Impact of Volunteering on Cognitive Decline of the Elderly

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November 18, 2015

Abstract

Cognitive decline amongst the elderly imposes a huge welfare and health care cost on the individual as well as society. Little however is known about factors that can mitigate such a decline. Using seven waves of the Health and Retirement Study, this study estimates the causal effects of pro-social engagement, specifically volunteering, on old age cognitive health. Our results shed light on how deliberate social behavior at prime age can be used to effectively ease cognitive decline which is otherwise an inevitable aspect of aging. The result of a significant protective effect of volunteering on cognitive health is robust to a wide array of sensitivity tests. Estimating roughly the monetary gains from volunteering, our estimates show that including volunteering as a determinant of dementia, which is viewed as an extreme negative outcome of cogntive decline, leads to a 6% reduction in predicted dementia. This in turn implies a $9.26-$15.16 billion (2010 prices) reduction in the annual health care cost of dementia patients, which is otherwise estimated to be between $157 and $215 billion (Hurd et. al, 2013). Furthermore, this is likely to be the lower bound of the total monetary gains from improved cognitive health due to volunteering as it does not take into account, health care costs of mild to moderate cognitive impairment, non-health care related individual welfare gains due to improved cognitive health and the value of the positive externalities that volunteer services will generate for the society as a whole.

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Keywords: cognitive health, pro-social engagement, volunteering, selectivity, health.
JEL codes: I12, J14, E32, N33, N13, C41.

Version January 2015. I am grateful to Prof. Mark Wilhelm, Dr. Vidhura Tennekoon and Prof. Richard Steinberg for valuable suggestions and comments during the course of this study.

1 Introduction

Cognitive decline amongst the elderly, an inevitable component of aging, imposes a huge personal and public health care cost. Recent estimates show that cognitive loss, along with its comorbidities of dementia and Alzheimers disease, affected 14.7% of the US population above age 70 in 2010, with an associated health care cost between $157 and $215 billion (Hurd et. al, 2013). This cost will likely rapidly rise with the aging of the baby-boomers. Several recent studies show that, even after controlling for education and other personal characteristics, cognitive impairment negatively impacts wealth and retirement savings (Smith et. al, 2010 and Banks and Oldfield, 2007). Suboptimal pension and asset management may cause significant welfare loss for the elderly individual and the household.

Huge personal and societal cost of cognitive impairment associated with aging has recently drawn attention to the determinants of cognitive declines at high ages. Age, gender, education, income, race, non-work related social network size (family and friends), mental and physical health and engagement in cognitive and physical activity have been found to be potential predictors of old age cognitive decline. Another recently studied predictor of cognitive development and cognitive impairment later in life is adverse conditions during brain development in early life (Mendez, M.A. and Adair, L.S. (1999), Factor-Litvak P., Susser E. (2004)). Normal cognitive aging is further aggravated by events like retirement. In addition to the negative income shock resulting from retirement, loss of an engaged lifestyle, including loss of a work related social network, (Rohwedder, S. and Willis, R.J. (2010)) is hypothesized to underlie the sudden decline in cognitive function immediately following these events.

Little however is known of factors that can slow down declining cognitive health amongst the elderly. One form of mental and social engagement that can perhaps serve as a substitute for the separation from formal employment and its social aspects is volunteering. Numerous descriptive studies find a positive association between pro-social behavior and the givers psychological wellbeing and cognitive health (Konrath, S. (2012)). A critical barrier in interpreting results from these studies as evidence of a causal impact of volunteering on individual cognitive health is that they do not take into account potential sources of unobserved endogeneity that might cause spurious associations.

Unobserved individual attributes such as conscientiousness (Wilson et. al (2007)) or early life conditions (Cunha, F. and Heckman, J. (2007)) may affect both pro-social behavior as well as cognitive health leading to a spurious relationship between the two. Consequently the estimation of the causal effect of pro-social engagement on cognitive impairment amongst the elderly, requires careful controlling for confoundedness and other potential sources of bias. This is exactly the exercise this study aims to accomplish using seven waves (1998-2010) of the Health and Retirement Study (HRS).

The HRS is a nationally representative, longitudinal sample of Americans over the age of 50. Starting in 1992, the biennial survey collects consistent detailed information on individuals volunteering activity and cognitive health (seven waves between 1998-2010). Specifically, all individuals are asked 'Have you spent any time in the past 12 months doing volunteer work for religious, educational, health-related or other charitable organizations?. In case of a positive response, interviewees are asked to estimate the time they have spent 'formally' volunteering in the last year close to 50, 100 or 200 hours. Our main regression model defines volunteering hours as the sum of hours spent in formal volunteering as well informal volunteering[1]. As a robustness check we re-estimated our model regressing cognitive health on just formal volunteering. For our dependent variable, we use the modified version of the Telephone Interview for Cognitive Status (TICS) based on Folsteins Mini Mental Status Examination (MMSE) and available in seven waves of the HRS. The HRS version of the TICS measures six tasks that evaluate the respondents memory and executive function (e.g., delayed word recall, and counting backwards).

The HRS also includes comprehensive data on employment status, job tenure, age, gender, education, income, race, social network size and participation as well as psychiatric and physical health of the indvidual which are other potential predictors of cognitive health. These are included as additional covariates in our study.

Controlling for indivdidual level time constant and time varying unobserved heterogene-

[1]Response to the questions: 'Have you spent any time in the past 12 months helping friends, neighbors, or relatives who did not live with you and did not pay you for the help?' followed by a time estimate in hours spent doing so

ity using an 'individual fixed-effect-instrumental variable' strategy (discussed in Section 4), along with several observable confounders of volunteering and cognitive aging, the results provide an estimate of the causal effect of volunteering on cognitive decline. Results show that increases in volunteering participation significantly slows down declines in cognitive health even after controlling for the individuals age, household income, lifestyle, social network, retirement status and mental and physical health. This is the first study, to the best of our knowledge, that attempts to pin down the causal relationship between volunteering and cognitive health. In so doing we make a significant contribution to existing literature on cognitive aging.

In sensitivity analysis, we compare the impact on cognitive health of other forms of mental and social engagement to that of volunteering. This is done by merging with the HRS panel, data from the off-year Consumption and Activities Mail Survey (CAMS), also routinely conducted by the HRS since 2001. CAMS part A provides detailed information on time use and activities of the interviewees that commonly substitute for formal work post-retirement (e.g., hours spent visiting friends and family, exercising, playing cards, attending movies and lectures etc.). Our results show that even after controlling for other alternate avenues of engagement, volunteering has a significant protective impact on the cognitive health of the volunteer.

Moreover, a series of sensitivity checks illustrate the robustness of our identification strategy as well as our results to alternative variable specifications.

Finally, the study has clear policy implications. As volunteering is significantly protective against cognitive aging, individuals can use this to mitigate cognitive decline associated to aging. Given the large health care costs associated with cognitive decline in the older population, any such significant negative causal effect of pro-social behavior on cognitive aging would imply huge public health care savings. In fact, extending the estimations of Hurd et. al, (2013) by including volunteering as a determinant of dementia, our estimates show volunteering leads to a 6% reduction in predicted dementia rates. This in turn implies a \$9.26-\$15.16 billion (2010 prices) decrease in the annual health care cost of dementia patients, which is otherwise estimated to be between \$157 and \$215 billion. This is likely to be the lower bound of the total monetary gains from improved cognitive health associated to volunteering as it does not take into account health care costs associated to mild and moderate levels of cognitive impairment, non-health care related individual welfare gains due to improved cognitive health. In addition to high private gains, volunteering, unlike other forms of mental engagement previously proposed like playing bridge, is also likely to have large positive spillovers by providing useful services to communities. For example, highly educated elderly could volunteer tutoring to disadvantaged inner city school students. Estimates of the total indivdiual and social gains from volunteering will help guide policy makers in determining how actively volunteering should be encouraged through public engagement programs.

2 Past Literature

Cognitive decline is an inevitable part of aging and imposes a huge personal and social cost. Understanding what determines cognitive health levels and trajectories therefore becomes even more important when facing a rapidly aging population. Past literature, which is largely descriptive in nature, has found several socioeconomic and demographic factors like gender, age, race, income and education (Karlamangla et. al 2009) to be correlated to cognitive health levels and declines. For instance, Karlamangla et. al (2009) find that cognitive declines in advanced ages are faster amongst amongst women, widows/ widowers and those never married and declines increases with age. Interestingly, cognitive health declined slower amongst Blacks (compared to whites) and for those in the bottom income quintile (compared with the top quintile). The authors also find no significant association between education and cognitive *declines*. However, education is found to significantly impact *levels* of cognitive health. For instance, Banks and Mazzonna (2012) study the causal impact of a one year increase in compulsory education in England resulting from a policy change in 1947 on the level of cognitive function at older ages. Using a regression discontinuity design around the timing of the policy change the authors find a significant increase in the cognitive function amongst those receiving an additional year of education as a result of the policy change. Consequently, ethnic and socioeconomic disparities in cognitive health in older Americans may culminate from differences in peak cognitive level achieved earlier in the life course as well as rate of declines in later life.

Recently literature has considered the impact of socioeconomic background and early life conditions and health (Van den Berg et. al, 2010) on later life cognitive function. Using business cycle conditions in year of birth as an exogenous indicator of early life economic circumstances Doblhammer, van den Berg and Fritze (2013) find that recessions have a negative impact on several dimension of cognitive functioning like numeracy, verbal fluency and recall abilities. Moreover, this effect is not mediated by education or job opportunities. Considering potential underlying mechanisms, Case and Paxson (2009) find that the signifiant association between early life conditions and later life cognitive health may be explained by pathways through adult physical health captured using adult height. Finally, not only are early life conditions found to be important determinants of late life cognitive health, adverse early life conditions further aggrevate the cognitive decline resulting from adverse later life events like loss of a relative or the onset of a chronic condition (Van den Berg et. al, 2010).

