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How much do depressive symptoms affect cognition at the population level? The Monongahela-Youghiogheny Healthy Aging Team (MYHAT) study

Mary Ganguli, MD, MPH[1,2,4], **Beth Snitz, PhD**[2], **Joni Vander Bilt, MPH**[1], and **Chung-Chou H. Chang, PhD**[3,5]

[1] Department of Psychiatry, University of Pittsburgh School of Medicine

[2] Department of Neurology, University of Pittsburgh School of Medicine

[3] Department of Medicine, University of Pittsburgh School of Medicine

[4] Department of Epidemiology, University of Pittsburgh Graduate School of Public Health

[5] Department of Biostatistics, University of Pittsburgh Graduate School of Public Health

Abstract

Objective—To examine the impact of subjective depressive symptoms on objective performance on tests of several cognitive domains, in a community-based sample of older adults.

Methods—An age-stratified sample of 2036 individuals aged 65+ years was drawn from the electoral rolls of a U.S. community, excluding individuals with moderate to severe cognitive impairment. A cognitive test battery and a modified Center for Epidemiologic Studies-Depression scale (mCES-D) were completed by 1982 participants. Cognitive test scores were compared across levels of depressive symptoms, and composite scores created to represent cognitive domains of attention, language, memory, visuospatial, and executive function. Multivariable regression models tested the association of depressive symptoms with cognitive domain composite scores, adjusting for age, sex, race, and education.

Results—Most participants reported no depressive symptoms. Small differences in cognitive scores were observed on all tests among those with 0, 1–2, and >=3 symptoms. Adjusting for demographic variables, depressive symptoms remained associated with lower performance on all cognitive composites except attention, most strongly with executive function. Depressive symptoms explained < 2 % of the variance in test scores, less than that explained by age or education.

Conclusion—In this population-based sample of older adults, restricted to those with normal or only mildly impaired cognition, a relatively small proportion reported any depressive symptoms. The number of depressive symptoms had strong statistically significant associations with performance in most cognitive domains. However, depressive symptoms explained little of the variance in cognitive performance, with relatively small differences in scores among those with and without symptoms.

Keywords

epidemiology; community; effect size

Address correspondence to Dr. Mary Ganguli, Western Psychiatric Institute and Clinic, 3811 O'Hara Street, Pittsburgh, PA 15213, USA. Phone: 412-647-6516; FAX 412-647-6555; gangulim@upmc.edu.

INTRODUCTION

The relationship between depression and concurrent cognitive function is now indisputable. Most studies have found depressive symptoms or disorders to be associated with poor cognitive test performance (Nebes *et al.*, 2000; Sheline *et al.*, 2006; Butters *et al.*, 2004; Bhalla *et al.*, 2006; Ganguli *et al.*, 2006). Depression should be actively recognized and appropriately treated because it is a significant source of morbidity and mortality in its own right. However, the magnitude of its independent impact on cognition should be examined more closely. If the effect is large, clinicians examining patients who are both depressed and cognitively impaired should be prepared to attribute a substantial degree of the impairment to depression. From a research perspective, an additional question is whether depression should be adjusted for in studies of cognition in later life, and whether depressed individuals should even be excluded from such studies.

In a large, new, population-based study cohort of older adults, we set out to examine the associations of depressive symptoms with performance on tests of specific cognitive domains. We looked at differences in absolute test scores, the strengths of the associations of depression with the different domains, and the proportion of variance explained by depression, among groups with greater and lesser levels of depressive symptoms.

METHODS

Study area

The small-town area selected for the study is in Allegheny County of Southwestern Pennsylvania, surrounding the confluence of the Monongahela and Youghiogheny rivers, south of the city of Pittsburgh. The study cohort was therefore named the Monongahela-Youghiogheny Healthy Aging Team (MYHAT). The steel industry was formerly the mainstay of the region's economy, which has remained depressed since that industry collapsed in the late 1970s. The older population of the area is stable, with low rates of in- and out-migration.

