**DEMENTIA AND COGNITIVE DECLINE IN OLDER ADULTHOOD: ARE AGRICULTURAL WORKERS AT GREATER RISK?**

* **Coding of *AFF worker***
* **Appendix Tables:**

**Table A1. Results of logistic regression with proxy sample**

**Table A2. Mediation analyses: formal test of indirect effect**

**Table A3. Accounting for selective mortality**

**Coding long-term exposure to agricultural work (*AFF worker*)**

This data was taken from the RAND HRS file. For occupation codes, the RAND documentation states: “Before Wave 7, the occupation codes are based on 1980 Census occupations, assigned to one of 17 categories. From Wave 7-10, they are based on 2000 Census occupations, assigned to one of 24 categories. Beginning in Wave 10, they are based on 2010 Census occupations, assigned to one of 23 categories.” Similarly, for industry codes, the RAND documentation states: “Before Wave 7, the industry codes are based on those used in the 1980 Census, assigned to one of 13 categories. From Wave 7-9, they are based on 2002 Census industries, assigned to one of 19 categories. From Wave 10 forward, they are based on 2007 Census industries, also assigned to one of 19 categories.”

**AFF worker coding:**

Longest Job - Occupation Code:

For HRS waves 4 (1998) to 6 (2002), we code longest held job based on the 1980 Census which comprises 17 occupational categories. Category most relevant for *AFF worker* coding: **“**10. Farming/ forestry/fishing.”

For HRS waves 7 (2004) to 9 (2008), we code longest held job based on the 2000 Census which comprises 24 occupational categories. Category most relevant for *AFF worker* coding: “19. Farm/Fish/Forestry.”

For HRS waves 10 (2010) to 12 (2014), we code longest held job based on 2010 Census which comprises 23 categories. Category most relevant for *AFF worker* coding: “18. Farming/Fishing/Forestry.”

Longest Job - Industry Code

For HRS waves 4 (1998) to 6 (2002), we code longest held job based on 1980 Census which comprises 13 industrial categories. Category most relevant for *AFF worker* coding: “01. Agric/Forest/Fish.”

For HRS waves 7 (2004) to 9 (2008), we code longest held job based on 2002 Census which comprises 19 industrial categories. Category most relevant for *AFF worker* coding: “01. Agric/Forest/Fish/Hunting.”

For HRS waves 10 (2010) to 12 (2014), we code longest held job based on 2007 Census which comprises 19 industrial categories. Category most relevant for *AFF worker* coding: “01. Agric/Forest/Fish/Hunting.”

**Table A1. Results of logistic regression with proxy sample a**

|  |  |
| --- | --- |
|  | **Odds Ratio [95% CI]** |
| AFF workers | 1.276\* [1.006,1.617] |
| Age | 1.129\*\*\* [1.121,1.137] |
| Female | 0.789\*\*\* [0.706,0.882] |
| *Race: White as reference and Ethnicity* | |
| Black | 1.589\*\*\*[1.376,1.835] |
| Other race | 1.284 [0.977,1.687] |
| Hispanic | 1.005 [0.802,1.260] |
| *Region of birth: New England as reference* | |
| Mid Atlantic | 0.855 [0.638,1.146] |
| EN Central | 0.930 [0.673,1.285] |
| WN Central | 1.112 [0.792,1.562] |
| S Atlantic | 1.580\*\* [1.164,2.143] |
| ES Central | 1.572\*\* [1.139,2.169] |
| WS Central | 1.466\* [1.064,2.020] |
| Mountain | 1.383 [0.926,2.065] |
| Pacific | 1.267 [0.871,1.841] |
| NS/NA Division | 0.731 [0.227,2.351] |
| Not U.S. | 1.161 [0.828,1.629] |
| Father education | 0.962\* [0.925,0.999] |
| Mother education | 1.028 [0.992,1.066] |
| *Family SES: Pretty well off as reference* | |
| About average | 1.014 [0.789,1.305] |
| Poor | 0.920 [0.710,1.191] |
| *Marital status: Married/ together as reference* | |
| Div/ separated | 1.003 [0.861,1.169] |
| Widowed | 1.070 [0.949,1.207] |
| Never married | 1.102 [0.840,1.446] |
| *Years of education: <12 yrs as reference* | |
| 12 years | 0.441\*\*\* [0.390,0.497] |
| 13-15 years | 0.405\*\*\* [0.344,0.477] |
| >= 16 years | 0.334\*\*\* [0.279,0.401] |
| *Non housing wealth: quartile 1 as reference* | |
| Quartile 2 | 0.455\*\*\* [0.411,0.503] |
| Quartile 3 | 0.340\*\*\* [0.299,0.386] |
| Quartile 4 | 0.253\*\*\* [0.214,0.298] |
| *Residence census reg: Northeast as reference* | |
| Midwest | 1.004 [0.809,1.246] |
| South | 0.981 [0.816,1.178] |
| West | 0.975 [0.780,1.220] |
| *Rural/ urban: Urban as reference* | |
| Suburban | 1.017 [0.900,1.149] |
| Rural | 1.135\* [1.003,1.284] |
| Wave dummies | ✓ |
| ***N*** | **66,620** |

