Journal of Geriatric Psychiatry and Neurology
2016, Vol. 29(6) 338-343

DOI: 10.1177/0891988716666381
jgpn.sagepub.com
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The Frontal Assessment Battery: Normative Performance in a Large Sample of Older Community-Dwelling Hospital Outpatient or General Practitioner Attenders

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Abstract

Background: The Frontal Assessment Battery (FAB) is a short battery designed to assess frontal executive functioning, but data for interpretation of performance are limited. **Objectives:** The Trinity, Ulster, Department of Agriculture (TUDA) study provided the opportunity to derive performance data from a large sample of community-dwelling hospital outpatient or general practitioner (GP) attenders. **Methods:** Normative analysis based on 2508 TUDA participants meeting these criteria: Mini-Mental State Examination (MMSE) >26/30, not depressed (Center for Epidemiologic Studies Depression <16) or anxious (Hospital Anxiety and Depression Scale <8), no history of stroke, or transient ischemic attack. Correlation and regression analyses were used to evaluate the effects of age, education, gender, and general cognition (MMSE). Norms for FAB were created stratified by age and education, using overlapping midpoint ranges of 10 years with a 3-year interval from age 60 to 97. **Results:** Age and education accounted for 9.6% of variance in FAB score ($r^2 = .096$) with no significant effect of gender. The FAB and MMSE were modestly correlated ($r = .29$, $P < .01$) with MMSE increasing the model's total explained variance in FAB score from 9.6% to 14%. **Conclusion:** This is the largest study to date to create normative data for the FAB. Age and education had the most significant impact on FAB performance, which was largely independent of global cognition (MMSE). These data may be of benefit in interpreting FAB performance in individuals with similar demographic/health status characteristics in hospital outpatient or GP settings.

Keywords

Frontal Assessment Battery (FAB), frontal-executive functioning, normative data, TUDA

Introduction

The Frontal Assessment Battery (FAB) was designed to provide a brief bedside cognitive and behavioral battery to assess frontal executive functioning.[1] It consists of 6 brief subtests evaluating similarities (conceptualization), verbal fluency (mental flexibility), motor programming, resistance to interference, inhibitory control, and environmental autonomy. It is becoming increasingly widely used, and Kopp et al[2] have identified 2 broad applications: (1) early and differential diagnosis of neurodegenerative diseases, in particular, behavioral variant frontotemporal dementia and Alzheimer disease (AD)[3-6] and (2) detection of executive dysfunction in various diseases that affect frontostriatal brain networks including Parkinson disease,[7-10] Huntington disease,[11] amyotrophic lateral sclerosis,[12,13] multiple system atrophy and progressive supranuclear palsy,[14-16] psychiatric disorders (eg, depression in Parkinson disease,[17,18] addictive substance abuse[19-20]), and stroke.[2,21]

The FAB has been well validated as sensitive to frontal lobe dysfunction and concords well with more detailed neuropsychological testing.[1,14] Significant correlations have also been shown between the FAB subtests and frontal metabolism in positron emission tomography (fluorodeoxyglucose positron emission tomography, FDG-PET) studies of patients with varying frontal lobe damage[22] and AD.[23] However, in keeping with other tests designed to target frontal lobe functioning, the FAB

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is not entirely specific to frontostriatal dysfunction. In a single-photon emission computed tomography study in Parkinson disease, Matsui et al[24] reported that parietal lobe dysfunction in addition to frontal lobe dysfunction contributed to reduced performance on FAB. Of note, Lee et al[23] found significant correlations in patients with AD between FAB scores and FDG-PET metabolism in various cortical regions including temporal and parietal cortices and frontal regions independent of age, gender, and education. However, after controlling for the effect of global disease severity (Mini-Mental State Examination [MMSE]), significant correlations between FAB and metabolism were found only in the bilateral prefrontal regions. To control for possible dyspraxic or aphasic confounds on FAB performance, Kopp et al[2] did a magnetic resonance imaging voxel-based lesion-behavior mapping study of FAB sensitivity to frontal lobe damage in patients with right hemisphere damaged first-ever stroke and concluded that several FAB scores including composite and item scores provided valid measures of right hemisphere lateral frontal dysfunction, particularly in the region of the anterior insula, middle frontal gyrus, and inferior frontal gyrus.