Sampling

The electoral rolls are considered comprehensive and have the added advantage of being publicly available. The 2004 voter registration list was obtained from the county elections office and used as the frame for an age-stratified random sample for recruitment beginning in 2006. An independently verified voter registration list and a commercial mailing list were also purchased; the three lists were merged and obvious duplicates and errors eliminated. Sampling ratios were derived to accrue a cohort of approximately 2,000 individuals with approximately equal numbers in the age-intervals 65–74, 75–84, and 85+ years. Given the relatively small number of individuals aged 85+, the decision was made to further oversample those who were aged 80–84 and would be expected to age into the 85+ group during the early years of their participation. For each town in the selected area, the voter-registration list was examined and checked against local telephone and real-estate listings, post-office/zip code listings, and obituaries to clean and update the information.

Outreach and recruitment

Community outreach and recruitment procedures were approved by the University of Pittsburgh Institutional Review Board and carried out as follows. First, a press release was prepared and distributed to the local newspapers, some of which carried the story. Speaking engagements were arranged with different community groups. The project coordinator made appointments to meet with the mayor, police chief, and other municipal officials of each selected town, to explain the study and obtain the support and approval of community

leaders. Then, a letter was mailed to each selected individual, enclosing a copy of the newspaper article, informing him/her that he/she had been randomly selected to participate in the study. The letter provided a toll-free telephone number for the individual to call if he/she did not wish to be contacted. After a period of two weeks, those who had not called the toll-free number were contacted by telephone. They were offered a brief explanation of the study over the phone or an appointment at which the study could be explained in a face-to-face interview. At the interview, the study was explained in detail. If the individual was eligible and willing, a trained interviewer obtained written informed consent was obtained from the participant.

When an individual could not be contacted by telephone (e.g. no telephone number listed, number disconnected or changed, no answer), the interviewer went to the listed address and delivered a flyer indicating that he/she had stopped by in an effort to contact. On these occasions, sometimes interviewers met the selected individual in person and were able to schedule an appointment; sometimes they met a neighbor or other individual who was able to provide information, e.g., that the individual had relocated or died. In some towns, municipal officers (e.g. tax collectors) volunteered to examine the list and identify individuals who had died or relocated). However, some individuals remained untraceable despite all efforts.

Recruitment criteria were (a) age 65 years or older, (b) living within the selected area, (c) not already in a long-term care institution. Individuals were considered ineligible if they (d) were too ill to participate, (e) had severe vision impairment, (f) had severe hearing impairment, (g) were decisionally incapacitated.

Assessment (overview)

A single-stage assessment was employed so as to avoid both delays and potentially non-random attrition between screening and definitive assessment stages (Prince, 2000). The participant was first asked for basic demographic information and self-report of memory functioning. Blood pressure was measured and written down for the participant's own records. The Mini-Mental State Examination (MMSE) (Folstein *et al.*, 1975) was administered and scored on the spot, applying a standard correction for age and education (Mungas *et al.*, 1996). Those scoring <21/30 (age-education corrected) were classified as having moderate to severe cognitive impairment and therefore not a target for the MYHAT study. To these individuals, information about locally available services and resources for memory problems was provided upon request. They were given the promised cash incentive payment, and their interviews were terminated with no further assessment or follow-up offered. These truncated interviews were designated as "short assessments."

The remainder of participants, who scored >=21 on the age-education corrected MMSE, proceeded to the "full assessment." In 93% of participants this assessment took place in a single session; however, if participants appeared fatigued, the assessment was split up over two sessions an average of 14 days apart.

The assessment included several components. This report is focused on the neuropsychological assessment and the screening questionnaire for depressive symptoms.

Neuropsychological assessment

Cognitive functioning was assessed by the following test battery, categorized here according to the principal cognitive domain tapped by that test.

Attention—Trailmaking Test A (Reitan, 1958), Digit Span Forward (Wechsler, 1987)

Executive Function—Trailmaking Test B (Reitan, 1958), Clock Drawing (Freedman *et al.*, 1994), Verbal Fluency for initial letters P&S (Benton and Hamsher, 1976)

Language—Boston Naming Test (Kaplan *et al.*, 2001), Verbal fluency for categories (animals) (Benton and Hamsher, 1976), Indiana University Token Test (Unverzagt *et al.*, 1999).

Memory—WMS-R Logical Memory (immediate and delayed recall) (Wechsler, 1987), WMS-R Visual Reproduction (immediate and delayed recall (Wechsler, 1987), Fuld Object Memory Test with Semantic Interference (Loewenstein *et al.*, 2003).