Some studies have considered individual personality traits as predictors of cognitive impairment amongst the elderly. For instance, Wilson et. al (2007) find that having a 'high conscientiousness score' was associated with a significant reduction in risk of Alzheimers diseases and mild cognitive impairment, even after controlling for age, sex and education. In another study neuroticism and extraversion are found to be significantly associated to lower cognitive function at higher ages (James, Wilson, Barnes and Bennett, 2011). However, it is worth noting that an individual's personality traits have been shown to be themselves determined by environment and experiences early in life (McLeod, J. and Shanahan M.J. (1996), Layous et. al (2012)).

Recent studies have looked at the impact of social isolation on cognitive functioning, particularly of the elderly, results however remain mixed. A range of studies considering different indicators of social isolation, including small social network, infrequent participation in social activities, lonliness and a perceived lack of social support have found social disconnectedness and perceived isolation to be associated to health risks that seem to operate through mental health (Cornwell and Waite, 2009). More specifically in case of cognitive well being, lonliness is associated with impaired cognitive health and faster cognitive decline over time (Hawkley and Cacioppo, 2010). Whereas, frequent participation in social activity [2] has been found to be associated to a lower rate of global cognitive decline (James, Wilson, Barnes and Bennett, 2011). Furthermore, the beneficial impact of social activity on health is not entirely due to the increased cardiopulmonary fitness resulting from more activity. In fact less physically intenstive social activities may be advantageous to health through psychosocial pathways (Glass et. al, 1999). However, since these earlier studies only consider associations the causal direction of the relationship between social activity and cognitive health remains unclear. It is not hard to imagine that poorer cognitive health may force individuals into more social isolation (Saczynski et. al, 2006). In fact, when considering longitudinal evidence Brown et. al, 2012 find no consistent evidence that changes in social activity correspond to immediate benefits in cognitive functioning. One reason for mixed results on the impact of social activity on cognitive health of the elderly may be that the term social activity encompasses a wide range of activities that may differentially impact cognition (Wang et. al, 2012).

Another recently studied plausible predictor of sharp cognitive decline amongst the elderly is retirement. In addition to the negative income shock resulting from retirement, the loss of an engaged lifestyle, for instance due to the loss of social network at work is hypothesized to underlie the sudden decline in cognitive function (Rohwedder and Willis (2010), , Mazzonna and Peracchi 2012,). However, results on the impact of retirement on cognitive health once again continue to be mixed. For instance distinguishing between blue collar and white collar workers Coe et. al (2012) find no clear reltaionship between retirement duration and later-life cognition for white-collar works and even a favorable impact of retirement on the cognitive wellbeing for blue-collar workers.

Determining socioeconomic and demographic predictors of cognitive health and trajectories like gender, race, education, early life conditions and age helps identify and target care for populations that may be particularly vulnerable to cognitive disfunction. However,

[2] Social activity included six common types of activities that involve social interaction (1) go to restaurants, sporting events or off-track betting or play bingo; (2) go on day trips or overnight trips; (3) do unpaid community or volunteer work; (4) visit relative or friends houses; (5) participate in groups , such as senior center, Knights of Columbus, Rosary Society, or something similar; and (6) attend church or religious services.

socioeconomic and demographic predictors of cognitive function and individual personality traits are infrequently malleable for the already adult population, making them less useful as policy instruments. An activity that can perhaps be protective of cognitive health is volunteering. Numerous descriptive studies find a positive association between pro-social behavior and the givers psychological wellbeing and mental health (Konrath (2012), Lum and Lightfoot (2005)). Since, volunteering simultaneously provides an avenue for mental engagement as well as social interaction, both of which have been recently linked to improved cognitive health, it is not hard to imagine that volunteering may have a favorable impact on the individuals cognitive health. But since these earlier works have only studied correlations between volunteering and self-reported mental health measures, like depression, and not specifically objective measures of cognitive health the direction of the relationship between volunteering and cognitive health remains unclear. For instance, poor cognitive health may impede a persons participation in volunteering activities. Furthermore, a critical barrier in interpreting results from these studies as evidence of a causal impact of pro-social engagement on individual cognitive health is that they do not take into account potential confounders. For instance, individuals early-life conditions have been shown to determine individual pro-social behavior as well as cognitive health and inability to control for such sources of unobserved heterogeneity might cause spurious associations.

In this study we aim to bridge some of the gap in the existing literature by attempting to pin down the causal relationship between volunteering and objective measures of cognitive health. In order to do so we will control for potential confounders of volunteering and cognitive health by using a fixed effects, instrumental variable strategy (discussed in detail in the Section 4). The study will also compare the favorable impact of volunteering on cognitive health to the effect that other social activities may have. Finally, we will use our estimates to calculate the monetary cost of volunteering in terms of health care savings of dementia patients.

Table 1: Volunteering by wave of the Health and Retirement Study (1998-2010).

	Wave							
	1	2	3	4	5	6	7	
Year	1998	2000	2002	2004	2006	2008	2010	Total
Panel A: Volunteering participation								
Non Volunteers	4102	3520	3412	4849	4155	4261	3700	27999
Volunteers	5,307	3713	3566	7254	5497	5455	5375	36167
Total	9409	7233	6978	12103	9652	9716	9075	64166
Panel B: Hours spent volunteering in past 12 months								
Mean	84.46	77.05	65.60	80.27	75.87	73.21	75.04	76.45
S.E.	1.37	1.53	1.38	1.09	1.20	1.16	1.22	0.48

3 Data

The study uses seven waves of the Health and Retirement Study (HRS, 1998-2010) for the individual level data. The HRS is a nationally representative, longitudinal sample of Americans over the age of 50. Starting in 1992, the biennial survey collects consistent detailed information on individuals volunteering activity and cognitive health over seven waves between 1998-2010. Specifically, all individuals are asked 'Have you spent any time in the past 12 months doing volunteer work for religious, educational, health-related or other charitable organizations?. In case of a positive response, interviewees are asked to estimate the time they have spent volunteering in the last year close to 50, 100 or 200 hours. Table 1 presents summary statistics of volunteering participation for the sample used in this study.

For our dependent variable, we use the modified version of the Telephone Interview for Cognitive Status (TICS) based on Folsteins Mini Mental Status Examination (MMSE) and available in seven waves of the HRS. The HRS version of the TICS measures six tasks that evaluate the respondents memory and executive function (e.g., delayed word recall, and counting backwards). Each correct answer gives an additional point to the interviewee. The resulting range of the cognitive test scores is 0-35. Table 2, Panel A provides mean cognitive scores by volunteering status while Panel B presents changes in cognitive health by changes in volunteering status. Summary statistics presented in Table 2 illustrate that cognitive health scores are significantly different for individuals who engage in volunteering activities from those who don't. Moreoever these differences can be found both in levels

Table 2: Summary Statistics of Cognitive Health and Volunteering Status.

	Mean	Standard error
Panel A: Mean levels of cognitive health by volunteering status		
Does not volunteer	21.32∗	(.05)
Volunteers	23.68	(.03)
N	46231	
Panel B: Mean changes in cognitive health by changes in volunteering status		
Stopped volunteering	−.70	(.08)
Started volunteering	−.60	(.09)
N	42396	

∗ : statistically significantly different at p≤.05

as well as changes in cognitive health and volunteering status. Descriptive differences in cognitive health by volunteering status from Table 2 however cannot be interpreted as a casual impact of the latter on the former as these correlations may result from confounding determinants of cognitive health and volunteering behavior as well reverse causality where poor cognitive health may impede a persons ability to volunteer.

Furthermore, the HRS includes comprehensive data on employment status, job tenure, age, gender, education, income, race, social network size and participation, psychiatric and physical health of the indvidual and their spouse, participation in other cognitive and physical activity, income, household wealth, and other relevant demographic variables that are other important controls in our study.

We also control for early life conditions that may confound pro-social behavior and cognitive health. Specifically, this is done by including as a regressor the cyclical component of the log per capita GDP in the year and month of birth of the individual which by now is an established exogenous indicator of the individuals early life conditions (Van den Berg et. al, 2010).

4 Methods

Two potential sources of endogeneity may hamper the identification of the causal effect of volunteering on cognitive health. The first arises due to existence of time constant individual level confounders of volunteering and cognitive health. For instance, personality traits like conscientiousness or early life experiences that remain fixed over the individual's lifetime and may jointly determine volunteering behavior as well as cognitive health of the individual. We address this source of endogeneity by exploiting the panel structure of the HRS and estimate individual fixed-effects (FE) models with changes in cognitive score as the dependent variable and changes in volunteering behavior, measured as number of hours spent volunteering, as the main explanatory variable. To start, we model cognitive health as:

$$C_{i,t} = \beta_0 + \beta_1 V_{i,t} + \beta_2 X^1_{i,t} + \beta_3 X^2_i + \alpha_i + u_{i,t} \tag{1}$$

where, $V_{i,t}$ represents volunteering and $C_{i,t}$ the cognitive health of individual i at wave t. X^2_i is a set of relevant time constant explanatory variables (e.g.,gender,race etc.) whereas $X^1_{i,t}$ captures time varying independent variable explanatory variables like retirement status, physical and mental health, lifestyle factors and age of the individual. Finally, β_0 is the intercept and $u_{i,t}$ is the random error term. β_1 is the coefficient of interest. Individual volunteering behavior $V_{i,t}$ now enters as a determinant of cognitive function $C_{i,t}$. In this specification of the production of cognitive health we directly acknowledge the presence of individual level time constant unobserved confounders of pro-social behavior ($V_{i,t}$) and cognitive score ($C_{i,t}$) like conscientiousness and early life conditions. These are often unobserved in the data and captured by α_i. The data generating process of the cognitive score at wave $t+1$ would be similar to equation (1) above, but with a time-subscript of $t+1$ instead of t. Using panel data and 'first differencing' equation (1) from a similar regression at time $t+1$ we will estimate the first-differenced version of (1) and in so-doing eliminate the confounders α_i. Fixed effects yield estimates of the 'causal effect' of volunteering on cognitive health that are robust against a major source of endogeneity – time constant unobserved heterogeneity.

