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Cognition and Income in Old Age

Emma Aguila (USC)
Maria Casanova (CSUF)

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Abstract

Cognitive function in older adults is related to independent living and functional ability, and performance in memory tasks can be used as a screening tool for dementia risk. Due to population aging, the burden of dementia on low- and middle-income countries (LMIC) is expected to increase rapidly over the coming decades. Interventions aimed at countering risk factors for dementia such as diabetes and hypertension are a standard part of clinical practice in high-income countries (HIC), but not in LMIC, where health system preparedness is limited. Cognitive training interventions have been proven successful in high-income countries (HIC), but widespread implementation would likely not be affordable in LMIC. We investigate whether an intervention providing individuals aged 70 and above with supplemental income---a type of intervention often implement in LMIC with the objective of decreasing old-age poverty--- was successful at improving cognitive performance. The intervention took place in the Mexican State of Yucatan. The city of Valladolid was randomly selected to be the treatment, and Motul was designated as a control. A representative sample of individuals aged 70 and above was interviewed in the two cities pre- and post-. We used a difference-in-difference (DID) regression model to assess the effect of the intervention on immediate and delayed word recall scores, and found that the intervention increased both scores significantly for both men and women. To test for support for different mechanisms through which the intervention may have affected cognition, we also analyzed a number of secondary outcomes. We found that the intervention did not have an effect on the number of diagnosed risk factors, but improved health care utilization, likely aiding in the managing of already diagnosed chronic conditions. Moreover, the intervention was associated with improvements in anemia and other markers of malnutrition.

Introduction

Increases in life expectancy over the last decades have been accompanied by a corresponding increase in the number of years lost to disability at the end of life (Salomon et al., 2012). In both low- and middle-income (LMIC) and high-income (HIC) countries, dementia is nowadays the leading contributor to disability in old age (Sousa et al., 2009; Wimo et al., 2013).

The burden of dementia on LMIC is expected to increase rapidly over the coming decades. The share of older people with dementia living in LMIC will increase up to 70.5% in 2050, from 57.7% in 2010 (Prince et al., 2013). Meanwhile, efforts to tackle the leading risk factors of dementia, such as diabetes, hypertension, obesity, and tobacco and alcohol use, are in their infancy in LMIC, and their already overstretched health systems are ill-equipped to meet the long-term care needs of individuals with dementia and their caregivers (Prince et al., 2013). Among LMIC, dementia rates are heterogeneous. Due to factors such as low average educational attainment and high vascular risk, the prevalence of dementia in regions such as Latin America is higher than would be expected for their level of population aging (Rizzi et al., 2014).

Different types of interventions have been advocated to address the major public health challenge that dementia will pose for LMIC. These include (1) implementing preventative strategies by improving access to education; tackling risk factors for vascular disease; and maintaining active lifestyles; (2) increasing public awareness to facilitate early diagnosis; (3) assessing needs and providing continued support after diagnosis; and (4) training primary care teams and caregivers to optimize the quality of care. However, the practical reality of public health systems with limited resources and already overstretched by the burden of communicable diseases and child/maternal

care means that the type of interventions that have been shown to be successful in HIC may seem out of reach for the ministries of health in developing countries (Epping-Jordan et al., 2005).

This paper explores the effectiveness of a supplemental income program pensions in tackling a leading risk-factor for dementia, namely abnormal cognitive decline. This type of intervention, which provides a subset of the population, usually defined in terms of age, with a non-contributory, non-means-tested pension, has been implemented in MLIC such as Mauritius, Namibia, Botswana, Bolivia, Nepal, Samoa, Brunei, Kosovo, and Mexico (Willmore, 2007). The intervention is not specifically designed to address risk factors of dementia, but rather to improve income security and reduce poverty in old age. However, given that old-age poverty can exacerbate risk factors for abnormal cognitive decline such as malnutrition or inappropriate care for other chronic diseases, from diabetes to hypertension, supplemental income programs may indirectly contribute to slowing or reversing cognitive decline.