Visuospatial Function—WAIS-III-Block Design (Wechsler, 1997)

Depression symptom assessment

The modified Center for Epidemiologic Studies-Depression scale (mCES-D) (Ganguli *et al.*, 1995; Radloff, 1977) consists of 20 symptoms of depression which the participant rates as having been present (scored as 1) or absent (scored as 0) over most of the preceding week. The maximum possible score is 20.

Statistical Methods

Cognitive composites—Because multiple cognitive tests were administered, they were grouped together to create a composite score for each cognitive domain listed above. Each test score was first transformed into a standardized score by centering to its mean value and divided by its standard deviation. The arithmetic mean of the corresponding standardized scores for each domain was then calculated as the final composite score for that domain, except for the visuospatial domain which is comprised of a single test (Block Design).

Depression symptom scores—Given the skewed distribution of scores on the self-reported depression symptom scale, the scale was categorized at the 50^{th}%ile and 90^{th} % ile scores into three groups representing those with scores of 0, 1–2, and >=3.

Descriptive statistics and univariable models—Distributions of the test scores were assessed by the mean and standard deviation (SD) for each of the three depressive symptom groups. The Cuzick test for trend was applied (Cuzick 1985). Simple linear regression models were fit to assess the relationship between each cognitive domain and each covariate of interest. The covariates of interest were age (categorized as 65–74, 75–84, and ≥85 years old), gender, education (categorized as <, =, and >high school education), race (White and Non-White) and the groups of depressive symptoms (categorized into 3 groups with mCES-D scores =0, 1–2, and ≥3).

Multivariable models—Multiple linear regression models were fit to assess the effect of each covariate on each cognitive domain adjusting for other covariates.

RESULTS

Recruitment

Over the approximately two-year recruitment period, a total of 19,226 recruiting letters were mailed out; 7289 individuals (37.9%) refused to participate. A small proportion(0.7%) of those on the list were found to be less than 65 years old; 13.0% were deceased; 2.8% had relocated from the study area; 0.6% were in long-term-care institutions; 23.3% were untraceable, 8.7% were believed to be at the listed address but not able to be contacted. A further 1.6% were too ill to participate, 0.2% had severe visual or hearing impairment, and

0.5% were considered decisionally incapacitated and unable to provide informed consent. Two individuals did not speak English, and six listings were found to be duplicates. The final recruited cohort comprised 2036 individuals, of whom 54 were classified as having moderate to severe cognitive impairment and underwent the short assessments. This report is based on the remaining 1982 individuals who underwent part or all of the full assessment.

Cohort characteristics

As noted, an age-stratified random sample was recruited with larger sampling fractions in the older age-groups and deliberate oversampling of those aged 80–84. The overall mean (SD) age was 77.6 (7.4) years; 61.1% were women. The median educational level was high school graduate; 13.8%, 45.1%, and 41.1% respectively had less than high school education, were high school graduates, and had more than high school education. As regards race, 94.8% were White, 4.9% were Black, 0.15% were Asian, and 0.15% reported more than one race. Hispanic/Latino ethnicity was reported by 0.7%. The racial/ethnic breakdown of the cohort is largely representative of older adults in this region. Table 1 shows the distribution within the White and non-White subgroups of the cohort by age, sex, and educational levels. We emphasize that the cohort described here excludes individuals with moderate to severe cognitive impairment (MMSE < 21 after age-education correction).

Depressive symptoms

On the mCES-D, each point represents the presence of one depression symptom during most of the preceding week Seven participants did not complete the depression scale. Of the remaining participants, 68.4% reported 0 symptoms, while 12.9%, 6.5%, and 3.8% reported one, two, and three symptoms out of a possible 20. The mean (SD) score was 0.93 (2.1); the median (50^{th} %ile) score was 0, and the 90^{th} %ile score was 3.

Cognitive screen (general mental status)

On the MMSE, without age-education adjustment, the cohort as a whole had a mean (SD) score of 26.9 (2.4) out of a possible 30. Those with 0 depressive symptoms had a mean (SD) MMSE score of 27.1 (2.3) while the mean (SD) scores in those with 1–2 depressive symptoms and ≥3 symptoms were 26.7 (2.6) and 26.2 (2.9). The test for trend was significant (P<0.001).