A limitation to the fixed-effects approach is that first-differencing also eliminates time constant characteristics like gender and race, captured by X^2_i in (1) above, from the model. However, with a large enough sample size the investigator may estimate fixed effects model within specific race-gender subgroups of interest to study if volunteering influences cognitively health differently within these groups. Subpopulation differences in the impact of volunteering on cognitive health changes is however not a focus of the study and is left to future work.

A second potential source of bias that may hinder the causal interpretation of (1) and that is not controlled for by the fixed-effects approach arises due to time-varying unobserved confounders of volunteering and cognitive health or reverse-causality. As a first step to reduce the impact of such potential biases we control for several observed time-varying determinants of cognitive health such as social network size and participation, health, participation in other cognitive and physical activity, income, household wealth etc that have been found to be correlated to the individuals cognitive wellbeing. It is not hard to imagine that despite such extensive controls some time varying heterogeneity may remain unobservable, thereby biasing our estimates of β_1. We additionally deal with this second source of endogeneity by employing a two-stage-least-squares (2SLS) strategy which instruments changes in the individual's volunteering with changes in their spouse's Instrumental Activities of Daily Living (SIADL), Activities of Daily Living (SADL) and mobility (SMOB) limitations. Five tasks included in the spouse's mobility (SMOB) index are walking several blocks, walking one block, walking across the room, climbing several flights of stairs and climbing one flight of stairs. Spousal ADL (SADL) includes the five tasks bathing, eating, dressing, walking across a room, and getting in or out of bed. Finally, spouse's IADL (SIADL) include using a telephone, taking medication, and handling money. Clearly there could be a high level of correlation between the various components of these functional limitation indices. For SIADL, SADL and SMOB to be suitable instrumental variables (IVs) for the individual's volunteering behavior two conditions need to be met. The first, which is easy to check is that the IV, in our caseΔSIADL, ΔSADL and ΔSMOB, have a significant impact on or are informative of the individual's volunteering behavior. Intuitively this makes sense. Worsening (or improvement) in the spouse's activities of daily living or mobility limitations would imply a larger (or smaller) opportunity time cost of volunteering for the individual potentially decreasing (or increasing) their volunteering participation. Statistically, informativeness of the instrument is directly tested in the first stage of the 2SLS process that regresses the endogenous regressor (volunteering, $\triangle V_{i,t}$ on the IVs (SIADL, SADL and SMOB) and a vector of other exogenous regressors. A large F-statistic [3] measuring the joint significance of the regressors from the first stage, suggests informativeness of the instrument. Results are presented in the following section and show that presence of SIADL, SADL and SMOB significantly reduce volunteering hours of the individual and F-statistics from the first stage easily exceed prescribed levels that satisfy the informativeness criteria of the IVs.

Our proposed instrumental variables (IVs) however also need to fulfill a second condition, referred to as the exclusion restriction criteria, before we can use them as IVs in our study. Exclusion restriction criteria requires the IVs (SIADL, SADL and SMOB) to influence the individual's cognitive health only via their volunteering behavior and not directly. Unlike the informativess of the IVs the exclusion restriction criteria is mostly non-testable. It is therefore important to think of situations in which exogeneity of the IVs may be violated. For instance, if there would be correlation between spousal physical health, in our case SIADL, SADL or SMOB, and own cognitive health in old age. Positive assortative mating literature finds strong correlation between physical attributes or intelligence of spouses. However, as far as we know, no study has found evidence of assortative mating patterns where individuals with certain cognitive intelligence disproportionately match with individuals with certain physical health conditions. Such a scenario seems particularly unlikely especially since the timing of marriage mostly preceeds, by several decades, development of SIADL, SADL or SMOB limitations.

Another situation where the exogeneity of our IVs would come into question would be caregiver burden. In this case, caring for a spouse with SIADL, SADL or SMOB limitations would impact the cognitive ability of the caregiving spouse directly. Impact of caregiving on cognitive health could be negative, if caregiving was mentally burdensome in a way that it would adversely influence the cognitive health of the care giver. While some descriptive literature has found higher incidence of depression amongst caregivers of patients of Alzheimers disease and dementia such an effect seems to be limited to caregivers of patients with behavioural disorders. Moreover none of these studies has an impact of caregiving on

[3] Critical values of the F-statistic to test for weak identification is a function of the number of endogenous regressors, the number of instruments and the desired maximal IV bias relative to the OLS estimates and have been made available in Stock-Yogo (2005)

the caregivers cognitive health. But, to ensure that our results are not influenced by any such direct impact of our IVs on the individual's cognitive health we limit our sample to individuals whose spouses and they themselves do not suffer from Alzheimers disease and dementia. This results in a loss of six percent of observations.

To further 'test' the validity of our instrument, we perform some 'balancing tests' (McClellan et. al, 1994). Conceptually, the 2SLS method does not compare cognitive health outcomes for the individuals based on their observed differences in volunteering participation, which could also reflect potentially unobserved factors. Instead we use IVs to compare groups with otherwise similar (observable and unobservable) characteristics but who differ in their volunteering behavior for reasons independent of their cognitive health. Section 5.1 provides evidence for selection bias and motivates how the proposed individual FE-IV methodology may addresses this issue. Despite efforts to have strong instruments that 'satisfy' the exclusion restriction criteria and our FE-IV model, it is not hard to imagine that some bias may remain in our FE-IV estimates. Especially since the exogeneity of the IV cannot strictly be tested. We discuss and compare in detail the extent of potential bias remaining in our FE-IV estimates compared to the OLS results in Section 5.2 following the regression results of the impact of volunteering on the cognitive health of the elderly. Results from three different models, with increasing levels of controls for potential selection bias, are presented and compared in order to get at the causal relationship between volunteering participation and cognitive health.

5 Results

5.1 Selection Bias and basis for Instrumental Variables

Table 3 presents descriptive characterisitcs of potential observable confounders of cognitive health and volunteering status. Proportions and means with standard errors are presented separately for non-volunteers and volunteers in order to shed light on differences in observables by volunteering participation. As seen in Table 3, volunteers are significantly more likely to be men, white, younger, have higher mean log household income, higher education, married, with children and retired compared to non-volunteers. In terms of lifestyle factors, volunteers are more likely to be non-smokers and occasionally consume alcohol compared to their non-volunteering counterparts. Volunteers also significantly vary from non-volunteers in their observable physical and mental health. Since, volunteers significantly differ from non-volunteers in most observable characteristics it is not hard to imagine that the two groups may differ in their unobservable characteristics as well, suggesting a potential for selection bias.

Table 4 considers the changes in descriptive characteristics by change in volunteering status. By considering changes rather than levels, summary statistics in Table 4 eliminate baseline differences in observables by volunteering behavior. Even when considering the association in changes rather than levels we find that individuals who stopped volunteering continue to differ significantly from individuals who started volunteering in several factors. Specifically, invididuals who start volunteering are more likely to have gotten retired, quit smoking, started drinking alcohol, and less likely to have ADL limitations, heart ailment, stroke, depression and cancer. This indicates that although by considering changes, rather than levels, in volunteering participation eliminates to an extent the potential selection bias individuals who start volunteering differ from those who stop volunteering in observables and potentially in unobservables. Econometrically, this implies that an individual fixed effects (FE) model may not sufficiently control for unoberved heterogeneity thereby allowing causal inference. Consequently, we consider IV methods to further control for some of the selection bias introduced by time varying confounders in order to study the impact of volunteering on the individual's cognitive health.

As instruments we compare individuals whose spouses start to experience IADL, ADL or MOB limitations versus those who no longer have IADL, ADL and MOB limitations. To illustrate the homogeneity of the sample across these two groups Table 5 compares two extremes which are likely to experience the biggest 'shock' in their spousal health and consequently on their ability to volunteer - individuals who transition from having no SIADL, SADL or SMOB to developing one SIADL and those who experience an improvement in

Table 3: Descriptive Characteristics (proportions and means by Volunteering Status

	Non volunteers	Volunteers
Socioeconomic and Demographic characteristics		
Females	.57	.50*
Race White	.84	.90*
Race Black	.13	.08*
Race Other	.03	.02*
Mean age (years)	70.76	70.16 *
Mean household income	49885.25	63880.74*
Religion important	.63	.69*
Education≥high school	.28	.47*
Single	.38	.27*
Mean no. children	3.49	3.29*
Retired	.64	.71*
Lifestyle factors		
Smoke now	.16	.09*
Smoke quit	.50	.49
Consume alcohol	.42	.57*
Health conditions		
Underweight BMI (<18.5 kg/m^2)	.02	.01*
Normal BMI (18.5-24.9 kg/m^2)	.29	.29
Overweight (BMI 25-29.9 kg/m^2)	.37	.42*
Obese (BMI≥30 kg/m^2)	.33	.28*
ADL limitations	.22	.08*
IADL limitations	.09	.03*
Mobility limitations	.60	.42*
High blood pressure	.64	.56*
Heart ailment	.31	.26*
Diabetes	.27	.19*
Stroke	.09	.05*
Depression	.19	.09*
Arthritis	.67	.65*
Chronic lung disease	.16	.10*
Cancer	.18	.17

∗ : statistically significantly different at p≤.05

their SIADL from one or more to none.