It is somewhat surprising given its widespread use that it is not entirely clear what constitutes impaired range performance on the FAB, with no clear recommendation for a cutoff score. Some limited control group (n = 42) versus patient group information was provided in the original paper[1] with control FAB = 17.3 ± 0.8 (mean ± standard deviation [SD]), which suggests that FAB < 16/18 would be "abnormal." However, <16/18 is not at all uncommon based on 4 studies that provide some limited normative information, 2 Italian (n = 236 and n = 364, respectively),[25,26] 1 Brazilian (n = 391),[27] and 1 Korean (n = 635).[28] Iavarone et al[25] found that 95% of their normal controls had a FAB score ≥12/18. For discriminating AD from normal controls, Kim et al[28] recommended a cutoff score of 10/11 (sensitivity 72% and specificity 83%). Slachevsky et al[3] found a cutoff score of 12 as optimal to differentiate frontotemporal dementia from AD in mildly demented patients (sensitivity 77% and specificity 87%).

An issue for interpreting performance on any test is the nature of the control sample. When stringent inclusion/exclusion criteria are applied, as is often the case, the control sample may comprise a "hypernormal" or "supernormal" sample that it not representative of the range of healthy individual performance encountered in the real world.[29] The alternative is to avoid over selective criteria (eg, Appollonio et al[26] and Duff et al[30]), which was an approach adopted in the present study.

Aim of the Present Article

The Trinity, Ulster, Department of Agriculture (TUDA) study[31] provided the opportunity to derive normative data from a large sample of community-dwelling hospital or general practitioner (GP) attenders that may be of benefit for reference purposes to interpret FAB performance in older adults.

Methods

Sample

The TUDA study has been described elsewhere.[31] It is a large cross-sectional study designed to create a phenotype/genotype database for 3 cohorts of community-dwelling adults older than 60 years attending outpatient hospital clinics (bone, cognitive cohorts) or GP (hypertensive cohort). For the TUDA study, individuals who were able to provide consent and scored ≥16 on MMSE were eligible for recruitment commencing in December 2008 and completed in September 2012. For the present study, data on the FAB were available for 2508 TUDA participants who met the following criteria: MMSE >26/30, not depressed on the Center for Epidemiologic Studies Depression[32] (CESD <16) scale, not anxious on the anxiety subscale of the Hospital Anxiety and Depression Scale[33] (HADS anxiety <8), no history of stroke, or transient ischemic attack (TIA). These criteria were applied with the intention of selecting a sample with "normal" range cognition on MMSE[34] without significant depression, anxiety, history of stroke, or TIA. Functional status was evaluated on the Instrumental Activities of Daily Living (IADL) scale.[35] All participants provided written consent, and ethical approval was obtained from research ethnic committees. Trained researchers and doctors conducted the study assessments.

Statistical Analysis

Statistical advice was sought and concluded that given the absence of any large outliers, the data are sufficiently robust for parametric analysis. Correlation and regression analyses were used to evaluate the effects of age, education, gender, and general cognition (MMSE) on the FAB. Based on the results of the regression modeling, a table of norms for FAB scores was created stratified by age and education (primary, secondary, and tertiary) using overlapping midpoint ranges of 10 years with a 3-year interval from age 60 to 97. This approach was adopted based on the previous work comparing several different methods for producing normative data for the MMSE and Montreal Cognitive Assessment, with the current method offering advantages of optimized data usage by maximizing the number of participants contributing to the normative distribution at each midpoint age interval.[30,36,37] This approach is similar to the overlapping strata approach recommended by Kim et al.[28] For each age/education stratum, data were presented in the form of mean, standard deviation, median, and range from 5th to 95th percentile.

Results

The sample characteristics are summarized in Table 1. The sample aged in range from 60 to 95 years (mean age ± SD, 71.73 ± 7.36), with 67% of females. In terms of medical comorbidities, these included hypertension (71.45%), hyperlipidemia (52.39%), diabetes (11.64%), and ischemic heart disease (11.48%). As expected, given the inclusion/exclusion

Table 1. Sample Characteristics (n = 2508).