We also examined the effect of applying the age-education MMSE correction (Mungas *et al.*, 1996) on our designation of individuals as moderately to severely impaired (defined as MMSE score <21). If the scores had not been adjusted for age and education, an additional 7 participants would have been classified as moderately to severely impaired, and not undergone the full assessment. Of these individuals, none were aged 65–74, 2 (28.6%) were aged 75–84, and 5 (71.4%) were aged 85+. Also, 5 (71.4%) had less than high school education, 2 (28.6%) were high school graduates, and none had more than high school education. Conversely, three had scores < 21 only after the age-education correction. All three had greater than high school education but had significant health and behavioral problems; two of them died within a year.

Neuropsychological test performance

Table 2 shows the mean (SD) score on each neuropsychological test among participants with 0, 1–2, and >=3 reported depression symptoms (i.e. mCES-D scores). On all tests, there was a significant trend (by Cuzick test) towards lower cognitive scores with higher levels of depression symptoms.

Table 2 also indicates the grouping of the individual tests within cognitive domains, based on which the domain composite scores were generated.

In univariable analyses (not in Table), higher levels of depressive symptoms were significantly associated with lower scores on all cognitive domain composites. Younger age, higher education, and self-identification as White were associated with better scores in all domains. Female gender was associated with better scores in the memory and language domains, while male gender was associated with better performance in visuospatial function. Attention and executive function domains were not associated with gender.

The multivariable analyses (Table 3) assessed the association of depressive symptoms with cognitive domain composites, adjusting for the effects of age, sex, race, and education. The strength of the association is indicated by the coefficient or the level of statistical significance (P value). The association of the attention composite with depression lost statistical significance after adjustment for demographics. All other domains remained significantly associated with depression, the strongest effect being observed for the executive function composite.

Effect size for each domain is reflected in percent of variance in cognitive scores explained, measured by the additional R^2 of the corresponding covariate in the multiple linear regression. (Table 3). For executive function, depression explained only 1.22% of the variance, which was less than that explained by age (10.24%), education (3.05%), and race (1.80%), but more than that explained by gender (0.48%). Similarly, depression explained 0.28% of the variance in attention, 0.79% of the variance in language, 0.64% of the variance in memory, and 0.95% of the variance in visuospatial function.

DISCUSSION

In this new, population-based cohort composed of individuals with normal or only mildly impaired cognition, the majority of individuals reported experiencing no depression symptoms over the course of the preceding week. Scores on individual cognitive tests were generally somewhat lower in participants with depressive symptoms than in those without them, but the differences in actual scores were small. Depressive symptoms explained less than 2% of the score variation in the different cognitive domains, a smaller effect than those of age or education. These data raise doubt about the extent to which depression can be invoked as an explanation for lower cognitive test performance at the population level.

Yet, there were clear associations between the presence of depression symptoms and lower scores in all cognitive domains. These associations remained statistically significant, after adjustment for demographics, for memory, language, visuospatial function, and executive function. The strongest association was with executive function. Not only the effect size but also the strength of association was greater for age and for education than for depressive symptoms.

A substantial literature now unequivocally demonstrates a cross-sectional association of depressive symptoms or depressive disorders with concurrently measured cognitive impairment in older adults, in both clinical and population-based samples. The direction of this association can, of course, only be established in longitudinal studies, among which there is much less consistency in findings. An earlier meta-analysis and qualitative literature review pointed to depression as a potential risk factor for future dementia (Jorm 2001). As shown in a recent comprehensive review (Butters *et al.*, 2008), there are appealing theoretic reasons, and some intriguing but as yet inconclusive data, to suggest that depressive illness contributes to the development of cognitive decline and dementia in some individuals. These hypotheses and lines of evidence will not be discussed further in the current report. Here, our focus is on the specific patterns of mild impairments in cognitive functioning that are

associated with the presence of depressive symptoms, and on the strength of these associations, at the population level.