*Notes*. a We used Langa-Weir classification of cognitive function for proxy respondents. Documentation is available in HRS website (Langa, K. M. ,2018; https://hrs.isr.umich.edu/news/langa-weir-classification-cognitive-function). In 1998, proxy assessment of respondent’s cognitive function is assessed using a 9-point scale, which includes: proxy assessment of respondent memory (0 to 4 points) and respondent’s IADL limitations (0 to 5 points). An 11-point scale is used for 2000 onwards, which includes proxy assessment of memory (0 to 4 points), IADL limitations (0 to 5 points), and the interviewer assessment of cognitive impairment (0 to 2 points). In 1998, respondents whose proxies score between 5 to 9 on the 9-point scale are classified as having dementia, 3-4 as having CIND, and 0-2 as normal. From 2000 onwards, respondents whose proxies scored from 6 to 11 on the 11-point scale are classified as having dementia, 3-5 as having CIND, and 0-2 as normal. Robust standard errors were clustered at individual level. \* *p*<0.05, \*\**p*<0.01, \*\*\* *p*<0.001.

**Table A2: Mediation analyses: formal test of indirect effect**

The results provided here supplement the mediation analyses results documented in Table 2. Because different mediator variables have different missing values, as a sensitivity check, we re-estimate the reduced and full models on comparable samples. We also test the statistical significance of the indirect effect (computed as the difference between *AFF worker* coefficients in reduced and full models). This was done using the -*khb*- command in Stata (Kohler and Karlson, 2010). This method derives standard errors for the difference in effects using the delta method (Sobel, 1982). The models below control for all covariates in the original regressions in Table 2.

|  |  |  |  |
| --- | --- | --- | --- |
| **Mediators (*sample size for reduced and full models*)** | ***OLS Coefficients (robust standard errors clustered at the individual level)*** | | **Indirect**  **Effect** |
| **Reduced model** | **Full model** |
| Hearing impairment  *(N= 61,698)* | -0.414  (0.164) | -0.393  (0.165) | -0.021 (0.041) |
| CES-D score  *(N= 61,476)* | -0.388  (0.162) | -0.393  (0.162) | 0.005  (0.069) |
| Physical health  *(N= 61,441)* | -0.399  (0.155) | -0.396  (0.155) | -0.003  (0.110) |

**Table A3: Accounting for selective mortality**

Respondents with lower cognitive scores, in this case AFF workers, are likely to experience higher mortality. AFF workers who survive may have less than expected cognitive decline. This selective attrition may lead us to underestimate the association between agricultural work exposure and cognitive decline as observed cognitive functioning trajectories for AFF workers are likely to be upward biased because AFF workers with poor cognition died. We see evidence of selective attrition in our sample. Mortality rates among AFF and non-AFF (unique) respondents were 43% and 34% respectively. During the study period, the average cognition score among AFF workers who died was 11.34 relative to 13.66 among AFF workers who survived.

