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Effects of Pension Eligibility Expansion on Men's Cognitive Function: Findings from Rural South Africa

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ABSTRACT

Two-thirds of people living with Alzheimer's disease and related dementias (ADRD) live in low- and middle-income countries, and this figure is expected to rise as these populations are rapidly aging. Since evidence demonstrates links between socioeconomic status and slower rates of cognitive decline, protecting older adults' cognitive function in resource-limited countries that lack the infrastructure to cope with ADRD is crucial to reduce the burden it places on these populations and their health systems. While cash transfers are a promising intervention to promote healthy cognitive aging, factors such as household wealth and level of education often confound the ability to make causal inferences on the impact of cash transfers and cognitive function. This study uses a quasi-experimental design, leveraging an exogenous expansion to the Old Age Pension for men in South Africa, to approximate causal associations with cognitive function. We found evidence that there is a potential benefit of cash transfers at an earlier age for older individuals. As such, transfers such as pensions or other forms of direct basic income transfers may hold promise as potential interventions to promote healthy cognitive aging.

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Cash transfers; cognitive function; natural experiment; pension; Rural South Africa

Introduction

Individuals living in low- and middle-income countries currently make up sixty-six percent of global cases of ADRD and this number is expected to rise due to improved economic and health conditions, as

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well increased access to health services and resources increasing life expectancies in these settings. Coupled with this is the concern that poor dietary behaviors and an increase in smoking may be followed by a rise in obesity and cardiovascular disease: a contributing risk factor for ADRD (Patterson, 2018). Thus, as resource-limited countries do not have adequate public health infrastructure to deal with the expected rise in chronic diseases, identifying strategies to protect their older adults' cognitive function is critical to reduce the future global burden of ADRD. Research shows that indicators of elevated socioeconomic status, and specifically income, are associated with better cognitive function, slower rates of cognitive decline, and lower risk of ADRD during aging (Glymour & Manly, 2008; Jefferson et al., 2011; Liu et al., 2010; Whalley et al., 2006). If these associations are causal, then government cash transfer programs such as pensions, social security grants, child and disability grants, or other forms of direct basic income transfers may bear promising strategies to promote healthy cognitive function in aging individuals at the population level.

Nevertheless, it is difficult to establish whether a causal association exists between increased personal and household income through cash transfers and cognitive aging outcomes. Observational study designs contain confounders such as socioeconomic status (e.g., household wealth and education level). These factors may affect an individual's cognitive function and the take up of cash transfer program benefits, and, in turn, bias results. Experimental trials, on the other hand, have a greater ability to disassociate treatments from confounders by nature of random assignment (Pourhoseingholi et al., 2012). This type of design was utilized in an experimental trial of social security benefits among adults aged 70+ in Yucatan, Mexico, finding that benefits improved memory outcomes by an amount equivalent to a 5–12 year reduction in the progression of cognitive decline, a substantial effect size (Aguila et al., 2015). Other than this study, however, no other research has evaluated the causal effects of cash transfers on cognitive function in aging individuals to our knowledge, despite their potential as a cost-saving, population-level policy solution to prevent or delay the onset of ADRD. While our study is not an experimental trial, exploiting an exogenous pension expansion available to all men, regardless of demographic characteristics, allows for a natural, quasi-experimental design that reduces the impact of confounding variables that may otherwise bias results.

In this study, we examine the potential causal association between receipt of cash transfers and cognitive function assessed in a rural South African older adult population. From 2008 to 2010, the means-tested South African Old Age Pension (OAP) expanded the eligibility age for men from 65 years to 60 years, providing between one and five extra years of pension to older men, depending on their year of birth at the time of the expansion. This exogenous increase

in income for some men provides an opportunity to assess the relationship between cash transfer income (the pension) and cognitive function.

Effect of social pensions on older adult health

This study contributes to a small body of literature on the evidence of social pension impacts on older adult health and well-being in low- and middle-income countries; several of which demonstrated mixed results (Ralston & Schatz, 2020). While Lloyd-Sherlock and Agrawal (2014) found that pensions increased health utilization, they did not, however, find an association between pension receipt and self-reported health, quality of life, or control of hypertension (Lloyd-Sherlock & Agrawal, 2014). A study conducted in Brazil and South Africa found that receiving pension was associated with higher levels of self-satisfaction. However, the study was unable to directly link the pension to this outcome (Lloyd-Sherlock et al., 2012). 2019) found positive associations between pension and perceived quality of life for both men and women, particularly for those reporting high levels of physical limitations (Ralston et al., 2019). Moreover, 2012) find that both men and women receiving pension in South Africa reported higher levels of happiness and quality of life; with the benefit for women occurring in their first four years of pension receipt and the benefit for men occurring in their first five years (Schatz et al., 2012).