The relatively small proportion of our population-based cohort reporting depression symptoms is consistent with previous studies, and their contrast with clinical samples is self-evident. Proportions vary slightly across community studies depending on the specific measurement tools as well as the nature of the sample. Using the same depression screening scale, we ourselves found a slightly higher proportion reporting depressive symptoms in our previous cohort study, the Monongahela Valley Independent Elders Survey (MoVIES) (Ganguli *et al.*, 1995) than in the current MYHAT cohort. The 90th percentile mCES-D score in MoVIES was 5, whereas in MYHAT it was 3. A likely explanation is that, being focused on older adults with normal or only mildly impaired cognition, MYHAT excludes from full assessment those with moderate to severe cognitive impairment. In contrast, the MoVIES study, whose primary focus was on dementia, included those individuals. Based on other studies reviewed below, it is plausible to speculate that individuals with moderate to severe cognitive impairment would also have reported more depressive symptoms. Also, some symptoms such as poor concentration and diminished interests could represent dementia rather than (or in addition to) depression.

In one case-control study, patients with depressive illness performed significantly worse than age-matched normal controls on measures of processing speed and working memory (Nebes *et al.*, 2000), and in fact these deficits persisted after the depression remitted. In another cross-sectional study (Butters *et al*., 2004), patients with late-life depression fared worse in all cognitive domains than the comparison group of cognitively normal older adults. Notably, all the observed impairments were mediated by slowed information processing. Education contributed to variance in cognitive functioning, but various disease measures did not. Slowed processing speed and impaired executive function were the core cognitive deficits in another study of patients with late-life depression (Sheline *et al.*, 2006. In a short prospective study (Bhalla *et a*l., 2006) visuospatial ability, processing speed, and delayed memory were persistently impaired in almost half the sample of individuals who had recovered from depressive illness a year later. Taken together, these previous studies of older patients with depressive disorders suggest a consistent pattern of association with diminished processing speed and executive function.

Our data, however, are drawn not from a sample of patients with depressive illness but from a cohort of individuals randomly selected from the population at large. At the population level, as in the clinical studies, the cognitive domain most strongly and independently associated with level of depressive symptoms was executive functioning. This finding is also consistent with those reported from our previous community study (MoVIES) even though that cohort had, as noted above, a higher prevalence of depression symptoms than the current cohort (Ganguli *et al.*, 2006). In a cross-sectional community-based study of younger Swedish adults aged 20–64, individuals with depressive disorders had impairments in episodic memory and mental flexibility (Trailmaking B, which in our study was included in the executive function composite (Airaksinen *et al.*, 2004). In the current study, attention, which is in part measured by tests of speed, was not significantly associated with depressive symptoms after adjustment for demographic variables. This apparent discrepancy with previous studies might be related to our having examined self-report of depressive symptoms over the preceding week, rather than clinically diagnosed major depression. It is also relevant that the majority of MYHAT participants reported no recent depressive symptoms at all.

Finally, our data also help to illustrate an important methodological point, sometimes conceptualized as the difference between clinical and statistical significance (Houle and

Stump, 2008). Depressive symptoms were significantly associated with the cognitive domain composite scores with *P* values ranging from 0.01 to <0.001. Yet, the differences in actual test scores between subgroups with and without depression symptoms were small. Also small was the percent of variance in the domain scores explained by depression symptoms, ranging from 0.28% to 1.22% (in contrast, up to 14.5% and 4.68% were explained by age and education). Clearly, the statistical significance of such small effects was only detectable because of the large size of our sample.

The effect of depression on cognition is real, in that the probability of its having been observed by chance alone is very slight. Therefore, the presence of depression should always be taken into account in studies of cognitive functioning in the elderly. However, at the population level, this real effect is also very small, and does not suggest a clinically significant impact of depressive symptoms on cognition. Both clinical and population-based studies on depressive symptoms as well depressive disorders should report data on effect size in addition to statistically significant associations.

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TABLE 1

MYHAT cohort demographic characteristics (N=1,982)

Non-White (n=104)						
Gender	**Women**			**Men**		
Education[1]	< HS	HSG	>HS	< HS	HSG	> HS
AGE						
65–69	3	6	7	0	5	4
70–74	2	7	9	1	1	0
75–79	5	4	5	3	3	2
80–84	4	6	4	4	1	2
85+	8	3	3	0	1	1
White (n=1,878)						
Gender	Women			Men		
Education[1]	< HS	HSG	>HS	< HS	HSG	> HS
AGE						
65–69	8	107	107	8	44	83
70–74	15	82	60	5	43	73
75–79	20	125	91	13	62	70
80–84	41	150	99	31	75	96
85+	64	112	53	38	57	46

[1]Educational categories: <HS: Less than High School; HSG: High School Graduate; >HS: More than High School

TABLE 2

Neuropsychological test performance and level of depression symptoms. (N=1,687 participants with complete data on neuropsychological tests, demographics, and depressive symptoms).

