33.48			22.13	21.26			42.40	42.67		
	3< times	19.02%	21.17	16.97			12.55	10.58			29.09	21.78		
work status	working	46.01%	68.98	24.25	214.98	***	74.28	25.82	108.99	***	64.15	23.07%	98.04	***
	not working	53.99%	31.02	75.75			25.72	74.18			35.85	76.93		
CESD	mean score	12.47	11.87	12.99	6.59	*	12.11	13.82	5.20	*	11.65	12.41	1.40	

Notes: * p<0.05; ** p<0.01; *** p<0.001

Table 4	OLS Results for episodic memory								
		Base Model				Full Model			
		β	se	t		β	se	t	
Female		-0.668	0.217	-3.08	**	-0.055	0.269	-0.21	
Female x north		-0.877	0.336	-2.61	*	-0.845	0.319	-2.65	*
Age		0.199	0.079	2.51	*	0.216	0.069	3.16	**
Age (quadratic)		-0.002	0.001	-3.72	***	-0.002	0.001	-3.94	***
Caste (base: other/none)	scheduled caste	-1.282	0.372	-3.45	**	-0.338	0.390	-0.87	
	scheduled tribe	-1.477	0.563	-2.62	*	-0.446	0.600	-0.74	
	other backward class	-0.248	0.279	-0.89		0.149	0.262	0.57	
Residence	Urban	0.863	0.254	-3.40	**	0.415	0.237	1.75	
	Punjab	1.871	0.532	3.52	***	1.871	0.490	3.82	***
	Rajasthan	-0.643	0.493	-1.30		0.063	0.330	0.19	
	Kerala	-1.118	0.386	-2.89	**	-1.728	0.335	-5.15	***
Literacy	literate					0.666	0.415	1.60	
Education	primary/ms					0.966	0.449	2.15	*
	hs or more					1.809	0.548	3.30	**
Food insecurity	not enough food					-0.046	0.758	-0.06	
BMI	underweight					-0.568	0.267	-2.13	*
(base: normal)	overweight					-0.238	0.219	-1.08	
	obese					0.672	0.321	2.10	*
Health	Cardiovascular disease					-0.176	0.166	-1.06	
	ADL limitation					-0.724	0.325	-2.22	*
	Grip strength					0.031	0.014	2.18	*
Health care (base: never visited)	ever visited MBBS					0.208	0.184	1.13	
Smoking	current					-0.739	0.223	-3.31	**
(base: never smoker)	former					0.142	0.424	0.33	
Exercise	some					1.025	0.332	3.09	**
(base: no exercise)	daily					0.086	0.336	0.26	
Social activities	per month					-0.005	0.050	-0.11	
Work status	working					-0.137	0.234	-0.58	
Emotional distress	CESD Score					-0.030	0.015	-2.05	*
Per capita consumption	mid					0.127	0.241	0.53	
(base: lowest tertile)	high					0.263	0.262	1.00	
Intercept		6.012	2.514	2.39	**	2.456	2.202	1.12	
N		1379				1335			
F-stat		17.02	***			6.76	**		
R-square		0.2594				0.3609			