Pension income has been found to be associated with higher cognitive function and slower rate of cognitive decline (Peng et al., 2022). A study of China's New Rural Pension scheme found that pension income was associated with better physical and cognitive health for elderly living in rural settings. The analysis found these associations were due to pension income improving dietary nutrition, access to health care and self-perceived financial condition (Cheng et al., 2018). Pension has also been associated with improved mental health outcomes. A study in South Korea found that pension expansion reduced depressive symptoms through pathways such as subjective well-being and improved financial condition (Pak, 2021).

Our study expands our knowledge on the health effects of pension for individuals in low- and middle-income countries with a focus on older adults' cognitive function. Moreover, our analysis differs from prior work in that we leverage a natural experiment resulting from the South African pension expansions for men to move toward understanding the extent to which different magnitudes of pension impact cognitive decline.

Hypotheses

Depending on their year of birth at the time of the South African Old Age Pension (OAP) expansion, men from 60 years to 65 years were

eligible for one to five extra years of pension. We hypothesized that while cognitive function, on average, would decline with age, the birth cohorts that were eligible for one to five years of additional pension would have higher cognitive function scores than predicted using comparative data from the birth cohorts who were not eligible for extra pension. We also hypothesized that the positive relationship between extra years of pension and cognitive function would be stronger as the years of extra pension increase.

Methods

Study setting and population

This study is conducted in the rural Agincourt sub-district in Mpumalanga province in northeastern South Africa covered by the Agincourt Health and Socio-Demographic Surveillance System (AHDSS) which is operated by the Medical Research Council/Wits University Rural Public Health and Health Transitions Research Unit (Gómez-Olivé et al., 2018; Kahn, Collinson, Xavier Gómez-Olivé, et al., 2012). The HDSS covers 31 villages, containing 116,000 inhabitants in 22,000 households. Agincourt is part of a former "homeland" region where xiTsonga-speaking Black South Africans belonging to the Shangaan ethnic group were forcibly relocated as part of legislated racial segregation during South African Apartheid from 1948 to 1994 (United Nations, 1963). The 1936 Land Act allotted Black South Africans, comprised of 75% of the population, 13% of the rural land; most of which had poor conditions for agriculture (Collinson, 2010). Moreover, during Apartheid, legally enforced restrictions ensured the Black population in the region had poor access to education, poor availability of public services, and high rates of unemployment (Abdi, 2002; Christie & Collins, 1984; United Nations, 1963). Rural settings in South Africa tend to have lower household income, education, median BMI, cognitive functioning and higher unemployment rates than those living in urban settings (Otwombe et al., 2014; Phaswana Mafuya et al., 2019). The Mpumalanga Province is representative of other rural settings in South Africa where Black South Africans were relocated. Since the end of the Apartheid regime in 1994, economic development has improved in the province; however, unemployment remains high, and there are substantial gaps in availability of basic services (Kahn, Collinson, Xavier Gómez-Olivé, et al., 2012). Prevalence of pit toilets and low levels of household sanitation are common in the area, as well as limited access to health care, paved roads and public transportation (Collinson, 2010). The setting is Human Immunodeficiency Virus (HIV) hyperendemic, with persisting high unemployment, and low food security (Kahn, Collinson, Xavier Gómez-Olivé, et al., 2012). Cash transfers from

social protection programs, including the OAP, continue to be an important source of income for this population (Kahn, Collinson, Xavier Gómez-Olivé, et al., 2012).

Data

The present analysis uses baseline data from the "Health and Aging in Africa: A Longitudinal Study of an INDEPTH Community' in South Africa (HAALSI)" cohort (Gómez-Olivé et al., 2018). HAALSI is a longitudinal study embedded within the Agincourt HDSS. It is designed to monitor economic, social, and biological risks for health conditions, with a particular focus on risk factors associated with HIV, cognitive function, dementia and cardiometabolic disease. Men and women aged 40 years or older as of July 1, 2014, who were permanently living in the Agincourt HDSS study area for 12 months were eligible for inclusion in HAALSI cohort. Using the Agincourt HDSS as a sampling frame, 6281 individuals meeting the eligibility criteria were randomly selected to participate and 5059 (2345 men and 2714 women) consented to participate. Home interviews were conducted by trained, local fieldworkers using the computer assisted personal interview (CAPI) system from November 2014 through November 2015. The interviews consisted of several demographic questions including family information, education, religion, socio-economic status, and social networks, as well as questions related to their physical and mental health and cognitive abilities. All interviews were conducted in the local Xitsonga language with interview materials translated from English and back translated for reliability (Gómez-Olivé et al., 2018).

Key measures

Our analysis examines the association between increased exposure to pension eligibility and cognitive function among older men in the HAALSI cohort (n = 2345) by exploiting age-based exogenous expansions in the eligibility criteria of the South African OAP for men that occurred between 2008 and 2010.