As instruments we compare individuals whose spouses start to experience activities of daily living (SIADL/ SADL) or mobility (SMOB) limitations versus those who no longer have any limitations. 70.85% of the sample have no spousal SIADL, SADL or SMOB (range 0-13), 11.66% of the sample experience one limitation, 6.12% have two, 3.63% have three, 2.71% have four and a meagre 5% suffer from five or more. Since several of the components of the three functional limitation indices of the spouses are correlated the extent of total spousal functional limitations is unlikely to be simply linear in the sum of SIADL, SADL and SMOB. Therefore for our descriptive analysis we use a simple binary indicator of having any SIADL, SADL or SMOB as the IV. This approach accounts for the potentially non linear impact of spousal health constraints on the individuals ability to volunteer in a simplistic way. Results are presented in the following section. In Table 5 we find that these two groups are far more similar in changes in their observable health and lifestyle, the only exception being losing a child and blood pressure, than groups of volunteers versus non-volunteers. The balance in observable changes in characteristics provides some validation of the exclusion restriction of our IVs: that despite being otherwise similar the individuals faced with worsening spousal IADL, ADL or mobility limitations volunteer less than individuals whose spousal health improved during the same observation window. Further standardized tests for the validity and strength of the instruments are presented the subsection 5.2.

5.2 Regression results

Table 6 presents regression results for the impact of number of hours spent volunteering on the MMSE score of cognitive health (range 0-35). Three different specifications are shown - ordinary least squares (OLS), individual fixed effects (FE) and the preferred individual fixed effects-instrumental variable (FE-IV) model. The most important result is that we find a significant favorable impact of volunteering on the cognitive health of the individual, irrespective of the model specification. Considering results from each of the specifications individually, a simple OLS estimation shows a significant but small positive effect of hours spent volunteering on the individual's cognitive health score. The OLS specification does not control for any selection bias. The individual fixed effects (FE) model estimates presented in column two controls for time contant individual unobserved heterogeneity. Comparing coefficients from the OLS specification with those from the FE model shows a significant but even smaller impact of volunteering on cognitive health. Since controlling for the individual level time constant unobserved heterogeneity reduces the size of the coefficient it suggests that the omitted individual level confounders, for instance the conscientiousness of the person, must be positively associated with the individual's cognitive health. A conscientious person may be more likely to volunteer and also might enjoy better cognitive health and so not controlling for conscientiousness will bias the estimates of the impact of volunteering on cognitive health upward. The last model we estimate is the FE-IV model, which in line with the balancing tests presented above, tries to correct for individual time constant as well as time varying unobserved heterogeneity. With the FE-IV model, estimates shown in the last column of Table 6, we still find a statistically significant and in fact a larger impact of volunteering on the cognitive health of the individual. This is a little unusual as correction for time varying unobserved heterogeneity using instruments 'usually' tends to drive the estimates downward. But theoretically, the change in the estimates post-instrumentation depends on how the omitted confounders might be associated to the coefficient on volunteering β_1 and cognitive decline. Omitted variables like engaging in new and challenging experiences, meditation and sleeping may take away time from volunteering but are linked to slower cognitive decline (Park et. al, 2014, LaMore et. al 2013, Wells et. al 2013 and Tamaki 2013). Controlling for such potential time varying unobservables with our IV will correct for the downward bias in our FE estimates. In the subsequent subsection, one of the robustness checks we present, compares the impact of volunteering with that of other forms of engagement on the cognitive change in our sample. Results presented in Table 7 below provide further support to our findings.

It is important to note that as with most IV estimates, given the non-testability of the exogeneity of the instruments to the model, unbiasedness of the estimates cannot be guaranteed. In fact if the instruments are not strictly exogenous, i.e. there exists a non-zero correlation between the instruments and the error term, the bias in the IV estimates can be potentially large. This is particularly so if the correlation between the instruments and the endogenous regressor (volunteering) is small, referred to as the weak instrument problem. The strength of the instrument is explicitly tested for in the first stage of the two-stage-least squares estimation (2SLS) that is used for our FE-IV specification. Our potentially endogenous regressor is hours of volunteering, and our instruments are indicators for spouse having activities of daily living (SIADL or SADL) or mobility (SMOB) limitations. The heteroscedasticity robust Kleibergen-Paap rk Wald F-statistic from the first stage to test the null hypothesis that the instrument is weak is 13.02. Stock and Yogo (2005) provide critical values for the test for different numbers of endogenous regressors, number of instruments and relative bias of the 2SLS estimator relative to the OLS that is acceptable. The F-statistic of 13.02 from our first stage of the 2SLS estimation exceeds the critical value of 9.08 at a 5% significance level for a 10% maximal bias in IV relative to OLS[4]. Hence, the null of weak instruments is rejected, providing some support for the FE-IV specification. Robustness of the 2SLS estimates is further investigated in the subsequent subsection using a series of recommended tests.

In line with earlier literature, results in Table 6 also control for other potential determinants of cognitive health like conditions at birth of the individual, income, education, age, gender, race, retirement status, importance of religion, smoking status, alcohol use, physical activity, BMI, social network and numerous physical and mental health measures. OLS results, in the first column of Table 6 that do not control for potential selection bias and mostly closely resemble specifications from earlier literature. We find that our results are in line with earlier findings where better cognitive health is associated to higher income, higher education, younger age, whites and higher level of physical activity. We also find the expected adverse effect of worse physical and mental health (depression) on cognitive health of the individual. Unlike past literature, in our OLS specification we do not find a statistically significant association between the individuals social network, captured by the individual's social status and the number of child they have, on their cognitive health. However, once we control for some of the time constant and time varying unobserved heterogeneity we find a significant negative impact of being single on individual cognitive decline in our FE as well as FE-IV specifications.

[4]In fact the F-statistic of 13.02 from our first stage of the 2SLS estimation is very close to the critical value of 13.91 at a 5% significance level which puts our estimates close to only a 5% maximal IV bias relative to the OLS results

5.2.1 Robustness of the 2SLS estimates

Angrist and Pischke (2008), recommend three further tests to investigate the extent of any potential bias in the IV estimates, in addition to considering the F-statistic from the first stage of the 2SLS. First, is running reduced form regressions of the instruments on the dependent variable, i.e. the cognitive health of the individual. The reduced form estimates are proportional to the causal effect of interest (Angrist and Krueger, 2001) and if there is a causal relationship we should find it in the reduced form as well. Reduced form results are presented in Table 7[5] and further strengthen our results.

Second, following Angrist and Pischke (2008), we run just identified models using one instrument at a time only; the idea being that a just identified model is median unbiased and therefore unlikely to be the subject to a weak instrument problem. Results are presented in Table 8. We see that except in the case of the spousal mobility limitation as an IV, our coefficients from the just identified models look very similar to those from our over identified model. However, our over identified model performs marginally better in terms of balancing the observable health outcomes across individuals with and without activities of daily and mobility limitations we take that to be our preferred model.

Finally, we compare the overidentified 2SLS estimates with the Limited Information Maximum Likelihood (LIML) estimates. Econometrically, although the LIML estimates are less precise than the 2SLS they are also less biased. Results presented in Table 9 show that the estimates from the two models are quantitatively and qualitatively remarkably similar, further increasing our confidence in the FE-IV estimates from Table 6.

[5] All regression results hereon, additionally control for other covariates included in Table 6. For sake of brevity these have not been reproduced in the robustness check tables, and have been discussed in the text only if coefficients on any of these qualitatively change significantly. Full results tables for all analysis are however available upon request from the author.

5.3 Sensitivity analysis

5.3.1 Impact of formal volunteering only

Our main regression model defines volunteering hours as the sum of hours spent in the past 12 months in formal volunteering activities for religious, educational, health related or other charitable organisations as well informal volunteering defined as helping aquaintences, who are not household members. As a sensitivity test we re-estimated our model regressing cognitive health on just formal volunteering. This allows us to somewhat distinguish between the gains in cognitive health from pure volunteering versus a social network effect that may naturally arise from informal volunteering. Helping ones' already existing friends, neighbors, or relatives could involve social interaction that has previously been associated to mental wellbeing (refer following subsection for more details). Results for the coefficient on formal volunteering are presented in Table 10. Although the coefficients of formal volunteering and total volunteering quantitatively differ from each other they are qualitatively similar. Volunteering, in both cases, significantly positively influences cognitive health amongst the elderly.

It is important to note that the distinction between formal and informal volunteering is somewhat arbitrary. Formal and informal volunteering, are likely to be highly correlated. Even in terms of the social network effect, the respondent may be initiated into volunteering at a charitable organisation through a friend who is already a volunteer there. Alternatively, one may develop a social network with other volunteers they might meet through a charitable organisation. A more useful distinction may be the motivation for volunteering - purely altruistic reasons versus volunteering driven by expectation of private gains, especially if that is what determines the impact of volunteering on cognitive health. But distinguishing between volunteering for charitable organizations versus informal volunteering is unlikely to capture differences in underlying motivations. Individual's may volunteer for charitable organisations purely out of altruistic motivations or for instance to get work experience or enhance future professional opportunities, with private gains in mind. Similarly individuals may help their peer out of the goodness of their heart or to develop stronger ties with individual's or communties from whom they expect to benefit in the future. In absense of data on motivation for volunteering[6] distinction between formal and infomal volunteering seems even more abstract. In any case, both formal and informal volunteering may influence cognitive health and not controlling for either may lead to ommitted variable bias. Considering the impact of formal volunteering alone on cognitive health while including informal volunteering as a control is also less appealing since the two forms of volunteering may serve as substitutes for each other. Hence, in our preferred specification we focus on the impact of total volunteering on cognitive health of the individual as the outcome of interest.