Domain	Test	Mean (SD) Among mCESD =0	Mean (SD) Among mCESD 1–2	Mean (SD) Among mCESD ≥3	Trend [3]
Attention	Trails A Connections/sec	0.62 (0.22)	0.59 (0.21)	0.56 (0.20)	0.004
	Digit Span	6.58 (1.03)	6.51 (1.02)	6.55 (1.02)	
Executive	Trails B Connections/sec	0.25 (0.10)	0.23 (0.10)	0.22 (0.09)	<0.001
	Letter Fluency	12.51 (4.43)	11.38 (4.23)	12.02 (4.32)	
	Clock Draw	13.82 (1.40)	13.56 (1.60)	13.29 (1.79)	
Language	Boston Naming	53.94 (5.21)	52.45 (5.83)	52.61 (5.28)	<0.001
	Animal Fluency	17.95 (5.28)	17.54 (5.05)	17.57 (5.46)	
	IU Token Test	22.92 (1.44)	22.75 (1.67)	22.62 (1.64)	
Memory	Logical Memory, Immediate[1]	20.48 (6.98)	19.08 (6.62)	18.85 (7.41)	<0.001
	Logical Memory, Delayed[1]	15.18 (7.29)	13.66 (7.18)	13.41 (7.29)	
	Object Memory Test	22.34 (3.96)	21.99 (3.74)	21.77 (4.24)	
	Visual Reproduction, Immediate[2]	28.50 (6.80)	27.82 (6.77)	26.95 (7.18)	
	Visual Reproduction, Delayed[2]	19.51 (10.38)	18.06 (10.16)	16.37 (10.59)	
Visuospatial	Block Design	29.71 (9.38)	27.18 (8.47)	26.51 (8.23)	<0.001

[1] Immediate and Delayed recall conditions of Logical Memory were summed before creating memory composite.

[2] Immediate and Delayed recall conditions of Visual Reproduction were summed before creating memory composite.

[3] Cuzick nonparametric test for trend. (Cuzick, 1985)

TABLE 3

depressive symptoms and demographics (multiple regression model)

	Age (3 groups)			Gender (2 groups)			Education (3 groups)			Race (2 groups)		
variance explained[1]	coeff	z (p value)	% variance explained[1]	coeff	z (p value)	% variance explained[1]	coeff	z (p value)	% variance explained[1]	coeff	z (p value)	% variance explained[1]
28	−.380	−10.09 (<0.001)	9.99	.079	2.22 (0.03)	0.26	.216	3.87 (<0.001)	0.19	.401	4.66 (<0.001)	1.11
	−.679	−13.13 (<0.001)					.274	4.82 (<0.001				
22	−.366	−11.20 (<0.001)	10.24	.100	3.24 (0.001)	0.48	.259	5.37 (<0.001)	3.05	.469	6.28 (<0.001)	1.80
	−.725	−16.15 (<0.001)					.395	8.02 (<0.001)				
79	−.305	−10.13 (<0.001)	10.91	.260	9.40 (<0.001)	3.93	.289	6.63 (<0.001)	4.68	.414	6.01 (<0.001)	1.68
	−.610	−15.06 (<0.001)					.447	10.05 (<0.001)				
64	−.443	−12.52 (<0.001)	14.50	.139	4.18 (<0.001)	0.81	.180	3.43 (<0.001)	2.79	.309	3.82 (<0.001)	0.67
	−.815	−16.75 (<0.001)					.374	7.01 (<0.001)				
95	−.410	−8.49 (<0.001)	6.68	−.134	−2.96 (0.01)	0.44	.283	3.97 (<0.001)	2.69	.843	7.65 (<0.001)	2.90
	−.716	−10.80 (<0.001)					.506	6.94 (<0.001)				

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