Exposure variable: mens' eligibility for expanded old age pension

The South African Old Age Pension (OAP) is a social protection cash transfer program for older adults and their families that was first established in 1928, exclusively for the White minority, and was expanded to include the country's Black population in the early 1990s. It is the largest social assistance program in South Africa, and provides benefits to 1.9 million South Africans (Burns et al., 2005; Department of Social Development). The OAP is a means-tested program that currently provides a monthly cash transfer of R1980 ($112 USD). A single individual qualifies if they are a South African citizen, permanent resident or refugee living in South Africa and do not earn more than R86,280

and have assets worth <R1,227,6000 (Republic of South Africa, 2022). In 2014, the time of data collection for this study, a single individual qualified for the program if their income was <R61,800 ($5,340) a year and had assets worth <R891,000 ($77,000) (Ralston et al., 2016). The pension amount is quite significant for individuals living in low-income households; being nearly twice the median per capita income for black South Africans, as well as providing access to credit markets for many households (Ralston et al., 2016). We cannot say with certainty whether individuals in the HAALSI cohort met the OAP means test because it is measured differently than the wealth asset index variable in the dataset. The wealth asset index variable used in this study was created from a principal components analysis on ownership of household items, as well as household characteristics (Gómez-Olivé et al., 2018). Proxying wealth by means of an asset index has been shown to be robust in studies in low-income countries, with results coinciding to data on per capita output and poverty (Filmer & Pritchett, 2001). There is reason to believe that most members of this study community would meet the eligibility requirements of the OAP. In 2015, 42.6% of individuals in the Mpumalanga Province were below the lower-bound poverty line (R647 per person per month) (Republic of South Africa, 2017). Moreover, there are high rates of unemployment and food insecurity in the province (Kahn, Collinson, Xavier Gómez-Olivé, et al., 2012). These sociodemographic characteristics underscore the low-income, low-economic opportunity setting for our study population in line with the target requirements for the OAP.

Historically, women become OAP eligible at the age of 60 years, while men were not eligible until the age of 65 years. Eligibility expanded for men in 2008 when the age of eligibility was reduced from age 65 years to 63 years. The age of eligibility was further reduced from 63 years to 61 years in 2009, and then from 61 years to 60 years in 2010. These changes over the short-term mean that adjacent birth cohorts of men have received different pension transfers for reasons that are unlikely to be related to factors that might affect their cognitive aging.

We calculated additional pension eligibility based on the men's dates of birth and the pension eligibility expansion dates. Specifically, men in the HAALSI survey who were born in 1944 and 1954 at the time of the 2014 baseline survey, had received one extra year of pension than they would have in the absence of the reform. Those born in 1945, 1946, and 1953 had received two extra years of pension. Those born in 1947 and 1952 had received three extra years. Those born in 1948, 1949, and 1951 had received four extra years, and those born in 1950 had received five extra years of pension. Because of the timing of the expansions relative to the survey administration, the eligibility expansion is not monotonic across birth cohorts, as some birth cohorts had not yet received the full addition to their pension eligible years. Men born in birth cohorts after 1954 had not yet aged into eligibility for the pension. Men

Table 1. Sociodemographic characteristics of men in HAALSI cohort, by eligibility for Old Age Pension ($n = 2345$).