Notes: * p<0.05; ** p<0.01; *** p<0.001

Table 5 OLS Results for global functioning

		Base Model				Full Model			
		β	se	t		β	se	t	
Female		-1.774	0.206	-8.60	***	-0.050	0.267	-0.19	
Female x north		-0.622	0.306	-2.03	*	-0.676	0.291	-2.32	*
Age		0.079	0.089	0.88		0.072	0.082	0.87	
Age (quadratic)		-0.001	0.001	-1.73		-0.001	0.001	-1.16	
Caste (base: other/none)	scheduled caste	-2.437	0.434	-5.62	***	-0.608	0.297	-2.05	*
	scheduled tribe	-3.386	0.500	-6.77	***	-1.406	0.365	-3.85	***
	other backward class	-0.956	0.337	-2.84	**	-0.326	0.212	-1.54	
Residence	Urban	1.677	0.340	-4.93	***	0.797	0.24	3.32	**
	Punjab	0.165	0.809	0.20		0.933	0.653	1.43	
	Rajasthan	-0.683	0.499	-1.37		1.035	0.365	2.84	**
	Kerala	2.373	0.442	5.37	***	0.818	0.314	2.61	*
Literacy	literate					2.212	0.466	4.75	***
Education	primary/ms					2.092	0.505	4.15	***
	hs or more					3.386	0.516	6.56	***
Food insecurity	not enough food					-0.278	0.396	-0.70	
BMI	underweight					-0.434	0.234	-1.85	
(base: normal)	overweight					-0.211	0.188	-1.12	
	obese					0.028	0.289	0.10	
Health	Cardiovascular disease					0.497	0.172	2.89	**
	ADL limitation					-0.522	0.226	-2.31	*
	Grip strength					0.030	0.010	2.98	**
Health care (base: never visited)	ever visited MBBS					0.436	0.223	1.96	
Smoking	current					0.178	0.248	0.72	
(base: never smoker)	former					1.306	0.272	4.81	***
Exercise	some					-0.297	0.201	-1.47	
(base: no exercise)	daily					0.108	0.267	0.41	
Social activities	per month					0.092	0.036	2.53	*
Work status	working					0.666	0.151	4.42	***
Emotional distress	CESD Score					-0.014	0.017	-0.82	
Per capita consumption	mid					-0.264	0.199	-1.32	
(base: lowest tertile)	high					0.143	0.252	0.57	
Intercept		6.609	2.691	2.46	***	-0.046	2.498	-0.02	
N		1364				1320			
F-stat		85.33	***			105.07	***		
R-square		0.3644				0.6059			

Notes: * 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	Female x North	Differences in female disadvantage coefficients	Differences in female x north coefficients
Model A				
Controls: Age, caste, residence	-0.668** (0.217)	-0.877* (0.336)		
Model B			Model A vs. Model B	Model A vs. Model B
(1) health: cardiovascular health, ADL, grip strength, ever visited MBBS, health behaviors (smoking, exercise), BMI, food insecurity	-0.536 (0.278)	-0.848* (0.344)	-0.131	-0.066
(2) education: literacy, schooling	-0.283 (0.185)	-0.835* (0.313)	-0.385***	-0.042
(3) social engagement: social activities, work status	-0.683* (0.269)	-0.869* (0.336)	0.015	-0.008
(4) emotional distress: CESD	-0.587** (0.212)	0.884* (0.340)	-0.081*	0.008
Model C			Model A vs. Model C	Model A vs. Model C
Controlling for all covariates, including per capita consumption	-0.055 (0.269)	-0.845* (0.319)	-0.613***	-0.031

Notes: * p<0.05; ** p<0.01; *** p<0.001.

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

Parameter coefficients (standard errors)	Female	Female x North	Differences in female disadvantage coefficients	Differences in female x north coefficients
Model A				
Controls: Age, caste, residence	-1.774*** (0.206)	-0.622* (0.306)		
Model B			Model A vs. Model B	Model A vs. Model B
(1) health: cardiovascular health, ADL, grip strength, ever visited MBBS, health behaviors (smoking, exercise) , BMI, food insecurity	-1.300*** (0.286)	-0.757* (0.333)	-0.477*	0.135
(2) education: literacy, schooling	-0.834*** (0.204)	-0.514 (0.275)	-0.940***	-0.109
(3) social engagement: social activities, work status	-1.468*** (0.240)	-0.542 (-0.302)	-0.307**	-0.080
(4) emotional distress: CESD	-1.729*** (0.203)	-0.584 (0.302)	-0.045	-0.039
Model C			Model A vs. Model C	Model A vs. Model C
Controlling for all covariates, including per capita consumption	-0.050 (0.266)	-0.676* (0.291)	-1.725***	0.053

Notes: * p<0.05; ** p<0.01; *** p<0.001.