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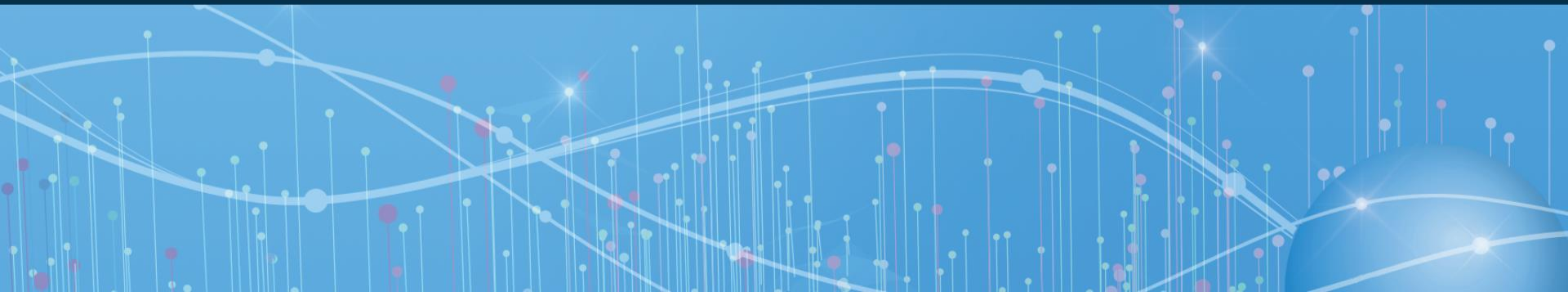


Montreal Cognitive Assessment (MoCA) and Mini-Mental State Examination (MMSE): Cutoff points for mild cognitive impairment and dementia

Team: Bug Attractor

Feier Han, Zhen Wu, Jing Shang, Yutong Zhang, Emory university

Instructor: Prof. Ko Yi-An

Table of Contents

1 TERMS & INTRODUCTION

2 DATA & DATA VALIDATION

3 ANALYSIS

4 RESULTS & VISUALIZATION

5 CONCLUSION & GENERALIZATION

6 SUGGESTIONS FOR FUTURE STUDIES

Glossary of Abbreviations and Notes

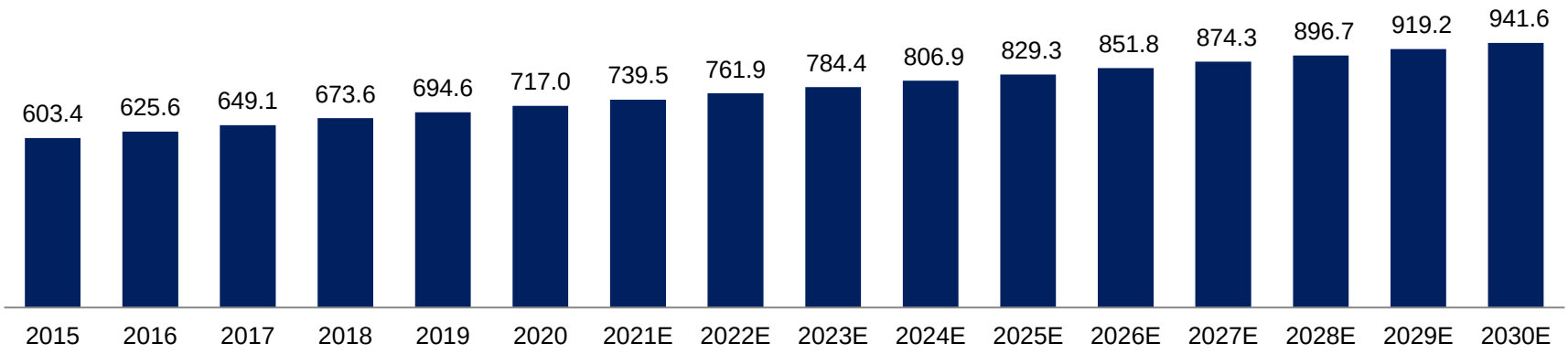
- CAGR: Compound Annual Growth Rate
- MoCA: Montreal Cognitive Assessment
- MMSE: Mini-Mental State Examination
- MCI: Mild Cognitive Impairment
- NACC: National Alzheimer’s Coordinating Center
- AD: Alzheimer’s Disease
- ROC: Receiver operating characteristic curve
- AUC: Area under the ROC curve

Global Aging Population Trend, 2015-2030E

- The world's aging population is experiencing growth in terms of both number and proportion. In 2030, It is estimated that there are 941.6 million people aged over 65 years old in the world, with CAGR is 2.6%.