Variables	No Pension Expansion Eligibility ($n = 1663$)	Pension Expansion Eligibility ($n = 681$)	P-value
Cognitive Function			
Standardized values of cognitive score	0.094	0.023	
Missing	$N = 109$	$N = 15$	
Age (Median, IQR)	56 (50–75)	64 (62–67)	
Missing	$N = 0$	$N = 0$	
Marital Status			
Never Married	151 (9.1)	15 (2.2)	<0.00
Separated/Divorced	225 (13.5)	75 (11.0)	<0.00
Widowed	194 (11.7)	82 (12.0)	<0.00
Currently married	1,093(65.7)	509 (74.7)	<0.00
Missing	$N = 0$	$N = 0$	
Country of Origin			
South Africa	1173 (70.5)	490 (71.9)	0.48
Other	491 (29.5)	191 (28.1)	0.48
Missing	$N = 0$	$N = 0$	
Education Level			
None	649 (39.1)	308 (45.4)	<0.00
Some Primary	551 (33.2)	282 (41.5)	<0.00
Some Secondary	254 (15.3)	60 (8.9)	<0.00
Finished Secondary or more	206 (12.4)	28 (4.1)	
Missing	$N = 3$	$N = 0$	
Wealth Index			
Quintile 1 (lowest)	363 (21.8)	139 (20.4)	0.015
Quintile 2	341 (20.5)	114 (16.7)	0.015
Quintile 3	331 (19.9)	119 (17.5)	0.015
Quintile 4	307 (18.5)	150 (22.0)	0.015
Quintile 5 (highest)	322 (19.3)	159 (23.4)	0.015
Missing	$N = 0$	$N = 0$	
Employment Status			
Currently working	372 (22.4)	71 (10.5)	<0.00
Not Currently working	1,287(77.6)	608 (89.5)	<0.00
Missing	$N = 4$	$N = 2$	
Self- Reported Literacy			
Able to read only	32 (1.9)	12 (1.8)	0.33
Able to write only	92 (5.5)	44 (6.5)	0.33
Able to both read and write	1012 (60.9)	388 (57)	0.33
Cannot read nor write	527 (31.7)	237 (34.8)	0.33
Missing	$N = 0$	$N = 0$	
Social Networks			
0 social contacts	89 (5.34)	31 (4.55)	0.17
1 social contact	258 (15.47)	73 (10.72)	0.17
2 social contacts	365 (21.88)	143 (21.00)	0.17
3 social contacts	424 (25.42)	169 (24.82)	0.17
4 social contacts	261 (15.65)	117 (17.18)	0.17
5 social contacts	115 (6.89)	63 (9.25)	0.17
6 social contacts	107 (6.41)	51 (7.49)	0.17
married	49 (2.94)	34 (4.99)	0.17
Missing	$N = 0$	$N = 0$	
ADL Scale			
Scale measures self-reported difficulty with performing daily tasks	0.24	0.17	
Missing	$N = 8$	$N = 6$	
Diagnosed Diabetes			
Diagnosed with diabetes	141 (9.36)	66 (10.41)	<0.00
Not diagnosed with diabetes	1,365(90.64)	586 (89.59)	<0.00
Missing	$N = 157$	$N = 47$	

(*Continued*)

Table 1. (Continued).

Variables	No Pension Expansion Eligibility ($n = 1663$)	Pension Expansion Eligibility ($n = 681$)	P-value
Diagnosed TB			
Diagnosed with TB	175 (10.53)	83 (12.22)	0.02
Not diagnosed with TB	1,487(89.47)	596 (87.78)	0.02
Missing	$N = 1$	$N = 2$	
Diagnosed Angina			
Diagnosed with angina	32 (1.92)	10 (1.47)	<0.00
Not diagnosed with angina	1,631(98.08)	671 (98.53)	<0.00
Missing	$N = 0$	$N = 0$	

Note: *Percent of total sample is in parentheses.

born in birth cohorts prior to 1944 had already reached pension eligible ages (65 years and above) when the expansions began.

Table 1 shows demographic information for individuals who were eligible for the extra years of pension and those were not. Men who were eligible for the pension expansion tended to be demographically similar to those who were not eligible. However, they were older, more likely to be currently married, less likely to have higher than secondary-level education and more likely not to work. Table 1 in the Appendix reports the demographic variable characteristics of each cohort of individuals eligible for one to five extra years of pension and those not eligible for extra pension. This table demonstrates that the cohorts were not drastically different for most demographic characteristics, except for a few points. Cohorts 4 and 5 had lower education and literacy levels than the other cohorts. Since the individuals within the five cohorts were all born between 1944 and 1954, a relatively short time span, there were not likely to be differences between them in terms of social, economic, and other policy change experiences (with the exception of the Old Age Pension expansion).

Outcome variable: cognitive function

To measure cognitive function, a cognitive assessment was administered to the study participants, which included measurements for time orientation (ability to correctly state the month, year, date, and South African President; 4 points total), and immediate and delayed recall of ten words that were read out loud by the interviewer (20 points total). This cognitive test was adapted from the US Health and Retirement Study. The composite summary score ranged from 0 to 24 and we z-standardized the score for analysis to have a mean of 0 and a standard deviation of 1. Some tasks from the HRS cognitive battery (backwards counting and object naming) were not included in the HAALSI cognitive battery. These tasks were excluded because they were deemed culturally and educationally inappropriate, due to low

numeracy levels and possible lack of familiarity with the object naming items in the study population. The backwards counting item from the HRS was adapted for HAALSI as a forward counting item (from 1 to 20), although we excluded it from this analysis as it primarily captures numeracy, rather than cognitive ability, given the low numeracy level of the study population (Wu et al., 2013).

Statistical analysis

We used a multi-step modeling approach to isolate the effect of exposure to increased pension eligibility years on cognitive function. First, we created a restricted cohort in which we removed the 5 birth cohorts exposed to the Old Age Pension expansion. Second, we specified a linear regression model on all the individuals in the dataset excluding the five birth cohorts exposed to extra pension. This linear regression was performed to get a linear function to estimate predicted cognitive scores for the individuals in previously excluded OAP expansion eligible birth cohorts. We included a robust set of variables in this model that included: age, wealth index (in quintiles), marital status, level of education, employment status, self-reported literacy level and country of origin.