5.3.2 Impact of volunteering versus other activities on cognitive health

Earlier descriptive studies have found a favorable impact of late life activity on cognitive health amongst the elderly. In particular, activities involving social interaction and mental engagement have been found to be protective against rapid cognitive decline. For instance, James et. al (2011) find going to restaurants, sporting events or teletract, playing bingo, going on trips, visiting friends and relatives, participating in senior centers and religious services to be correlated with less cognitive decline in old age. In order to see how these alternative avenues of social and mental engagement compare to the impact of volunteering on the cognitive health of the elderly we wanted to control for participation in other activities in our model. The HRS itself does not provide time use information on these other activities. However since 2001 the HRS also routinely conducts the Consumption and Activities Mail Survey (CAMS) for a much smaller sub-sample of the HRS. CAMS part A provides detailed information on time use and activities of the interviewees like visiting friends and family, exercising, playing cards, attending movies and lectures etc. For the sensitivity analysis, each wave of the HRS is merged with the time use data from the CAMS from one year earlier in order to control for other activities that could be potentially protective of cognitive declines. While merging the CAMS to the HRS allows us to control for other activities of the individual's in our sample it comes at a cost. Firstly, it reduces our sample size from about

[6] Even if the surveys asked individuals to report their motivation for volunteering, individuals may be more likely to report altruistic reasons. Objective measurement of motivation seems hard to conceptualize but may be feasible within an experimental framework.

65,000 individual's to just about 9,500. Secondly, since the CAMS is an 'off year' study of the HRS, i.e. the data on other activities for the individuals in the sample is from a year earlier than the data on volunteering, results need to be interpreted with caution. A one year lag could potentially allow for some reverse causality and selection that the currently available data cannot control for. Bearing in mind potential shortcomings, Table 8 presents for the CAMS sample the impact of volunteering and other activities on the individual's cogntive health. OLS and FE models are first reproduced from Table 6 for the model that only controls for volunteering participation. Columns (3) and (4) then present results with additional controls for other activities, specifically watching television, reading books and magazines, sleeping, communicating with others by means of phones, letters and emails, using the computer, praying, doing housework, managing finances, exercising and playing cards and puzzles. These activities collectively control for a wide array of social, physical and mental engagment opportunities and are in addition to social network effects that was already controlled for in our main specification presented in Table 6.

Results in Table 8 are in line with earlier literature. In the OLS specification we find a significant favorable impact of reading, using a computer, money management and playing cards and puzzles in addition to that of volunteering on cognitive health. Noticably, all these activites involve a relatively higher level of mental engagement. Interesting, praying and housework are significantly negatively correlated to cognitive health scores. These results however cannot be interpreted causally. Comparing OLS results to FE results in columns (3) and (4), we see that none of the activities significantly impact cognitive change once individual time constant heterogeneity is controlled for. Infact volunteering comes closest to be statistically significant at a p-value of 0.11. This is not surprising since the much smaller CAMS sample has resulted in a significant loss of power and a three fold increase in the standard errors. It is important to mention that like volunteering, these alternative avenues of mental and social engagement are also potentially confounded by time varying unobserved heterogeneity. However, in the absence of a large number of exogenous instrumental variables that could control for the array of activities we are unable to estimate our prefered FE-IV specification. Coefficients on all other controls remain qualitatively unchanged.

5.3.3 Placebo test of the outcome variable: Impact of volunteering on cancer

It is important to check that our results are not capturing a spurious relationship between volunteering and cognitive health. We do so by estimating our model but this time regressing a physical health condition that is unlikely to be impacted by prosocial behaviour on individual volunteering behaviour. Specifically we consider the impact of volunteering on cancer. Table 8 presents results of this placebo test, impact of volunteering on cancer versus cognitive health. The results are in line with what we would expect. It is not hard to imagine that cancer patients and survivors may get highly motivated to volunteer in cancer related charities and events. This is captured by a significant association between cancer and volunteering in a simple OLS as well as an FE model. However, in our FE-IV model even if the individual's volunteering efforts change in response to spousal health limitations, but spousal health limitations are less likely to have a significant impact on the individual's incidence or treatment of cancer. Results in Table 12 render further support to the informativeness and validity of our instrument. This test suggests that there really is something about the social and mental aspect of volunteering that benefits an individual's cognitive well being.

Table 4: Change in descriptive characteristics proportions and means by change in volunteering status (first out of two parts of the table)

	Stopped vol.	Started vol
Socioeconomic and Demographic characteristics		
Mean age (years)	2.09	2.07*
Mean household income	-531.60	-1827.99
Marital status		
Became single	.04	.04
Got married	.01	.01*
Children *(ref. no change)*		
Had child	.02	.02
Lost child	.03	.04
Retired *(ref. no change)*		
Got retired	.11	.14*
Came out of retirement	.07	.07
Lifestyle factors		
Smoke now *(ref. no change)*		
Started smoking	.01	.01
Quit smoking	.03	.02
Consume alcohol *(ref. no change)*		
Started drinking alcohol	.06	.09*
Quit drinking alcohol	.09	.08*
Health conditions		
Underweight (BMI<18.5 kg/m^2) *(ref. no change)*		
Became underweight	.01	.01*
No longer underweight	.00	.00
Normal BMI (18.5-24.9 kg/m^2) *(ref. no change)*		
Became normal BMI	.05	.04*
No longer normal BMI	.06	.05
Overweight (BMI 25-29.9 kg/m^2) *(ref. no change)*		
Became overweight	.09	.09
No longer overweight	.09	.09
Obese (BMI≥30 kg/m^2) *(ref. no change)*		
Became obese	.04	.06*
No longer obese	.05	.04
ADL limitations *(ref. no change)*		
Developed ADLlimitations	.11	.07*
No longer ADL limitations	.07	.06
IADL limitations *(ref. no change)*		
Developed IADLlimitations	.05	.04*
No longer IADL limitations	.03	.03
Mobility limitations *(ref. no change)*		
Developed mob. limits.	.30	.23*
No longer mob. limits.	.17	.10

$*$: statistically significantly different at p≤.05

Table 4: (continued; second out of two parts)

	Stopped vol.	Started vol
High blood pressure *(ref. no change)*		
Developed high blood pressure	.05	.05
No longer high blood pressure	-	-
Heart ailment *(ref. no change)*		
Developed heart ailment	.05	.04*
No longer heart ailment	.01	.01*
Diabetes *(ref. no change)*		
Developed diabetes	.04	.03
No longer diabetes	.01	.01
Stroke *(ref. no change)*		
Had	.02	.02
Depression *(ref. no change)*		
Developed depression	.08	.06
No longer depression	.07	.08
Arthritis *(ref. no change)*		
Developed arthritis	.04	.05
No longer arthritis	.02	.02
Chronic lung disease *(ref. no change)*		
Developed chronic lung disease	.02	.02
No longer chronic lung disease	.01	.01
Cancer *(ref. no change)*		
Got cancer	.03	.03
No longer cancer	.00	.01

∗ : statistically significantly different at $p \leq .05$

Table 5: Change in descriptive characteristics proportions and means (std. errors) by changes in spousal Instrumental Activities of Daily Living (IADL), Activities of Daily Living (ADL) and mobility (MOB) limitations (first out of two parts of the table)

	Fewer activity limitations of spouse	More activity limitations of spouse
Socioeconomic and Demographic characteristics		
Mean age (years)	2.09	2.10
Mean household income	-2927.63	-875.87
Children *(ref. no change)*		
Had child	.02	.03
Lost child	.02	.02
Marital status		
Became single	.09	-
Got married	-	.02
Retired *(ref. no change)*		
Got retired	.12	.13
Came out of retirement	.06	.06
Lifestyle factors		
Smoke now *(ref. no change)*		
Started smoking	.01	.01
Quit smoking	.02	.02
Consume alcohol *(ref. no change)*		
Started drinking alcohol	.07	.07
Quit drinking alcohol	.08	.07
Health conditions		
Underweight (BMI$<$18.5 kg/m^2) *(ref. no change)*		
Became underweight	.00	.00
No longer underweight	.00	.01
Normal BMI (18.5-24.9 kg/m^2) *(ref. no change)*		
Became normal BMI	.04	.05
No longer normal BMI	.04	.04
Overweight (BMI 25-29.9 kg/m^2) *(ref. no change)*		
Became overweight	.08	.07
No longer overweight	.06	.09*
Obese (BMI$\geq$30 kg/m^2) *(ref. no change)*		
Became obese	.03	.06*
No longer obese	.05	.04
ADL limitations *(ref. no change)*		
Developed ADLlimitations	.07	.08
No longer ADL limitations	.05	.04
IADL limitations *(ref. no change)*		
Developed IADLlimitations	.03	.04
No longer IADL limitations	.02	.02
Mobility limitations *(ref. no change)*		
Developed mob. limits.	.21	.22
No longer mob. limits.	.17	.16

$*$: statistically significantly different at p$\leq$.05

Table 5: (continued; second out of two parts)

	Fewer activity limitations of spouse	More activity limitations of spouse
High blood pressure *(ref. no change)*		
Developed high blood pressure	.05	.05
No longer high blood pressure	-	-
Heart ailment *(ref. no change)*		
Developed heart ailment	.04	.05
No longer heart ailment	.01	.01
Diabetes *(ref. no change)*		
Developed diabetes	.04	.03
No longer diabetes	.00	.01
Stroke *(ref. no change)*		
Had	.01	.01
Depression *(ref. no change)*		
Developed depression	.06	.05
No longer depression	.06	.05
Arthritis *(ref. no change)*		
Developed arthritis	.05	.06
No longer arthritis	.02	.01
Chronic lung disease *(ref. no change)*		
Developed chronic lung disease	.02	.02
No longer chronic lung disease	.01	.00
Cancer *(ref. no change)*		
Got cancer	.03	.03
No longer cancer	.00	.00

$*$: statistically significantly different at $p \leq .05$

Table 6: OLS, Individual Fixed Effects and Fixed Effects - Instrumental Variable Estimates of impact of volunteering (formal+informal) on individual cognitive health