Previous research has found that non-contributory pensions have a measurable and significant impact on household poverty and inequality (Case and Deaton, 1998; Pestieau et al., 2010), food availability (Aguila et al. 2015a; Lund 2002), self-reported health status (Case, 2004) mental health (Galiani et al., 2016), (Salinas-Rodríguez et al., 2014), markers of physical health such as lung function and anemia, (Aguila et al., 2015a), and health care utilization (Aguila et al., 2015b). This is the first study to focus on the effect of a non-contributory pension program on cognition for men and women.

The intervention that is the focus of this paper provided a non-contributory pension to individuals over age 70 in the State of Yucatan, Mexico. Mexico is the second largest country in Latin America, with a population of 127 million. Due to declines in fertility and increasing life expectancies, the country is experiencing rapid population aging, with the share of adults aged 65 and over projected to increase from 7% in 2017 to 19% in 2050 (World Bank, 2017). The prevalence of dementia is estimated at 6 to 8% for those aged 60 and above (Mejia-Arango and Gutierrez, 2011, Rodriguez et al., 2008). Compared to other Mexican States, Yucatan ranks slightly below average in terms of social and economic development. Its Human Development Index was 0.739 in 2012, compared with a Mexican average of 0.753 (Programa de las Naciones Unidas para el Desarrollo en México, 2015), (United Nations Development Programme, 2016). The poverty rate in 2010 was 48.5%, compared with a national average of 46.3% (Consejo Nacional de Evaluación de la Política de Desarrollo Social, 2012). The intervention carried out in Yucatan was designed as a randomized control trial. We used a difference-in-difference (DID) intention to treat regression model to explore its effectiveness in raising word recall scores for men and women and discuss the mechanisms underlying the effects.

Methods

Study Site and Population

The experimental design included two communities with similar socioeconomic and demographic characteristics and geographic location in the northeastern part of the state of Yucatan: Valladolid (45,868 inhabitants) and Motul (21,508 inhabitants). Both sites rank above the State and national averages in terms of poverty. In 2010, the poverty rates was 59.1% in Motul, 64.4% in Valladolid,

48.5% at the State level and 46.3% at the national level. 15.3% of individuals lived in extreme poverty in Motul, versus 20.2 in Valladolid and 11.7% at the State level (CONEVAL 2012).

Study Design and Participants

In 2008, the Government of Yucatan rolled out the first stage of an income supplement program (*Reconocer Urbano*) targeted to individuals aged 70 and older living in urban areas of more than 20,000 inhabitants in that State. The program provided a non-contributory, flat-rate pension of 550 Mexican pesos per month (US\$58.7 per month at 2014 purchasing power parity, or PPP). A detailed description of the study design, sampling frame, and follow-up procedures has been previously published (Blinded for review).

To allow for evaluation of the impact of the non-contributory program, it was rolled out in stages, using an experimental design. Valladolid was randomly selected by the state government to be the first town to receive the pension, disbursed monthly to persons 70 and older. The take-up rate of the program was 94%. The city of Motul---which was deemed the most similar to Valladolid among cities in the State fulfilling the program's criteria---was chosen as a control. The study was double blinded because the interviewers did not know which one would receive the noncontributory pension during the baseline interview.

Baseline surveys (W1) were conducted in Valladolid and Motul between August and November 2008 among all households with persons aged 70 or older prior to the December 2008 introduction of the state pension program in Valladolid. Follow-up surveys (W2) were conducted simultaneously in Valladolid and Motul between July and September 2009. Response rates--- computed using American Association for Public Opinion Research guidelines (The American

Association for Public Opinion Research, 2011)--- were 91.5 percent in Valladolid and 95.3 percent in Motul at W1; and 87.9 percent in Valladolid and 81.9 percent in Motul at W2.

The survey questionnaires were comparable to those for the Mexican Health and Aging Study (MHAS) and the U.S. Health and Retirement Study (HRS), and included a comprehensive assessment of health, disability, and socioeconomic characteristics. The surveys also collected anthropometric measurements (height, weight, waist circumference) and performance measures (lung capacity, walking speed, grip strength) for age-eligible respondents. The original sample consisted of 1,136 men and 1,215 women aged 70 or older.

Ethical considerations

The Internal Review Board at RAND Corporation revised and approved the protocol (approval number 2008-0513-CR07). The study complied with U.S. and Mexican requirements and standards for conducting ethical research. An informed-consent form that followed the Helsinki Declaration II was provided to each participant. Informed written consent was obtained separately for anthropometric and biomarker assessments (Blinded for review).