To account for the effect of selective mortality, we follow Hale et al (2020) and estimate a joint model that simultaneously estimates the parameters of a linear mixed model for the continuous measure of cognitive function and the parameters of a proportional hazards model for mortality. The shared random effects link the two components of the joint model. In the longitudinal model of cognitive function scores, the shared random effects allow for individually heterogeneous intercepts and age slopes, and in the survival model, they raise or lower the log-hazard of death, thereby controlling for differential mortality of subjects in the sample (Hale et al., 2020). To carry out this joint model in Stata, we use the add-on command, *stjm* (Crowther et al., 2013).

The results of the joint model using *stjm* are presented in Table A3 below. We set the data as “time-span” data and thus, cannot utilize the last score observation (wave 12). In Table A3, we present the results of our original mixed model with all covariates (model 3 in Table 4) in column 1, followed by results from the mixed model after excluding wave 12 observations (column 2). Finally, in column 3, we present the results of the joint model computed using *stjm*. In the joint model, the coefficient on *AFF worker* is smaller in magnitude but continues to be negative and statistically significant. Similarly, the coefficient on the interaction term between *AFF worker* and age (capturing whether the effect of being an AFF worker on cognitive functioning varies by age) remains positive and statistically significant. The consistent, statistically significant, and positive coefficient on the interaction term across all three models implies that our findings are robust and not biased by selective mortality.