Third, we calculated difference scores for each person in the five OAP eligible expansion birth cohorts by subtracting the predicted values derived from the restricted sample linear regression from the observed cognitive function values for the individuals in the five birth cohorts. Fourth, we estimated a linear model on the difference score to get estimated mean difference scores for each cohort.

To better understand the linear trend across the restricted and derived cohorts and estimate the difference score for receiving one extra year of pension, we also specified a linear model treating the years of additional pension eligibility as a continuous variable. The results from this model estimated the difference between the predicted and observed cognitive function z-score for each additional year of pension eligibility, assuming a linear relationship.

As a negative control analysis, we recreated the analysis outlined in Steps 1–4 above in HAALSI women. This type of negative control analysis serves to check the robustness of findings using samples where the effect would not be expected to be observed (Lipsitch et al., 2010). As women were not subject to the pension eligibility expansion (historically women have always been pension eligible at age 60), if a pension effect was observed in the cohort of HAALSI men, we would not expect to see similar findings in HAALSI women.

Moreover, we conducted several sensitivity analyses, adding variables to our predictive model that may be correlated with cognitive function and, in turn, may bias results if excluded. First, we added a social network variable to the

Table 2. Main Model: Difference between predicted and observed cognitive scores in cohorts of HAALSI men exposed to additional years of pension eligibility.

Cohort	Predicted Cognitive z-score in SD	Observed Cognitive z-score in SD	Estimated Difference in SD (95% CI)	P-value
1	0.051	0.043	−0.006 (−.162, .151)	0.943
2	0.020	−0.038	−0.059 (−.189, .071)	0.375
3	0.005	0.106	0.095 (−.039, .230)	0.166
4	−0.079	−0.060	0.020 (−.099, .139)	0.737
5	−0.080	0.133	0.222 (.056, .389)	0.008

Note: *Based on linear regression model with the following predictors: birthyear, wealth index, marital status, level of education, employment status, self-reported literacy level and country of origin.

Table 3. Robustness check: difference between predicted and observed cognitive scores in cohorts of HAALSI women.

Cohort	Predicted Cognitive z-score in SD	Observed Cognitive z-score in SD	Estimated Difference in SD (95% CI)	P-value
1	−0.010	−0.009	0.000 (−.182, .182)	0.999
2	−0.012	0.078	0.095 (−.082, .23)	0.291
3	−0.013	0.088	0.092 (−.059, .243)	0.232
4	−0.014	0.036	0.050 (−.089, .191)	0.479
5	−0.024	−0.023	0.003 (−.197, .203)	0.976

Note: * based on linear regression model with the following predictors: birthyear, wealth index, marital status, level of education, employment status, self-reported literacy level and country of origin.

predictive model (Appendix Table 2), as social networks have been shown to have positive impacts on cognitive function (Kelly et al., 2017). This social network variable is a self-reported list of all the individuals the person has had contact with in the last 6 months. An additional analysis was conducted including an Activities of Daily Living (ADL) scale, as well as variables for chronic illnesses to the predictive model. The chronic illness variables we introduced are diagnosed diabetes, angina, and TB. The ADL scale measures how many of the following daily activities the person has difficulty with: walking, dressing, bathing, eating, getting in/out of bed and using the toilet. Research has found negative correlations between ADL and cognitive functioning (Moritz et al., 1995), as well as negative correlations between cognitive function and chronic illnesses (Comijs et al., 2009). The models including the ADL scale and chronic disease variables are in Table 3 of the Appendix. Lastly, we conducted a sensitivity analysis restricting the sample to only to men who self-reported receiving the pension (AppendixTable 7).

Missing data did not occur at a frequency that would be likely to introduce bias in our results. Our exposure was ascertained based on birthdate, a variable for which we had complete data. The cognitive function outcome variable was missing for 5% of the sample. Covariate information for our predictive model was fairly complete, with all covariates having <10% missingness. Given this low magnitude, we opted to conduct complete case analyses wherein only those with complete covariate information contributed to each of our models.

We used both Stata (version 16.1) and R (version 4.1.1) statistical software for all analyses.

Results

Overall, $n = 2345$ men enrolled in the HAALSI primary cohort and provided baseline data for this study. There were approximately $n = 100–200$ men in each of the five sub-cohorts with extra years of pension eligibility and $n = 1663$ men who had not received any exposure to additional pension eligibility (Table 1). Most men in the primary cohort were currently married (68%), born in South Africa (71%) and not working (81%). Almost half of the men had received no formal education (41%).