Primary outcomes

Cognitive ability was assessed by immediate and delayed recall using the number of words recalled from a list of 8 nouns (e.g., mouse, house, cat, etc.) read to the respondent and then asking the respondent to recall as many words immediately after reading the list and 5 minutes after.

Immediate and delayed recall are measures of episodic memory (Fisher et al., 2017), an outcome that is used in the early assessment of dementia (Spaan et al., 2005).

Secondary outcomes

The secondary outcomes examined in the paper are indicators of health, health care utilization, and malnutrition. The health indicators are as follows: A diagnosed risk factors score (0-5), which aggregates five binary variables equal to one for individuals who have ever been diagnosed with a heart attack, stroke, hypertension, congestive heart failure, and diabetes, respectively. A depression score (0–7) from the Composite International Diagnostic Interview Short-Form (CIDI-SF) from HRS. CIDI-SF evaluates major depressive episodes (feeling depressed, tired or having low energy, appetite change, trouble sleeping, trouble concentrating, feeling worthless, and thinking about death) (Steffick, 2000). Number of activities of daily living that the individual has difficulties performing (0-5), including bathing, dressing, eating, getting into or out of bed, and sitting down or standing up from the toilet.

The measures of health care utilization included a variable counting the number of doctor visits in the last 3 months and a health care utilization score (0-3) which aggregates 3 binary variables measuring whether the individual visited a doctor in the previous 3 months (1 = yes, 0 = no), avoided going to the doctor despite facing a serious health problem in the previous 3 months (1 = no, 0 = yes), and avoided taking medicines because they were too costly in the previous 3 months (1 = no, 0 = yes).

The nutritional outcomes considered in the analysis were an indicator that the individual was anemic based on the hemoglobin level (measured with a blood test) (1 = yes, 0 = no) and a food

availability score (0-9). The food availability score includes nine binary variables of a household food availability scale based on questions that inquired whether, over the last 3 months, the individual sometimes did not have enough to eat, run out of food before receiving money to buy more, run out of food and could not get more, skipped meals, ate less than they felt they should, felt hungry but did not eat, did not eat all day, received emergency food from an institution, and received food they did not have to pay for.

Covariates

Our covariates include age, age squared, marital status (1 = married or consensual union, 0 = otherwise), total years of formal education, study wave (1 = W2, 0 = W1), whether respondent lives in Valladolid and received the treatment (1), or Motul for the control group (0), and an interaction variable between W2 and the indicator for the treatment (1 = treatment * W2, 0 = otherwise).

Statistical Analysis

Our analysis focuses on post-intervention changes in cognition and the secondary outcomes. Changes were estimated using a Difference-in-differences (DID) intention-to-treat (ITT) model. We also conducted the analysis for the treatment on the treated (TOT), but given that the take-up rate of the program is above 90%, the results with ITT or TOT are very similar (results available upon request). DID estimates were derived from a linear regression model with a dataset including measures of the outcome variables in the treatment and control groups at baseline (W1) and post-intervention (W2) the intervention, expressed as:

$$(2) \quad Y_{it} = \beta_0 + \beta_1 D^{post} + \beta_2 D^{treat} + \beta_3 D^{post} D^{treat} + \beta_4 X + \varepsilon_{it}$$

where Y_{it} is the outcome of interest for individual i in wave t ; D^{post} is the time dummy, D^{treat} is the intervention group dummy; $D^{post} D^{treat}$ is the time and intervention interaction; X is a vector of covariates; and ε_{it} is the error term. The parameter β_3 measures the causal effect of the non-contributory pension program. We estimate standard errors that are robust to heteroscedasticity and clustered at the household level. The statistical analysis is carried out using Stata version 13.1, and significance is set at $P \leq 0.05$. To test multiple hypotheses, we apply a Holm-Bonferroni correction (Holm 1979). Attrition and other sample selection issues were analyzed in (Blinded for review). Their findings do not indicate attrition or mortality biases because they find no differences between treatment and control groups.