	(1) OLS		(2) FE		(3) FE-IV	
Volunteering	0.0044*	(25.30)	0.0014*	(6.53)	0.013*	(2.14)
Business cycle at birth	-0.73*	(-3.16)	.	.		
Household income	0.00	(1.12)	-0.00	(-1.08)	-0.00	(-1.39)
Edu≥high school	2.10*	(38.39)	.	.		
Age in years *(reference '≤65 years')*						
65-69	-0.76*	(-10.42)	-0.76*	(-5.29)	-0.65*	(-4.79)
70-74	-1.50*	(-18.69)	-1.60*	(-10.55)	-1.39*	(-8.21)
75-79	-2.30*	(-25.99)	-2.57*	(-15.66)	-2.18*	(-8.98)
80-84	-3.42*	(-34.12)	-3.88*	(-21.34)	-3.25*	(-9.15)
85+	-5.04*	(-42.26)	-5.93*	(-28.52)	-5.04*	(-10.21)
Female	1.07*	(18.29)	.	.		
Race *(reference 'White')*						
Black	-2.94*	(-32.56)	.	.		
other	-1.93*	(-10.91)	.	.		
Retired	0.084	(1.59)	-0.16*	(-2.83)	-0.24*	(-3.89)
Religion very important	-0.25*	(-4.80)	0.030	(0.43)	-0.0067	(-0.11)
Smoking status *(reference 'Never smoked regularly')*						
Current smoker	-0.28*	(-3.12)	-2.00	(-0.94)	-1.23	(-0.73)
Past smoker	-0.030	(-0.51)	-2.31	(-1.08)	-1.56	(-0.92)
Drinks alcohol	0.85*	(17.04)	0.18*	(2.82)	0.12	(1.83)
BMI *(reference 'Underweight BMI<18.5 kg/m^2')*						
Normal (18.5-24.9 kg/m^2)	0.58*	(3.53)	0.72*	(3.36)	0.64*	(3.60)
Overweight (25-29.9 kg/m^2)	0.82*	(4.90)	0.99*	(4.38)	0.83*	(4.21)
Obese (≥30 kg/m^2)	0.96*	(5.64)	1.28*	(5.37)	1.10*	(5.17)
Have ADL limits.	-0.77*	(-11.92)	-0.53*	(-8.02)	-0.44*	(-5.73)
Have IADL limits.	-3.00*	(-31.62)	-1.43*	(-14.71)	-1.35*	(-15.00)
Have mobility limits.	-0.20*	(-4.15)	-0.17*	(-3.10)	-0.085	(-1.36)
Depression	-1.25*	(-19.78)	-0.19*	(-2.93)	-0.17*	(-3.10)
High blood pressure	-0.16*	(-2.95)	-0.35*	(-4.02)	-0.29*	(-3.65)
Stroke	-0.81*	(-7.90)	-1.07*	(-6.80)	-0.91*	(-6.25)
Arthritis	0.14*	(2.55)	0.086	(1.08)	0.076	(1.11)
Chronic lung disease	0.26*	(3.27)	0.069	(0.61)	0.18	(1.55)
Cancer	0.36*	(5.38)	-0.057	(-0.53)	0.14	(0.97)
Diabetes	-0.45*	(-6.94)	-0.045	(-0.46)	-0.029	(-0.33)
Heart ailment	0.047	(0.82)	-0.27*	(-3.29)	-0.20*	(-2.44)
Single	-0.22*	(-3.75)	-0.21*	(-2.40)	-0.31*	(-3.49)
Number children	-0.073*	(-5.73)	-0.049	(-1.40)	-0.059	(-1.91)
Constant	22.4*	(116.46)	25.0*	(19.81)		
N	64161		64161		55696	

t statistics in parentheses, * $p < 0.05$

NOTES:

(1) Additional controls, not shown, include dummies for missing values.

Table 7: Reduced form regression of cognitive health on instruments.

		(1) OLS, Reduced form
Spousal IADL limitations	-0.14	(-1.79)
Spousal ADL limitations	-0.16*	(-2.50)
Spousal mobility limitsations	-0.21*	(-4.80)
N	65576	

NOTES:

(1) t statistics in parentheses, * $p < 0.05$

(2) Additional controls include business cycle conditions at birth, income, education, age dummies, gender, race, retirement status, religious importance, drinking and smoking behavior, physical activity, BMI, social network, physical and mental health conditions and dummies for missing values.

Table 8: Individual Fixed Effects - Instrumental Variable Estimates of impact of volunteering (formal+informal) on individual cognitive health, preferred 3 IV (SIADL, SADL and SMOB) specification versus just identified models.

	(1) FE-IV, 3IVs†		(2) FE-IV, SIADL		(3) FE-IV, SADL		(4) FE-IV, SMOB	
Volunteering	0.013*	(2.14)	0.011	(1.40)	0.015	(1.93)	0.048	(1.81)
N	55696		55701		55699		55701	

NOTES:

(1) † Replicated from Table 6 above for ease of comparison

(2) t statistics in parentheses, * $p < 0.05$

(3) Additional controls include business cycle conditions at birth, income, education, age dummies, gender, race, retirement status, religious importance, drinking and smoking behavior, physical activity, BMI, social network, physical and mental health conditions and dummies for missing values.

Table 9: 2SLS and LIML models

	(1) 2SLS†		(2) LIML	
Volunteering	0.013*	(2.14)	0.015*	(2.07)
N	55696		55696	

NOTES:

(1) † Replicated from Table 6 above for ease of comparison

(2) t statistics in parentheses, * $p < 0.05$

(3) Additional controls include business cycle conditions at birth, income, education, age dummies, gender, race, retirement status, religious importance, drinking and smoking behavior, physical activity, BMI, social network, physical and mental health conditions and dummies for missing values.

Table 10: OLS, Individual Fixed Effects, Instrumental Variable and Individual Fixed Effects - Instrumental Variable Estimates of impact of total volunteering (formal+informal) and formal volunteering on individual cognitive health

	(1) OLS		(2) FE		(3) FE-IV	
Volunteering (formal+informal)†	0.0044*	(25.30)	0.0014*	(6.53)	0.013*	(2.14)
Volunteering (formal)	0.0059*	(22.81)	0.0017*	(5.15)	0.022*	(2.01)
N	64161		64161		55696	

NOTES:

(1) † Replicated from Table 5 above for ease of comparison

(2) t statistics in parentheses, * $p < 0.05$

(3) Additional controls include business cycle conditions at birth, income, education, age dummies, gender, race, retirement status, religious importance, drinking and smoking behavior, physical activity, BMI, social network, physical and mental health conditions and dummies for missing values.

Table 11: OLS and Individual Fixed Effects estimates of impact of volunteering (formal+informal) and other forms of engagement on individual cognitive health, CAMS data

	(1) OLS		(2) FE		(3) OLS Extended		(4) FE Extended	
Volunteering	0.0029*	(7.90)	0.0011	(1.66)	0.0026*	(7.36)	0.0011	(1.60)
TV watching					-0.0051	(-1.84)	-0.0013	(-0.27)
Reading					0.030*	(5.97)	0.0061	(0.75)
Sleeping					0.015*	(5.12)	-0.0014	(-0.33)
Phone/ letters/ emails					-0.0041	(-0.65)	0.0077	(0.82)
Computer use					0.039*	(8.56)	0.0038	(0.36)
Praying					-0.013*	(-2.29)	-0.00093	(-0.10)
Housework					-0.0058*	(-2.45)	0.0028	(0.68)
Money mgmt.					0.016*	(2.69)	0.0030	(0.59)
Playing cards/ puzzles					0.0090*	(3.51)	0.00040	(0.10)
N	9465		9465		9465		9465	

NOTES:

(1) t statistics in parentheses, * $p < 0.05$

(2) Additional controls include business cycle conditions at birth, income, education, age dummies, gender, race, retirement status, religious importance, drinking and smoking behavior, physical activity, BMI, social network, physical and mental health conditions and dummies for missing values.

Table 12: OLS, Individual Fixed Effects, Instrumental Variable and Individual Fixed Effects - Instrumental Variable Estimates of impact of volunteering (formal+informal) on individual cognitive health and cancer

	(1)		(2)		(3)		(4)		(5)		(6)	
	OLS		OLS		FE		FE		FE-IV		FE-IV	
	Cognition†		Cancer		Cognition†		Cancer		Cognition†		Cancer	
Volunteering	0.0044*	(25.25)	-0.000035	(-1.73)	0.0014*	(6.56)	-0.000074*	(-3.61)	0.013*	(2.14)	-0.00058	(-0.93)
N	64161		64132		64161		64132		55696		55667	

NOTES:

(1) † Regressions for impact of volunteering on cognitive health without controls for cancer.

(2) t statistics in parentheses, * $p < 0.05$

(3) Additional controls include business cycle conditions at birth, income, education, age dummies, gender, race, retirement status, religious importance, drinking and smoking behavior, BMI, social network, physical and mental health conditions and dummies for missing values.

5.3.4 Placebo test of the independent variable: Impact of vigourous exercising at least 3 times per week on cognitive health

In table 6 controlling for time varying unobserved heterogeneity using our FE-IV strategy led to a ten fold increase in our coefficient of the impact of volunteering on cognitive health. As mentioned above this is unusual but plausible. If our omitted variables are positively correlated to cognitive health, for instance time spent medidating or sleeping (Park et. al, 2014, LaMore et. al 2013, Wells et. al 2013 and Tamaki 2013), but take away time from volunteering our FE estimates would be biased downwards and instrumenting would result in higher estimates of the impact of volunteering on cognitive health. But it would still be useful to get a feel for how realistic is the magnitude of our FE-IV estimates. We do so by comparing the impact of volunteering with that of physical exercise, a known determinant of cognitive well-being (Bherer et. al and the references therein.), on our MMSE scores. Results are presented in Table 13. Comparing columns (4) and (6), we find that the impact of vigourous exercising 3 or more times a week on cognitive health is many fold larger than that of volunteering. This renders some credibility to the magnitude of the volunteering coefficient from the FE-IV model.