Men with three or more years of increased exposure to the pension eligibility tended to have higher cognitive function z-scores than expected. The strength of these associations differed across the degree of exposure to the pension eligibility expansion (Table 2, Figure 1). Most notably, five additional years of expanded eligibility were associated with a 0.222 (95% CI: .056, .389) higher observed cognitive score compared to their predicted cognitive score. The trends observed with each additional year of pension eligibility generally suggest a larger difference between observed and predicted cognitive function with increasing years of pension eligibility exposure (Figure 1). We observed the strongest effects for the benefits of the pension in Cohort 5, and this cohort

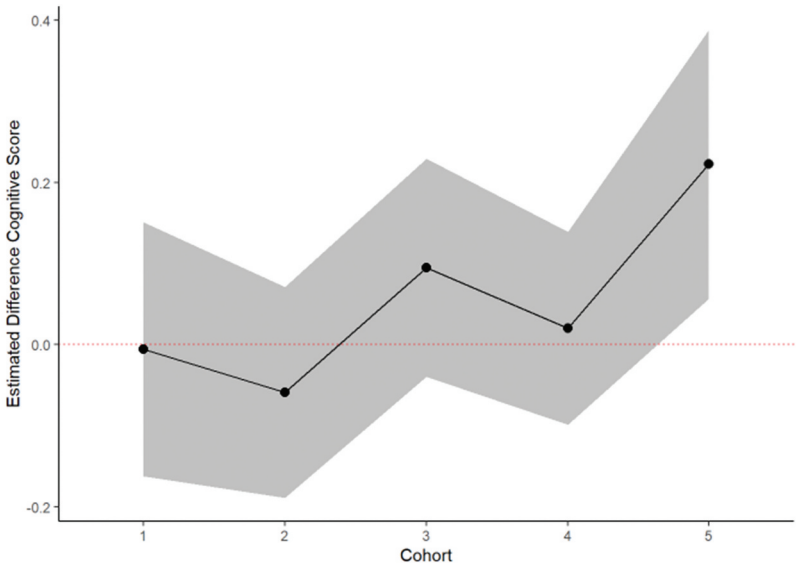

Figure 1. Difference between predicted and observed cognitive scores in cohorts of HAALSI men exposed to aditional years of pension eligibility. * X-axis displays each cohort in terms of their number of extra years of pension eligibility.

also had lower education and literacy levels than the other cohorts. Lower education and literacy levels may be associated with lower cognitive function, so the fact that our strongest effects were found in this cohort is notable. This conclusion is also supported by the results of a linear regression model treating the number of years of pension eligibility continuously. From this model, each one-year increase in pension eligibility was associated with a larger difference between observed and predicted cognitive scores of 0.055 Standard Deviations (SD) (p-value .092).

To check the robustness of our findings, and to assess for birth cohort effects or other potential sources of bias, we reran the analysis above in the sample of 2714 HAALS women, in whom we would not expect to find any pension effect. Overall, we did not find the same patterns in women as we observed in men (Table 3). The evidence did not suggest significant differences at any of the cohorts that mapped onto years of expanded eligibility in men (Table 3). Women with dates of birth in the same range as men exposed to five years of additional pension eligibility had cognitive scores that were not significantly different than would have been predicted given their covariate structure [difference = 0.003 SD, 95% CI (−.197, .203)]. Similarly, the observed trends did not suggest stronger difference scores than would be with increasing exposure to pension eligibility (Figure 2). While all the coefficients were positive, they were lower in magnitude than the estimates from HAALSI men,

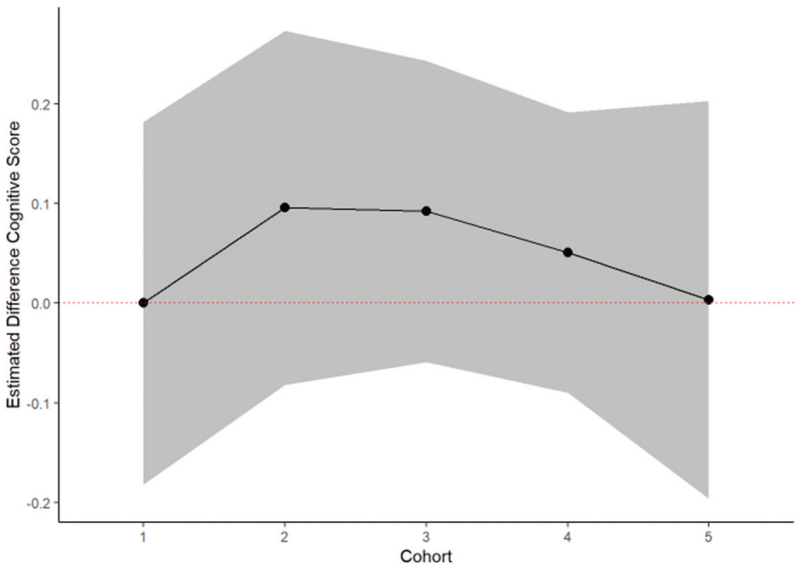

Figure 2. Robustness check: difference betweeen predicted and observed cognitive scores in cohorts of HAALSI women. *X-axis displays each cohort in terms of their number of extra years of pension eligibility

and the overall shape appeared to decrease with what would be increasing exposure beyond the second cohort.