Demographics	Mean (SD) or %
Age	71.73 (7.36; range: 60-95)
Gender: female	66.87% (n = 1677)
Education (years)	12.69 (3.21)
CESD (depression)	3.34 (3.72)
HADS anxiety	2.0 (2.08)
MMSE	28.44 (1.0)
IADL	25.8 (3.08)
Medical morbidity	
Hypertension	71.45%
Diabetes	11.64%
Hyperlipidemia	52.39%
Ischemic heart disease (IHD)	11.48%
Myocardial infarction (MI)	8.13%
Atrial fibrillation history (AF)	8.93%
Lifestyle factors	
Alcohol (current drinker)	62.16%
Alcohol (past drinker)	14.39%
Current smoker	10.41%
Past smoker	40.71%

Abbreviations: CESD, Center for Epidemiologic Studies Depression; HADS, Hospital Anxiety and Depression scale; IADL, Instrumental Activities of Daily Living; MMSE, Mini-Mental State Examination; SD, standard deviation.

criteria, MMSE was high (28.44 $\pm$ 1.0) as was the level of functional ability (IADL scale = 25.8 $\pm$ 3.08), whereas levels were low for anxiety (HADS anxiety = 2.0 $\pm$ 2.08) and depression (CESD = 3.34 $\pm$ 3.72). Of note, regarding alcohol consumption, 14.39% of the sample were past drinkers, 62.16% were current drinkers, and 23.45% never drank. Rates of chronic alcoholism were not recorded, but data on units of alcohol consumed per week were available for 87.15% of female current drinkers (n = 868) and for 96.27% of male current drinkers (n = 542). We evaluated how many current drinkers drank above the recommended levels (health recommendations from Irish Health Services Executive [HSE][38]: $\geq$14 U per week for females and $\geq$21 U per week for males). A total of 10.71% of female current drinkers and 26.38% of male current drinkers drank above the recommended limits, and this represents 9.4% of the entire sample.

The distribution of FAB scores was skewed due to a ceiling effect. In a linear regression model age and education accounted for 9.6% of the variance in FAB scores ($r^2 = .096$), while no significant effect of gender was identified (adding gender to the model did not alter the estimates). The FAB and MMSE were correlated ($r = .29$, $P < .01$) with the addition of MMSE to the model increasing the explained variance in FAB scores from 9.6% to 14%.

Discussion

This is the largest study to date to create normative data for the FAB. Consistent with previous studies,[25-28] age and education but not gender were found to have significant impacts on FAB performance, which was largely though not entirely independent of global cognition as assessed by the MMSE (including MMSE in the regression model increased explained variance in FAB scores from 9.6% to 14%). Performance at the 10th percentile (a commonly used normative cutoff for below average performance)[39] was found on the FAB to fall between approximately 10/18 and 14/18 depending on the above factors.

The sample comprises individuals who were attending hospital clinics or GP practices and are not free of disease as evidenced by the presence of hypertension (71.45%), hyperlipidemia (52.39%), diabetes (11.64%), or ischemic heart disease (11.48%). Regarding alcohol consumption, 14.39% of the sample were past drinkers, 62.16% current drinkers, and 23.45% never drank. Data available for 87.15% of female current drinkers and 96.27% of male current drinkers indicated that 10.71% of female current drinkers and 26.38% of male current drinkers drank above the recommended levels (HSE health recommendations).[38] This sampling approach can be seen either as a limitation or a strength of the study, depending on one's perspective. As a limitation, the question arises as to the limited general applicability of these normative data, given the presence of medical comorbidities and other factors that can impact executive functioning. On the other hand, the common practice of selecting as controls individuals who are free of a variety of factors present in the general aging population leads to a problem of supernormal controls who are not in fact representative of the general population and while considered as representing "normality" are likely to be performing at "above average" levels. The crucial issue in selecting norms for test interpretation is whether a given control sample is similar in character (eg, demographics, health status, etc) to the cases for whom the control data are being use for normative comparison. The current data provide a large reference sample for comparison of individuals who are hospital clinics or GP attenders with medical comorbidities. Individuals in our normative sample are not cognitively impaired on MMSE and are functionally normal without anxiety, depression, a history of stroke, or TIA.

The issues of supernormal controls versus limited general applicability when stringent inclusion/exclusion criteria are applied or not applied was also addressed by Duff et al when developing norms for the widely used Repeatable Battery for the Assessment of Neuropsychological Status. They selected a sample that included medical comorbidities (15% with cancer, 17% with diabetes, 46% with hypertension). They argued that their sample likely represents what the American Psychological Association (APA) Working Group on the Older Adult[40] refer to as "typical" aging (which includes older adults with 1 or more medical illnesses), which can be contrasted with "optimal" aging (individuals who report no physical illnesses and have aged particularly well). For normative comparison purposes, optimal aging individuals are more akin to hypernormal or supernormal controls who do not represent the range of healthy individual performance encountered in everyday settings. Strauss et al[39] argue that using exclusion criteria in older adults based on health status may

Table 2. Norms for FAB Stratified by Age and Education, Using Overlapping Midpoint Ranges of 10 Years With a 3-Year Interval From Age 60 to 97.