Results

Sociodemographic characteristics

Table 1 shows sociodemographic characteristics at baseline for men and women. Average age for men is 77.6 in the treatment site and 77.2 in the control site. Average age for women is 77.4 and 77.1 in the treatment and control sites, respectively. The proportion of individuals who have a couple is higher for men (73.5 in the treatment site and 62.3 in the control site) than for women (36.2 in the treatment site versus 43.4 in the control site). Men have more years of education (2.5 in the treatment site versus 2.4 in the control) than women (1.9 in both treatment and control). 12.5% of men in the treatment site live alone, versus 14.2 in the control. The corresponding figures for women are 13.4 in the treatment site and 12.6 in the control site. The average number of household residents is 3.5 for men in both treatment and control, and between 3.4 (treatment) and 3.6 (control) for women. Average household income was 1,516 Mexican pesos for men in the treatment site, and 1,474 Mexican pesos for those in the control site. Household income was 1,168

and 1,321 Mexican pesos for women in the treatment and control sites, respectively. Differences between the control and treatment site are not statistically significant for any sociodemographic characteristics except for marital status. The regression analyses reported in the results section control for all the sociodemographic characteristics just discussed.

[TABLE 1 ABOUT HERE]

Cognition

The first two rows of Table 2 show results from the DID analysis of the intervention's effect on the cognitive ability of males. At baseline, both immediate and delayed recall were higher in the control site compared to the intervention site. Post-intervention, immediate recall decreased by 0.4% on the control site, and increased by 10.3% on the treatment site, while delayed recall decreased by 2.9% on the control site and increased by 34% on the treatment site. According to the DID estimates, the immediate recall score of men increased by 0.37 words (equivalent to a quarter of one standard deviation) relative to the control group, while the delayed word recall had increased by 0.94 words (equivalent to one half of one standard deviation) relative to the control group. For women, the immediate recall score increased by 0.65 words (equivalent to 0.4 standard deviations), and the delayed recall score by 0.90 words (equivalent to 0.4 standard deviations) relative to the control group post-intervention. Increases in both immediate and delayed recall for both men and women remain statistically significant after applying the Holm-Bonferroni correction for multiple hypothesis testing.

[TABLE 2 ABOUT HERE]

Secondary outcomes

The second panel of Table 2 shows DID estimates of the effect of the intervention on the secondary outcomes for men. Post-intervention, those in the treatment group display statistically significant increases in the health care utilization score and the food availability score, and a statistically significant decrease in anemia, relatively to the control group. The depression score also displays a statistically significant improvement relative to the control group, but in this case it is not statistically significant after the Holm-Bonferroni correction. There was no effect of intervention on the number of diagnosed risk factors, number of ADLs, and number of doctor visits in the sample of men.

DID estimates of the effect of the intervention on the secondary outcomes for women are shown in Table 3. Relative to the control group, there are statistically significant increases in the health care utilization score, the number of doctor visits, and the food availability score; and a statistically significant decrease in anemia post-intervention in the treatment group. Of those, only the increase in the health care utilization score is statistically significant after applying the Holm-Bonferroni correction. There was no effect of intervention on the number of diagnosed risk factors, the depression score or ADLs.

[TABLE 3 ABOUT HERE]

Discussion

In this study, we have examined whether an intervention providing supplemental income in the form of a non-contributory pension to adults aged 70 and over affects two indicators of abnormal cognitive decline, namely immediate and delayed word recall, using Mexican data. The two recall scores decreased slightly in the control site for both men and women between the baseline and

post-intervention interviews. In the treatment group, the two recall scores increased for both men and women six-months post-intervention. The DID analysis showed that the intervention was positively associated with a 0.25-standard-deviation increase in immediate recall for and a 0.5-standard deviation increase in delayed recall for men; and a 0.4-standard-deviation increase in both immediate and delayed recall for women.

Previous research on cognition suggests several mechanisms that may delay or even reverse cognitive decline in older adults. These include improvements in the following: (a) potentially modifiable risk factors such as diabetes or cardiovascular disease (Barnes et al., 2003; Barnes and Yaffe, 2011; Gunstad et al., 2005); (b) depression (Barnes and Yaffe, 2011; Butters et al., 2000; Modrego and Ferrández, 2004); and (c) malnutrition (Denny et al., 2006; Saka et al., 2010).