Furthermore, we conducted several sensitivity analyses, adding variables that may impact cognitive function and, in turn, bias results, to the predictive model. Table 2 in the Appendix displays results from a sensitivity analysis, adding a social network variable to the predictive model. We found results from the predictive model including the social network variable to be consistent with our main model. As in our main model, those who received five extra years of pension in the model that included a social network variable had higher observed cognitive scores 0.205 (95% CI: .040, .370). This result is very close to the main model result for cohort five (0.222 (95% CI: .056, .389). Moreover, we ran a sensitivity analysis, adding chronic diseases (diagnosed diabetes, angina, and TB), as well as an ADL scale variable to the predictive model (Table 3 in the Appendix). Results of this model were consistent with findings from our main model. As in our main model, those who received five extra years of pension in the model including chronic diseases and ADL scale had higher observed cognitive scores 0.202 (95% CI: 0.029, 0.377) and the coefficient is similar to the main model coefficient of 0.222 (95% CI: .056, .389).

Figure 1A in the Appendix displays all the individuals in the sample over 60 years old that self-reported receiving the pension. The histogram shows that out of 1,322 men over 60 years old in the dataset, 772 (58%) reported receiving the Public Old Age Pension. Since the self-reported pension rate was relatively low, we have some concerns of possible under-reporting with this self-reported variable. The Mpumalanga Province, where data for this study originates, has high rates of poverty and unemployment (Kahn, Collinson, Gómez-Olivé, et al., 2012), and the Old Age Pension is a means-tested program. Social welfare grants like the OAP have been a crucial and stable income source for individuals in this area (Schatz & Ogunmefun, 2007). Nonetheless, as a further sensitivity analysis, we included a restricted model for individuals who self-reported receiving the pension. The results of this analysis are in Table 7 of the Appendix. While the restricted model reduced our sample size, our results were largely robust to the restriction. As in our primary model, those who received five extra years of pension in our restricted model had higher observed cognitive scores. This result is statistically significant in the restricted model and has a similar coefficient as in the main model (restricted model: 0.210 (95% CI: .031, .388), main model: 0.222 (95% CI: .056, .389). For our study, we created our cohorts based on men's eligibility for receiving the pension, therefore our main model is an intent-to-treat model. Since the restricted model contains only individuals who self-reported receiving the pension, the sensitivity analysis is an as-treated analysis. Therefore, these results are evidence that the effects we found in our main model are robust.

Discussion

In this study, we found that a pension eligibility expansion for men in rural South Africa was associated with elevated cognitive function. The observed cognitive scores were higher than the predicted cognitive scores for three of the five birth sub-cohorts which were exposed to expanded pension eligibility and were significantly higher for those with the highest exposure (five years). The estimated difference in cognitive function for the men who were eligible for five years of expanded pension eligibility was 0.222 SD. Analysis of the cognitive function distribution by age in the HAALSI primary cohort indicates that cognitive function declines 0.02 SD for every one year of aging. Thus, our findings show an effect equivalent to a decade of aging. We also observed a positive linear trend in these effects, with generally stronger effects for those with more pension eligibility exposure. Importantly, these findings were not replicated in our negative control analysis among women, indicating that the results are not due to birth cohort differences in cognitive function. The findings were also robust to sensitivity analyses adding a social network variable, ADL scale and chronic diseases to the predictive model, as well in a restricted model for only men who self-reported receiving the pension. Taken together, our findings suggest that receiving extra pension may be associated with enhanced cognitive function among older men in rural South African settings.

Our findings add to the small, but growing body of research supporting the use of cash transfers to promote healthy cognitive aging (Aguila et al., 2015; Hughes et al., 2018). Several studies in middle to high-income countries suggest a positive association between income and positive cognitive aging outcomes (Glymour & Manly, 2008; Jefferson et al., 2011; Liu et al., 2010; Whalley et al., 2006). New evidence from the United States has also found that exogeneous expansions to social security income were associated with improvements in cognitive function for older adults (Ayyagari & Frisvold, 2016). This study joins a randomized trial in Mexico as the existing non-observational research examining the causal impact of cash transfers on cognitive function among older adults in upper middle-income countries. The experimental trial of social security benefits for adults aged 70+ in Mexico observed substantial improvements in memory, equivalent to a reduction in cognitive aging by five to twelve years (Aguila et al., 2015). Cognitive decline can begin in middle-aged adults and can accelerate with age beyond 65 years (Singh-Manoux et al., 2012). Since an accelerated progression of cognitive decline can be a risk factor for ADRD, such interventions earlier in adult life may serve preventative purposes (Hughes et al., 2018).