Age Education	60-70 (Mid 65)	63-73 (Mid 68)	66-76 (Mid 71)	69-79 (Mid 74)	72-82 (Mid 77)	75-85 (Mid 80)	78-88 (Mid 83)	81-91 (Mid 86)	84-94 (Mid 89)	87-97 (Mid 92)
Primary education										
N	314	420	462	451	381	291	200	123	68	32
Mean	16.03	15.96	15.81	15.72	15.71	15.51	15.41	15.15	14.87	14.50
SD	1.80	1.78	1.80	1.89	1.90	1.93	2.11	2.10	2.18	2.33
95th percentile	18	18	18	18	18	18	18	18	18	18
90th percentile	18	18	18	18	18	18	18	18	18	17
75th percentile	17	17	17	17	17	17	17	17	16	16
Median	16	16	16	16	16	16	16	15	15	15
25th percentile	15	15	15	15	15	15	14	14	14	13.50
10th percentile	13.50	13	13	13	13	13	12	12	12	12
5th percentile	12.75	13	12	12	12	11.60	11	11	10.45	8.95
Secondary education										
N	534	508	423	360	328	254	195	138	76	36
Mean	16.61	16.50	16.43	16.40	16.22	16.09	15.88	15.51	15.41	15.11
SD	1.48	1.58	1.67	1.68	1.74	1.87	2.11	2.20	2.09	2.07
95th percentile	18	18	18	18	18	18	18	18	18	17.15
90th percentile	18	18	18	18	18	18	18	18	18	17
75th percentile	18	18	18	18	18	18	18	17	17	17
Median	17	17	17	17	17	17	16	16	16	15
25th percentile	16	16	16	16	15	15	15	14.75	15	14
10th percentile	15	14.90	14	14	14	14	13	12.9	12.70	11.70
5th percentile	14	13	13	13	13	12	11	10.95	10.85	10.70
Tertiary education										
N	393	405	379	340	279	203	149	92	52	21
Mean	17.03	17.00	16.97	16.91	16.88	16.67	16.53	16.23	16.13	16.19
SD	1.18	1.24	1.23	1.37	1.35	1.62	1.67	1.88	1.93	1.57
95th percentile	18	18	18	18	18	18	18	18	18	18
90th percentile	18	18	18	18	18	18	18	18	18	18
75th percentile	18	18	18	18	18	18	18	18	18	17
Median	17	17	17	17	17	17	17	17	16	17
25th percentile	16	16	16	16	16	16	16	15	15	15
10th percentile	15	15	15	15	15	14.40	14	13.30	13.30	14
5th percentile	15	15	15	14	14	13.20	13	12	12	12.20

Abbreviations: FAB, Frontal Assessment Battery; SD, standard deviation.

> disproportionately restrict normative samples because of the increased prevalence of medical and other conditions in this age group. The result is a 'normal' sample that includes only the upper ranges of scores for older individuals, and which will disproportionately render impairment scores for low functioning but typically ageing elders. (p. 52)

There are therefore arguments for and against the use of more or less stringent inclusion/exclusion criteria. In the end, the best practice is to find the "best fit" between a patient's demographic characteristics and those of the study sample, as recommended by Mitrushina et al.[41] In conclusion, the norms presented here provide a useful reference to interpret performance on the FAB in research or clinical settings.

Acknowledgments

The authors are grateful to the TUDA participants. Thanks also to Dr Cathal Walsh, TCD, for statistical advice.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Funded by the Mercer's Institute for Research on Ageing, the Irish Department of Agriculture, Food & the Marine and Health Research Board, and the Department for Employment and Learning Northern Ireland under its Cross-Border Research and Development Program, "Strengthening the all-Island Research Base."