Table 13: OLS, Individual Fixed Effects and Individual Fixed Effects - Instrumental Variable Estimates of impact of volunteering (formal+informal) or vigourous exercising at least 3 times per week on individual cognitive health

	(1) OLS Vol.		(2) OLS Vig. Ex.		(3) FE Vol.		(4) FE Vig. Ex.		(5) FE-IV Vol.		(6) FE-IV Vig. Ex.	
Volunteering[†]	0.0044*	(25.30)			0.0014*	(6.53)			0.013*	(2.14)		
Vigourous ex. $\geq$3/wk			0.48*	(9.49)			0.41*	(7.08)			5.17*	(2.90)
N	64161		64097		64161		64097		55696		55636	

NOTES:

(1) † Replicated from Table 6 above for ease of comparison

(2) t statistics in parentheses, * $p < 0.05$

(3) Additional controls include business cycle conditions at birth, income, education, age dummies, gender, race, retirement status, religious importance, drinking and smoking behavior, BMI, social network, physical and mental health conditions and dummies for missing values.

5.3.5 Potential threats to identification: Measurement error in volunteering

Identification of the causal effect of volunteering on cognitive health may fail under certain conditions. For instance if there is consistent over reporting of volunteering activity by the cognitively impaired as a means to earn more socially desirability. Empirically this is a case of measurement error (ME) where $Vol^{Reported} = Vol^{Actual} + ME$. In the case where the cognitively impaired seek more social desirability they would consistently over report their volunteering i.e. ME≥0. We expect that the opportunity cost of actual volunteering levels Vol^{Actual}, would increase in presence of SIADL and SMOB thereby making our IVs take care of the endogeneity problem if Vol^{Actual} were accurately noted in the data. But it is unlikely that the measure error (ME) would be correlated with the IV, once again introducing endogeneity and may threaten identification of the causal effect of volunteering on cognitive health. But if the ME is constant across waves the fixed effects part of our FE-IV model would eliminate it from the model thereby leading to consistent estimates of the causal effect. However if the ME is time varying, it is safe to assume that higher the cognitive decline probably higher the misreporting and so higher the ME. That is, higher the cognitive decline higher the reported volunteering. But actually what we find is that higher levels of volunteering imply higher cognitive levels not lower. So our results in fact are the lower bound of the potential favorable impact of volunteering on cognitive health in presence of ME. In absence of ME our estimates could be even larger.

5.3.6 Potential threats to identification: Sample selection over time

Our result of a statistically significant positive association between volunteering and cognitive health could be biased if there is panel attrition due to worsening health and/or death of respondents. This would be particularly likely if the same cohort was followed over time. With increasing age individuals with the worst cognitive health would drop out of the panel. The remaining panel would likely be younger, with better cognitive health and probably higher volunteering participation resulting from better over all health. Not controlling for attrition would then result in a spurious significant positive relationship between volunteering and cognitive health.

We first investigate this descriptively by considering the pattern of mean age, volunteering partcipation and mini MMSE scores for cognition by HRS waves. Table 14 shows that the mean age of the sample is significantly different in each wave but the change is not monotonic over time. Even though each wave is approximately two years apart the mean age is not consistently increasing by about two years. This is in part due to the evolution of the sampling design of the HRS. The 1998 wave, the first used in this study, is cross-sectionally representative of the US population older than 50. Since then steady state has been maintained by adding a new six-year cohort every six years (Willis 1999). For instance, in 2004, a fresh screening sample of Early Boomers born in 1948-1953, who were between 51 to 56 years old then was added. This generated a random sample of younger cohorts in the subsequent waves of the HRS. This would explain the visibly larger sample size in 2004, which is also associated to a lower mean age and higher cognitive score in wave 4. But unlike mean age, it is worth mentioning that mean volunteering hours and cognitive scores are not statistically significantly different across the waves (refer Table 14).

Table 14: Age, hours of volunteering in past 12 months and cognitive score, by wave of HRS.

		Wave							
		1	2	3	4	5	6	7	
Year		1998	2000	2002	2004	2006	2008	2010	Total
Age	Mean	69.78	74.38	74.42	68.60	74.06	74.46	75.03	72.68
	S.E.	0.12	0.09	0.09	0.11	0.08	0.08	0.08	0.04
Hours of Vol. past 12 mths.	Mean	84.46	77.05	65.60	80.27	75.87	73.21	75.04	76.45
	S.E.	1.37	1.53	1.38	1.09	1.20	1.16	1.22	0.48
Cognitve score (0-35)	Mean	22.06	21.40	21.50	22.18	21.64	21.79	21.28	21.73
	S.E.	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.02
Total N		9409	7233	6978	12103	9652	9716	9075	64166

We more formally evaluate for potential attrition bias by weighting our observations in our preferred FE-IV model with the inverse of their estimated attrition probability. We follow the method proposed by Becketti, Gould, Lillard and Welch (1988) that gives more weight to observations who have same initial characteristics to those that attrit than to those with characteristics that make them more likely to remain in the panel[7] Results presented in

[7] Specifically we estimate the unrestricted probit model $A = x_{i1}\gamma + a_{i1}\delta + v_i$ where A is a dummy that takes

Table 15 show that regression estimates of impact of volunteering on cognitive health are qualitatively similar with or without attrition weights.

a value of 1 if the respondent is not in the panel for at least two waves. x_{i1} is a vector of auxiliary variables which can be related to both attrition and cognitive health and includes indicator for economic conditions at time of birth, age, dummy for retirement, smoking status, dummy for whether respondent consumes alcohol or not, controls for BMI and dummies for various health conditions. a_{i1} includes other controls like gender, race, education, income, and importance of religion. Next, we estimate a restricted version of the equation without the auxiliary variables, $A = x_{i1}\gamma + \varphi_i$. The ratio of the predicted probabilties from the restricted and the unrestricted model, $W_i = \frac{p^r}{p^u}$, gives the inverse probability weights.

Table 15: Linear regression of cognitive health - without and with attrition probabilties

	OLS				FE				FE-IV			
	(1)		(2)		(3)		(4)		(5)		(6)	
	w/o att. probs		with att. probs		w/o att. probs		w/o att. probs		w/o att. probs		w/o att. probs	
hlpvolhrs	0.0044*	(25.29)	0.0038*	(17.73)	0.0014*	(6.53)	0.0013*	(5.03)	0.013*	(2.14)	0.018*	(2.55)
N	64157		64157		64157		64157		55696		55696	

t statistics in parentheses

* $p < 0.05$

5.3.7 Accounting for missing values: dummy value approach versus multiple imputations

The sample used for all the analysis is restricted to include observations for whom our dependent variable of cognitive score and main explanatory variable, hours of volunteering, is non-missing. Almost all other controls in our regressions are coded as categorical variables. Consequently missing values, if any, are accounted for simply by an indicator which takes a value of one in case of a missing, 0 otherwise. This is the traditional method of coding missing values and helps retain observations that may be otherwise lost if they are missing, for instance, even just one explanatory variable value. More recently, multiple imputations to recode missing values has been proposed as a preferred method since it accounts for the possibility of non-random missing values. Also, each imputation can account for whether the variable is continous, categorical, ordered etc and use the appropriate imputation model. For instance, since individual ADL's range from 0-3 we used ordered probits to impute any missing values while logits were used to impute missings for whether an individual has diabetes or nto. We tested for the sensitivity of our results these alternative methods of recoding missing values. Results presented in Table 16 show that our results our robust to the alternative specifications.

Table 16: FE-IV impact of volunteering on cognitive health - dummies versus multiple imputation of missing values.

	(1)		(2)	
	Dummy for missing		Multiple imputation	
Volunteering	0.013*	(2.14)	0.014*	(2.25)
N	55696		53047	

t statistics in parentheses

* $p < 0.05$

6 Financial implications - Impact of volunteering on the monetary cost of dementia

Quantifying the monetary gains from volunteering is difficult since estimating the total cost of cognitive decline is itself challenging. Some cognitive decline is a natural aspect of aging. This may be associated with some memory loss and/ or quickness of reflexes, but otherwise would allow the individual to function normally in their day to day life. Once cognitive decline progresses further, where it begins to hinder the independent functioning of an individual associated costs begin to become quantifyable. Depending on the extent of cognitive decline, the individual may be classified as having Mild Cognitive Impairment (MCI) or worse dementia. MCI is the middle ground between normal aging and dementia. A person with MCI is often aware that they have lost memory, and tests can confirm some loss. But they may have mostly normal overall mental functioning and can carry out most normal activities of daily living. Although not all individuals with MCI progress to develop dementia, health care providers should routinely evaluate people who have memory loss, and those with MCI as they are at a much higher risk for dementia. MCI in itself or frequent monitoring of its progress may result in increased health care costs some of which may be met more informally by friends and family or within the bounds of routine health care provision for the elderly.