A potential pathway by which cash transfers may impact cognitive function is via building cognitive reserve (Stern, 2012). Cognitive reserve is a construct that is believed to improve the brain's ability to cope with pathological damage

and can be built across one's life course via cumulative cognitively stimulating exposures (Stern, 2012; Stern, 2002). Socioeconomic status indicators such as income are considered proxy measures for cognitive reserve and thus may shape cognitive outcomes in older adults (Turrell, et al., 2002). Cash transfers, which increase income, may impact cognitive function by providing individuals with resources that can promote healthy cognitive aging (Glymour & Manly, 2008). For instance, additional income allows adults to access nutritious food, better housing, and health care and improve their physical, intellectual, and social activities (Glymour & Manly, 2008; Richards & Deary, 2005). Furthermore, cash transfers, including the OAP, can help reduce stress and worry, improve perceived quality of life, and overall feelings of wellbeing and sense of financial security (Møller & Devey, 2003). In many cases, the old age pension makes significant increases in the household income and can help in alleviating household poverty (Møller & Devey, 2003). It has also been linked to greater spending power, better access to basic services and higher levels of satisfaction with their living environment, which in turn can improve pensioners general health and well-being (Møller & Devey, 2003). Thus, the increased cash transfers due to pension expansion policies may plausibly exert a protective effect on beneficiaries' cognitive function.

Findings from our study are strengthened by the quasi-randomized design, in which we exploit the exogeneous expansion of the South African Old Age Pension to attempt to identify causal effects on cognitive function. This quasi-experimental design reduces the potential for confounding factors associated with income and cognitive function to bias our model. Our analysis using women as a negative control group also helps to support our conclusions. We observed some elevated point estimates in the cohort of women, though they were not significant and much smaller in magnitude than observed for men. Further research is needed to assess the reasons why we see higher cognitive function for both men and women during this time. Evidence shows that older individuals receiving pension tend to share it with other members of their household, therefore the pension likely has positive externalities beyond the benefits for just older South Africans (Lloyd-Sherlock et al., 2012; Niño-Zarazúa et al., 2012; Ralston & Schatz, 2020). It may be the case that there are spillover effects from the OAP expansions if men who received extra pension amounts contributed some of the extra money to benefit women and households in their lives. If this were the case, then women may have also benefited from the OAP expansion policy.

A good area of future research would be to examine the impacts of increased pension on women's cognitive function. Studies in South Africa show that women head of households spend more money on food and medical expenses than men, and considerably less on alcohol and tobacco; substances that are detrimental to cognitive function (Carranza & Niles, 2019; Case & Deaton, 1998; Sullivan et al., 2010). Therefore, it is possible, that increased pension

expansions for women may be beneficial for women's cognitive reserve if they are spending it in ways that improve their cognitive function. However, studies have also shown that women tend to spend their cash transfer payments differently than men do, and in ways that benefit others in their households, especially children (Burns et al., 2005). It is therefore possible that we may observe lower direct benefits of for women pensioners if they are less likely to invest the added income in their own health/well-being.

Some elements of our study design and analysis suggest that our findings should be interpreted cautiously. One limitation is that the dataset used for this study includes measurements of cognitive function at a single point in time. Moreover, the cognitive function outcome variable was missing for 5% of the sample. These individuals were missing data for the cognitive function variable because they had severe cognitive impairment. Therefore, the results of our analysis are relevant to individuals without severe cognitive impairment. Our study area was restricted to a single setting in rural South Africa. Income interventions may have different impacts for individuals living in rural vs. urban areas. However, making this comparison is outside the scope of our data availability for this study. Moreover, our study is restricted to looking at the impacts of pension expansions for only men. Since women in South Africa have always been eligible for pension at age 60, we were not able to design a similar natural experimental study of the impacts of extra years of pension for women. Identifying natural experiments in cash transfer programs that target women would be helpful to understand the cognitive function impacts more fully across gender and would be an interesting area of future research. Future studies should seek to extend these findings in other settings, such as urban populations and settings beyond South Africa, to better understand their generalizability.

As the global population rapidly ages, it is important to identify novel areas for policy intervention to promote healthy cognitive aging and prevent or delay the onset of ADRD at the population level. This is particularly important now, as the COVID pandemic has exacerbated unemployment and isolation effects from lockdown policies in March/April 2020 which are scheduled to continue to end in March 2022. This underlies the importance of government-sponsored relief which has temporarily augmented the value of all transfers including the OAP.

Conclusion

We found evidence that there is a potential benefit of cash transfers at an earlier age for older individuals living in resource-poor communities. Particularly, transfers occurring for three to five years may have an influence in improving cognitive function. As such, cash transfer programs such as pensions, social security grants, or other forms of direct basic income

transfers may hold promise as potential policy interventions to promote healthy cognitive aging. Future research should examine the effects of cash transfers for both men and women and their effects on both cognitive decline and ADRD risk.

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