References

1. Dubois B, Slachevsky A, Litvan I, Pillon B. The FAB: a Frontal Assessment Battery at bedside. *Neurology*. 2000;55(11): 1621-1626.
2. Kopp B, Rösser N, Tabeling S, et al. Performance on the Frontal Assessment Battery is sensitive to frontal lobe damage in stroke

patients. *BMC Neurol*. 2013;13:179. doi:10.1186/1471-2377-13-179.
3. Slachevsky A, Villalpando JM, Sarazin M, Hahn-Barma V, Pillon B, Dubois B. Frontal Assessment Battery and differential diagnosis of frontotemporal dementia and Alzheimer disease. *Arch Neurol*. 2004;61(7):1104-1107.
4. Lipton AM, Ohman KA, Womack KB, Hynan LS, Ninman ET, Lacritz LH. Subscores of the FAB differentiate frontotemporal lobar degeneration from AD. *Neurology*. 2005;65(5):726-731.
5. Castiglioni S, Pelati O, Zuffi M, et al. The Frontal Assessment Battery does not differentiate frontotemporal dementia from Alzheimer's disease. *Demen Geriatr Cog Disord*. 2006;22(2): 125-131.
6. Gleichgerrcht E, Roca M, Manes F, Torralva T. Comparing the clinical usefulness of the Institute of Cognitive Neurology (INECO) Frontal Screening (IFS) and the Frontal Assessment Battery (FAB) in frontotemporal dementia. *J Clin Exp Neuropsychol*. 2011;33(9):997-1004.
7. Lima CF, Meireles LP, Fonseca R, Castro SL, Garrett C. The Frontal Assessment Battery (FAB) in Parkinson's disease and correlations with formal measures of executive functioning. *J Neurol*. 2008;255(11):1756-1761.
8. Santangelo R, Vitale C, Trojano L, Verde F, Grossi D, Barone P. Cognitive dysfunctions and pathological gambling in patients with Parkinson's disease. *Mov Disord*. 2009;24(6):899-905.
9. Koerts J, Tucha L, Leenders KL, van Beilen M, Brouwer WH, Tucha O. Subjective and objective assessment of executive functions in Parkinson's disease. *J Neurologic Sci*. 2011;310(1-2): 172-175.
10. Marconi R, Antonini A, Barone P, et al. Frontal Assessment Battery scores and non-motor symptoms in parkinsonian disorders. *Neurologic Sci*. 2012;33(3):585-593.
11. Rodrigues GR, Souza CP, Cetlin RS, et al. Use of the Frontal Assessment Battery in evaluating executive dysfunction in patients with Huntington's disease. *J Neurol*. 2009;256(11): 1809-1815.
12. Oskarsson B, Quan D, Rollins YD, Neville HE, Ringel SP, Arciniegas DE. Using the Frontal Assessment Battery to identify executive function impairments in amyotrophic lateral sclerosis: a preliminary experience. *Amyotroph Lateral Scler*. 2010;11(1-2):244-247.
13. Ahn SW, Kim SH, Kim JE, et al. Frontal Assessment Battery to evaluate frontal lobe dysfunction in ALS patients. *Can J Neurologic Sci*. 2011;38(2):242-246.
14. Paviour DC, Winterburn D, Simmonds S, et al. Can the Frontal Assessment Battery (FAB) differentiate bradykinetic rigid syndromes? Relation of the FAB to formal neuropsychological testing. *Neurocase*. 2005;11(4):274-282.
15. Brown RG, Lacomblez L, Landwehrmeyer BG, et al. Cognitive impairment in patients with multiple system atrophy and progressive supranuclear palsy. *Brain*. 2010;133(pt 8):2382-2393.
16. Sitek EJ, Konkel A, Dabrowska M, Slawek J. Utility of Frontal Assessment Battery in detection of neuropsychological dysfunction in Richardson variant of progressive supranuclear palsy. *Neurol Neurochir Pol*. 2015;49(1):36-40.
17. Kummer A, Harsányi E, Dias FM, Cardoso F, Caramelli P, Teixeira AL. Depression impairs executive functioning in Parkinson disease patients with low educational level. *Cogn Behav Neurol*. 2009;22(3):167-172.
18. Santangelo R, Vitale C, Trojano L, et al. Relationship between depression and cognitive dysfunctions in Parkinson's disease without dementia. *J Neurol*. 2009;256(4):632-638.
19. Cunha PJ, Nicastri S, de Andrade AG, Bolla KL. The Frontal Assessment Battery (FAB) reveals neurocognitive dysfunction in substance-dependent individuals in distinct executive domains: abstract reasoning, motor programming, and cognitive flexibility. *Addict Behav*. 2010;35(10):875-881.
20. Fontes MA, Bolla KI, Cunha PJ, et al. Frontal Assessment Battery (FAB) is a simple tool for detecting executive deficits in chronic cannabis users. *J Clin Exp Neuropsychol*. 2011;33(5):523-531.
21. Tang WK, Chen Y, Lam WWM, et al. Emotional incontinence and executive function in ischaemic stroke: a case-controlled study. *J Int Neuropsychol Soc*. 2009;15(1):62-68.
22. Sarazin M, Pillon B, Giannakopoulos P, Rancurel G, Samson Y, Dubois B. Clinicometabolic dissociation of cognitive functions and social behavior in frontal lobe lesions. *Neurology*. 1998; 51(1):142-148.
23. Lee JH, Byun MS, Sohn BK, et al. Functional neuroanatomical correlates of the Frontal Assessment Battery performance in Alzheimer disease: a FDG-PET study. *J Geriatr Psychiatry Neurol*. 2015;28(3):184-192.
24. Matsui H, Udaka F, Miyoshi T, et al. Frontal Assessment Battery and brain perfusion image in Parkinson's disease. *J Geriatr Psychiatry Neurol*. 2006;19(1):41-45.
25. Iavarone A, Ronga B, Pellegrino L, et al. The Frontal Assessment Battery (FAB): normative data from an Italian sample and performances of patients with Alzheimer's disease and frontotemporal dementia. *Funct Neurol*. 2004;19(3):191-195.
26. Appollonio I, Leone M, Isella V, et al. The Frontal Assessment Battery (FAB): normative values in an Italian population sample. *Neurologic Sci*. 2005;26(2):108-116.
27. de Paula JJ, Moura S, Bocardi MB, de Moraes EN, Malloy-Diniz L, Haase VG. Screening for executive dysfunction with the Frontal Assessment Battery: psychometric properties analysis and representative normative data for Brazilian older adults. *Psicologia em Pesquisa*. 2013;7(1):89-98.
28. Kim TH, Huh Y, Choe JY, et al. Korean version of Frontal Assessment Battery: psychometric properties and normative data. *Demen Geriatr Cog Disord*. 2010;29(4):636-670.
29. Rossetti HC, Lacritz LH, Munro Cullum C, Weiner MF. Normative data for the Montreal Cognitive Assessment (MoCA) in a population-based sample. *Neurology*. 2011;77(13):1272-1275. Web site. https://www.neurology.org/content/77/13/1272/reply[
30. Duff K, Patton D, Schoenberg M, Mold J, Scott J, Adams R. Age- and education corrected independent normative data for the RBANS in a community dwelling elderly sample. *Clin Neuropsychol*. 2003;17(3):351-366.
31. McCarroll K, Beirne A, Casey M, et al. Determinants of 25-hydroxyvitamin D in older Irish adults. *Age Ageing*. 2015; 44(5):847-853.
32. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. *Appl Psychol Meas*. 1977;1(3): 385-401.