Dementia is a more severe form of cognitive decline and often involves decline in memory or other thinking skills severe enough to reduce a person's ability to perform everyday activities. Dementia is not a disease in itself but is infact a consequence of other conditions. Alzheimer's disease, for instance, accounts for 60-80% of cases. Vascular dementia, which occurs after a stroke, is the second most common dementia type. But there are many other conditions that can cause symptoms of dementia, including some that are reversible, such as thyroid problems and vitamin deficiencies. Just like the cause, symptoms of dementia can vary greatly. At least two core mental functions - memory, communication and language, ability to focus and pay attention, reasoning and judgment and visual perception - must be significantly impaired to be classified as having dementia. People with dementia may have problems with short-term memory, keeping track of a purse or wallet, paying bills, planning and preparing meals, remembering appointments or traveling out of the neighborhood. For these reasons individuals with dementia and related comorbidities require significant amount of caregiving - either provided by a family member or friend or purchased in the market place in the form of home health care or care in a nursing home setting. Furthermore, caregivers of dementia patients may also need some support as caring for patients with behavioral disorders may be particularly mentally and physically burdensome, especially as dementia progresses over time. 14.7% of persons ages 70 years and above were estimated to suffer from dementia in 2010. This proportion is expected to increase in the years to come as a result of the aging population.

The monetary cost of dementia, while still hard to pin down due to its large non-market component, has been recently carefully estimated by Hurd et. al, 2013. The HRS itself lacks a measure of dementia but a subset of 856 respondents from the HRS participated in the nationally representative Aging, Demographics and Memory Study (ADAMS) and underwent detailed in-home clinical assessment for dementia. The authors merged detailed health and socioeconomic information[8] for the ADAMS subsample from the HRS interviews from the prior waves. This information was then used to estimate a probability model in order to pin down the significant predictors of dementia using the ADAMS sample. The monetary cost of dementia was estimated as the sum of formal market purchased care for dementia patients and a valuation of the informal (unpaid) care provided by friends and family. The value of the market purchased care could be formally defined and estimated using self reported out-of-pocket spending, nursing home care and Medicare claims associated to dementia. Valuation of the informal component of care however varied greatly by the method of imputation - cost of equivalent formal paid care or the estimated wages forgone by informal caregivers. Depending on the method used to evaluate the informal cost of caregiving to dementia patients the total (formal+informal) monetary cost of dementia in 2010 was estimated to be between $157-$215 billion. Medicare paid about $11 billion of this cost.

We extend Hurd et. al's (2013) probability model[9] for predicting dementia by including

[8] Age, educational level, sex, ADL limitations, IADL limitations and cognitive scores

[9] An ordered probit is estimated with three potential outcomes- normal, cognitive impairment but not dementia (CIND) and demented. Please refer to the Supplementary Appendix of Hurd. et al (2013) available

volunteering as an additional predictor of dementia. This is a logical extension since our estimates show that volunteering has a significant impact on individual cognitive well being and dementia can be viewed as an extreme negative case of cognitive decline. Out of the 285 cases ADAMS clinically classified as demented the probability model of Hurd et. al (2013) correctly classified 222 as demented as well for a sensitivity of 77.9%. Using all 856 ADAMS respondents our re-estimated the Hurd et. al model and correctly classified 237 out of 308 clinical cases of dementia for a slightly lower sensitivity of 76.9%. Of the 541 cases with the clinical ADAMS classification of non-demented, Hurd et. al (2013) correctly identify 486 as non-demented for a specificity of 89.8%. Our re-estimation provided a similarly high level of specificity of 88.9% by correctly classifying 487 out of 548 non-demented cases. This exercise assures us that our replication of the Hurd et. al (2013) estimations is reasonably accurate.

Next, we extend the model to include an additional predictor of dementia status - volunteering participation. A simple likelihood ratio test to compare the smaller Hurd et. al (2013) model with our extended model that includes volunteering as a predictor of dementia status we get a test statistic of 9.36. With a $\chi^2(1)$ critical value of 6.64 we reject the null that the smaller model is better at the 1% level of significance.

The extended model predicts 14 fewer cases, i.e. a 5.9% decline in the predicted incidence of dementia. Equating this to an equal reduction in monetary costs of caring for patients with dementia, volunteering is associated to cost savings roughly between 9.26-15.16 billion in 2010 dollars. This is probably a lower bound of the savings and monetary gains associated to volunteering as it does not account for health care savings for CIND patients and also does not take into account the monetary value of the positive externalities that volunteers will generate.

7 Conclusion

This is the first study, to the best of our knowledge, that attempts to pin down the causal relationship between volunteering and cognitive health. In so doing we make a significant

at NEJM.org for details of the method of estimation of dementia status.

contribution to existing literature on cognitive aging. We use seven waves of the nationally representative sample of Americans over the age of 50 from the Health and Retirement Study (HRS), covering an observation window from 1998-2010 to estimate the impact of volunteering participation on cognitive health. We implement a fixed effects-instrumental variable (FE-IV) methodology that aims to control for time constant and time varying unobserved heterogeneity, thereby producing results that suffer from significantly less bias[10] than previously estimated OLS estimates. In doing so, our results suggest even after controlling for significant selection on unobservables and observables into volunteering, there is a significant favorable effect of volunteering on cognitive health that be interpretted causally.

Several sensitivity tests are conducted. The first set of sensitivity tests are done to test the extent of any remaining bias in our FE-IV estimates. Median unbiased just-identified models, reduced form regressions as well as limited information maximum likelihood (LIML) all speak to the robustness of our FE-IV estimates. These tests suggest that our identification strategy is robust and the bias, if any, in our FE-IV estimates of the protective effect of volunteering on the volunteer's cognitive health is limited.

A second battery of tests is undertaken to test for the sensitivity of our results to alternative specifications of variables and additional controls. Our results are qualitatively robust to the definition of volunteering - formal or formal and informal. Volunteering also continues to be a significant determinant of cognitive health even after controlling for other activities involving social and mental engagment. Moreover, a 'placebo' test that estimates the impact of volunteering, instrumented with spousal health limitations, on cancer helps rule out a spurious relationship between volunteering and cognitive well being. Our fixed effect-instrumental variable (FE-IV) estimates show that our IV, spousal activilty and mobility limitations significantly impacts volunteering participation which in turn significantly determines cognitive health of the individual. On the other hand, our FE-IV estimates find the expected insignificant causal effect of volunteering on cancer. Further tests, show that the magnitude of the causal effect of volunteering on cognitive health seems plausible. Results are additionally robust to potential measurement error, attrition over time and method of

[10]FE-IV estimates have 10% maximal bias in IV relative to OLS

accounting for missing values.

The study has clear policy implications. Cognitive decline is a natural aspect of aging, and in 2010 cognitive loss, along with its comorbidities of dementia and Alzheimers disease, affected 14.7% of the US population above age 70. Incidence of patients with varying degrees of cognitive loss is likely to rapidly increase with the aging of the baby-boomers. Evaluating the monetary cost of cognitive impairment is challenging as the severity of cognitive decline can vary considerably. Progressively large cognitive impairment would imply rapidly increasing health care needs. Hurd et. al (2013) estimate the monetary cost of dementia, which is an extreme form of cognitive impairment, to be between \$157- \$215 billion in 2010 dollars.

Our results show that volunteering could be one factor that could slow down declining cognitive health amongst the elderly. Extending the model proposed by Hurd et. al (2013) we estimate a probability model predicting dementia status with volunteering participation as an additional independent variable. Our estimation reveal a 5.9% decline in the number of predicted cases of dementia which would translate roughly into saving worth 9.26-15.16 billion in 2010 dollars. It is important to note that these estimates are likely to be the lower bound of the financial gains from volunteering. Firstly, these simple estimations do not account for any health care cost savings associated with caring for individuals with Cognitive Decline but Not Dementia (CIND). People with CIND are at much higher risk of dementia and have to be frequently evaluated by a health care provider. Also CIND individuals are likely to be utilizing some amount of care, probably informal and occasional, which remains completely unaccounted for. In addition to health care cost savings and personal welfare gains associated to improved cognitive health due to volunteering, our study does not account for the value of the positive externalities generated by volunteers. Depending on the nature of the volunteering services provided, for instance free tutoring to disadvantaged students by highly educated retirees or volunteering at a soup kitchen, value generated by the volunteers could potentially be very large. Since, our data does not provide any information on the nature of their volunteering work an evaluation of the positive externalities generated by volunteers is beyond the scope of the current study and is left to future work.

The result that volunteering continues to be protective of cognitive health even after controlling for other socially and mentally engaging activities, makes one wonder why volunteering is special in its impact on cognitive health, compared to other activities of engagment. Firstly, volunteering could be unique in its ability to provide mental, physical and social stimulation simultaneously. Other activities may provide one or maximum two of these favorable outcomes but not all. Secondly, many volunteering opportunities may expose the volunteer to individuals who are significantly more disadvantaged than themselves. Realization of ones relative advantage may provide the volunteer with an improved sense of well being which may translate into better cognitive health[11].Thirdly, helping others may give a purpose of life to volunteers. This is particularly true in case of retirees. A purposeful life may provide the volunteer with greater focus and a sense of personal worth, both of which could be mental health and cognition improving. Pinning down the mechanism underlying the significant positive impact of volunteering on cognitive health would require data on motivation for volunteering and the nature of volunteering activities that the volunteers are engaging in. In absense of this data we are unable to comment any further on the mechanism underlying the protective effect of volunteering on cognitive health.

Like any research study, the current work also has its limitations. Despite a careful attempt at checking the validity of our instruments and the robustness of our results some bias may still remain in our estimates. Consequently, we can only claim to have probably come 'closer' to the true effect of volunteering on cognitve effect and at least some of it is causal. Secondly, our estimates of the cost savings in dementia care from volunteering are at best lower bounds of the huge potential monetary gains that volunteering may generate. More accurate measures of monetary gains from volunteering, inclusive of cost savings associated to health care provision for CIND patients and positive externalities generated by volunteering service, would be needed to gauge how actively volunteering should be promoted as a public health measure. Third, more work needs to be undertaken to pin down the mechanism underlying the favorable impact of volunteering on cognitive health.

[11]Depression has been linked to cognitive decline. Realizing that there are others in the world in worse situations than ourselves may make volunteers more appreciative of what they have generating a feeling of wellbeing that may result in slowing down cognitive decline

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