**Table A3. Comparing mixed models with joint regression models of cognitive score**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Model 1**  **Mixed model** |  | **Model 2**  **Mixed model without wave 12** |  | **Model 3**  **Joint model** |  |
| **Fixed Effects** |  |  |  |  |  |  |
| Intercept | 13.11 (0.23) | \*\*\* | 13.12 (0.23) | \*\*\* | 13.34 (0.20) | \*\*\* |
| Linear slope (Centered age) | -0.13 (0.01) | \*\*\* | -0.13 (0.01) | \*\*\* | -0.17 (0.01) | \*\*\* |
| AFF workers | -0.92 (0.21) | \*\*\* | -0.91 (0.21) | \*\*\* | -0.73 (0.22) | \*\*\* |
| Centered age cube | -0.0002 (0.00) | \*\*\* | -0.0002 (0.00) | \*\*\* | -0.0002 (0.00) | \*\*\* |
| AFF worker \* Centered ag | 0.06 (0.02) | \*\*\* | 0.06 (0.02) | \*\* | 0.05 (0.02) | \* |
|  |  |  |  |  |  |  |
| Female | 0.97 (0.06) | \*\*\* | 0.94 (0.06) | \*\*\* | 1.11 (0.06) | \*\*\* |
| *Race: White as reference* | | | | | |  |
| Black | -2.19 (0.09) | \*\*\* | -2.17 (0.09) | \*\*\* | -2.20 (0.09) | \*\*\* |
| Others | -1.01 (0.15) | \*\*\* | -1.04 (0.16) | \*\*\* | -1.12 (0.16) | \*\*\* |
| Hispanic | -0.79 (0.12) | \*\*\* | -0.82 (0.12) | \*\*\* | -0.79 (0.13) | \*\*\* |
| *Marital status: Married/ together as reference* | | | | | |  |
| Divorced/ separated | 0.07 (0.07) |  | 0.14 (0.07) |  | 0.06 (0.08) |  |
| Widowed | 0.07 (0.05) |  | 0.10 (0.05) | \* | 0.08 (0.05) |  |
| Never married | -0.23 (0.14) |  | -0.19 (0.14) |  | -0.19 (0.14) |  |
| *Years of education: <12 yrs as reference* | | | | | |  |
| 12 years | 2.11 (0.07) | \*\*\* | 2.10 (0.07) | \*\*\* | 2.20 (0.08) | \*\*\* |
| 13-15 years | 2.87 (0.08) | \*\*\* | 2.85 (0.09) | \*\*\* | 2.94 (0.09) | \*\*\* |
| >=16 years | 3.88 (0.09) | \*\*\* | 3.83 (0.09) | \*\*\* | 4.02 (0.09) | \*\*\* |
| *Non housing wealth: quartile 1 as reference* | | | | | |  |
| Quartile 2 | 0.46 (0.04) | \*\*\* | 0.48 (0.05) | \*\*\* | 0.51 (0.05) | \*\*\* |
| Quartile 3 | 0.72 (0.05) | \*\*\* | 0.74 (0.05) | \*\*\* | 0.81 (0.06) | \*\*\* |
| Quartile 4 | 1.03 (0.06) | \*\*\* | 1.06 (0.06) | \*\*\* | 1.14 (0.07) | \*\*\* |
| Years of education: father | 0.02 (0.02) |  | 0.02 (0.02) |  | 0.02 (0.02) |  |
| Years of education: mother | -0.01 (0.02) |  | -0.02 (0.02) |  | -0.02 (0.02) |  |
| *Family SES: Pretty well off as reference* | | | | | |  |
| Above average SES | 0.01 (0.12) |  | 0.001 (0.12) |  | 0.10 (0.12) |  |
| Poor SES | 0.06 (0.12) |  | 0.06 (0.12) |  | 0.18 (0.13) |  |
| *Region of birth: New England as reference* | | | | | |  |
| Mid Atlantic | 0.47 (0.14) | \*\* | 0.48 (0.14) | \*\*\* | 0.47 (0.15) | \*\* |
| EN Central | 0.16 (0.15) |  | 0.17 (0.16) |  | 0.20 (0.16) |  |
| WN Central | 0.09 (0.16) |  | 0.07 (0.16) |  | 0.15 (0.17) |  |
| S Atlantic | -0.38 (0.15) | \* | -0.39 (0.16) | \* | -0.40 (0.16) | \* |
| ES Central | -0.31 (0.16) |  | -0.35 (0.17) | \* | -0.33 (0.17) |  |
| WS Central | -0.35 (0.16) | \* | -0.38 (0.16) | \* | -0.36 (0.17) | \* |
| Mountain | -0.17 (0.20) |  | -0.24 (0.21) |  | -0.15 (0.21) |  |
| Pacific | -0.14 (0.18) |  | -0.13 (0.19) |  | -0.10 (0.19) |  |
| NS/NA Division | -0.01 (0.72) |  | -0.07 (0.72) |  | 0.13 (0.74) |  |
| Not U.S. | -0.19 (0.16) |  | -0.18 (0.17) |  | -0.07 (0.17) |  |
| *Residence census reg: Northeast as reference* | | | | | |  |
| Midwest | -0.03 (0.11) |  | -0.03 (0.11) |  | -0.03 (0.11) |  |
| South | 0.08 (0.09) |  | 0.09 (0.09) |  | 0.06 (0.09) |  |
| West | 0.18 (0.11) |  | 0.19 (0.11) |  | 0.18 (0.12) |  |
| Other | 1.40 (3.68) |  |  |  |  |  |
| *Rural/urban status: Urban as reference* | | | | | |  |
| Suburban | -0.04 (0.05) |  | -0.03 (0.06) |  | -0.02 (0.06) |  |
| Rural | -0.25 (0.06) | \*\*\* | -0.26 (0.06) | \*\*\* | -0.27 (0.06) | \*\*\* |
| No. of appearances | 0.12 (0.02) | \*\*\* | 0.13 (0.02) | \*\*\* |  |  |
| Died | -0.86 (0.08) | \*\*\* | -0.87 (0.08) | \*\*\* |  |  |
| Wave dummies | ✓ |  | ✓ |  | ✓ |  |
| ***N*** | **61,735** |  | **54,683** |  | **53,180** |  |

***Notes.*** Standard errors in parentheses. \* *p*<0.05, \*\**p*<0.01, \*\*\* *p*<0.001.

**References**

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