33. Zigmond AS, Snaith RP. The Hospital Anxiety and Depression Scale. *Acta Psychiatr Scand*. 1983;67(6):361-370.
34. Folstein MF, Folstein SE, McHugh PR, Fanjiang G. *MMSE. Mini-Mental State Examination. User's Guide*. Odessa, FL: Psychological Assessment Resources, Inc; 2001.
35. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. *The Gerontologist*. 1969;9(3):79-186.
36. Sexton G. *A Comparison of Methods for the Production of Normative Data for MMSE and MoCA in an Irish Population* [Unpublished Master's thesis]. Dublin: School of Psychology, Trinity College; 2011.
37. Coen RF, Dockree P, Sexton G, et al. The Irish longitudinal study of ageing (TILDA): preliminary data on the Montreal cognitive assessment (MoCA) in community dwelling Irish older adults. *Ir J Med Sci*. 2011;180(suppl 10):S333-S334. doi:10.1007/s11845-011-0742-0.
38. Health Services Executive. Ireland. 2016. http://www.hse.ie/eng/health/hl/change/Alcohol/
39. Strauss E, Sherman EMS, Spreen O. *A Compendium of Neuropsychological Tests: Administration, Norms, and Commentary*. 3rd ed. New York, NY: Oxford University Press; 2006.
40. APA Working Group on the Older Adult. What practitioners should know about working with older adults? *Profession Psychol*. 1998;29(5):413-427.
41. Mitrushina M, Boone KB, Razani J, D'Elia LF. *Handbook of Normative Data for Neuropsychological Assessment*. 2nd ed. New York, NY: Oxford University Press; 2005.