We have examined whether the intervention affected outcomes (a) to (c). Our results indicate that the intervention had no effect on the number of diagnosed risk factor (heart attack, stroke, hypertension, congestive heart failure and diabetes) or ADLs for neither men nor women. It is unlikely that the short time span between the baseline and post-intervention interviews is enough to reverse conditions whose onset likely spans years or even decades. However, the intervention improved health care utilization. The health care utilization score improved significantly for both men and women. This score is based on answers to questions regarding whether, in the last three months, the individual consulted a doctor, avoided visiting a doctor despite a serious health event, and avoided taking medications because they were unaffordable. These results suggest that, even though the number of chronic condition did not change post-intervention, the management of those conditions (through medication adherence and improved contact with primary care services) did. For women, the intervention is also associated with a statistically significant increase in the number

of doctor visits, although it is not statistically significant after applying the correction for multiple hypothesis testing.

Regarding mental health, the intervention did not affect the depression score of women. The depression score of men decreased significantly, although it is not statistically significant after correcting for multiple hypothesis testing.

Finally, the intervention is associated with improvement in malnutrition indicators. The share of both men and women diagnosed with anemia increased in the control site, but decreased in the treatment site. The difference between treatment and control was statistically significant in both regressions, even though it is only statistically significant after correcting for multiple hypothesis testing in the sample of men. Finally, the analysis of the food availability score indicates a statistically significant increase in food security for men.

Although we cannot identify all the reasons for the increase in the recall scores post-intervention, the analysis of the covariates suggests that the intervention may have affected cognition through two main mechanisms, namely, improvements in health care utilization leading to better management of chronic conditions and other conditions, and declines in malnutrition.

Demographic pressures had led to increasing calls for interventions aimed at preventing dementia in LMIC. Standard prevention efforts aimed at countering risk factors such as vascular disease, hypertension, obesity, and diabetes are routinely integrated into clinical care in HIC, but are just in their embryonic stages in most LMIC. Our results show that the provision of supplemental income through non-contributory pensions, a type of intervention that has been carried out in many LMIC countries with the aim of improving income security and reducing poverty, can also have positive effects on cognitive function. Given that performance in memory tasks such as the ones

considered in the analysis has been advocated as a screening tool for cognitive impairment and early-stage dementia, our results suggest that this type of intervention has promise as a potential preventative strategy against dementia. However, a longer follow-up is required to determine whether the improvements in cognition are maintained reducing the incidence of dementia.

Limitations

We recognize a number of limitations with this study. Firstly, we study an intervention that was not specifically designed to affect cognition or dementia. As a result, the number of questions related to cognitive decline is limited, and we can only measure two of the several instruments that common screening approaches for abnormal cognitive impairment and dementia would use (for example, the version of the Cross Cultural Cognitive Examination used by Mejia-Arango and Gutierrez (2011) to assess cognitive levels in Mexico has three additional instruments in addition to the two considered in this paper).

Secondly, while the DID analysis shows unequivocally that the intervention is associated with increases in cognition, it does not allow us to determine the exact mechanisms that led to the observed increases in cognitive ability. We tested for changes in some of the known risk factors for cognitive impairment and dementia and found evidence of improvement in at least two of them, but there may be other risk factors modified by the intervention that we did not consider in the analysis.

Conclusion

An intervention implemented in the Mexican State of Yucatan that provided elderly individuals with supplemental income through a non-contributory pension was effective in increasing two makers of cognitive function, namely immediate and delayed word recall. These indicators are used when screening for abnormal cognitive decline and early-stage dementia, suggesting that the intervention can potentially act as a preventative measure against abnormal cognitive decline and dementia.

Our findings are relevant to the public health debate around the world. The significant increase in ageing populations in LMIC who lack social security coverage has led more than 80 LMIC to introduce non-contributory pension programs (HelpAge International, 2012). So far, these programs have been aimed at decreasing old-age poverty. However, our results suggest that additional income provides older adults with better access to health care services and medicines as well as reduces malnutrition, and through those mechanisms the interventions may be effective in slowing cognitive decline, and hence improving functional ability in old age.

Conflict of Interest. None.

Author Contributions. EA and MC framed the scope of the paper, conducted the statistical analysis and literature review, and wrote and revised the manuscript. All authors reviewed and approved the final draft.

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