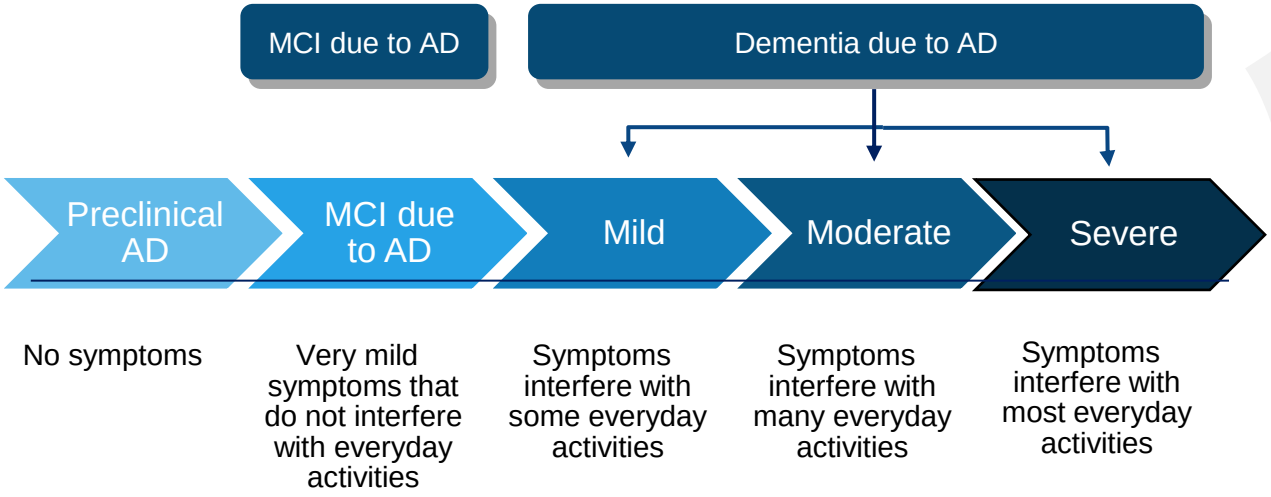
Global Aging Population Trend, 2015-2030E

Period	CAGR
2015-2019	3.6%
2019-2024E	3.0%
2024E-2030E	2.6%



Alzheimer's Disease (AD) Continuum

- As the population ages, the prevalence and incidence of dementia and mild cognitive impairment (MCI) continues to increase, about 5-8% of Americans aged 60 or above are diagnosed with dementia [1], and 6.7-12.5% of them have MCI [2].
- It is critical to diagnose cognitive impairment and prescribe proper interventions in a timely manner.
- Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) are two commonly used cognitive function screening tools to improve the efficiency and accuracy of MCI and dementia diagnosis.



MMSE: The Mini–Mental State Examination or Folstein test is a 30-point questionnaire that is used extensively in clinical and research settings to measure cognitive impairment. [3]

MoCA: The Montreal Cognitive Assessment is a widely used screening assessment for detecting cognitive impairment. It was validated in the setting of MCI and has subsequently been adopted in numerous other settings clinically. [4]

Table of Contents

1 TERMS & INTRODUCTION

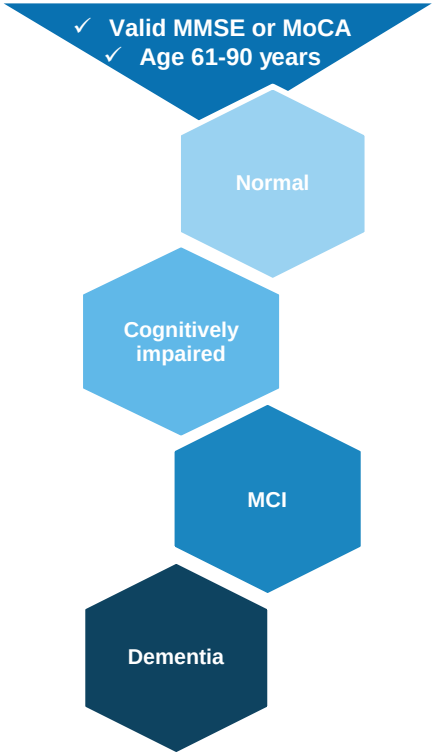
2 DATA & DATA VALIDATION

3 ANALYSIS

4 RESULTS & VISUALIZATION

5 CONCLUSION & GENERALIZATION

6 SUGGESTIONS FOR FUTURE STUDIES



24 subgroups for cutoff point investigation

Age Groups	Education Groups	Binary Cognitive Status Variables [5]
• 61-70 Years Old • 71-80 Years Old • 81-90 Years Old	• High school degree or below • College or bachelor's degree • Graduate school or master's degree • Doctorate or above	• I: Normal vs. cognitively impaired, MCI, or dementia • II: Normal or cognitively impaired vs. MCI or dementia • III: Normal, cognitively impaired, or MCI vs. dementia

Table of Contents

1 TERMS & INTRODUCTION

2 DATA & DATA VALIDATION

3 ANALYSIS

4 RESULTS & VISUALIZATION

5 CONCLUSION & GENERALIZATION

6 SUGGESTIONS FOR FUTURE STUDIES

Analysis Procedures

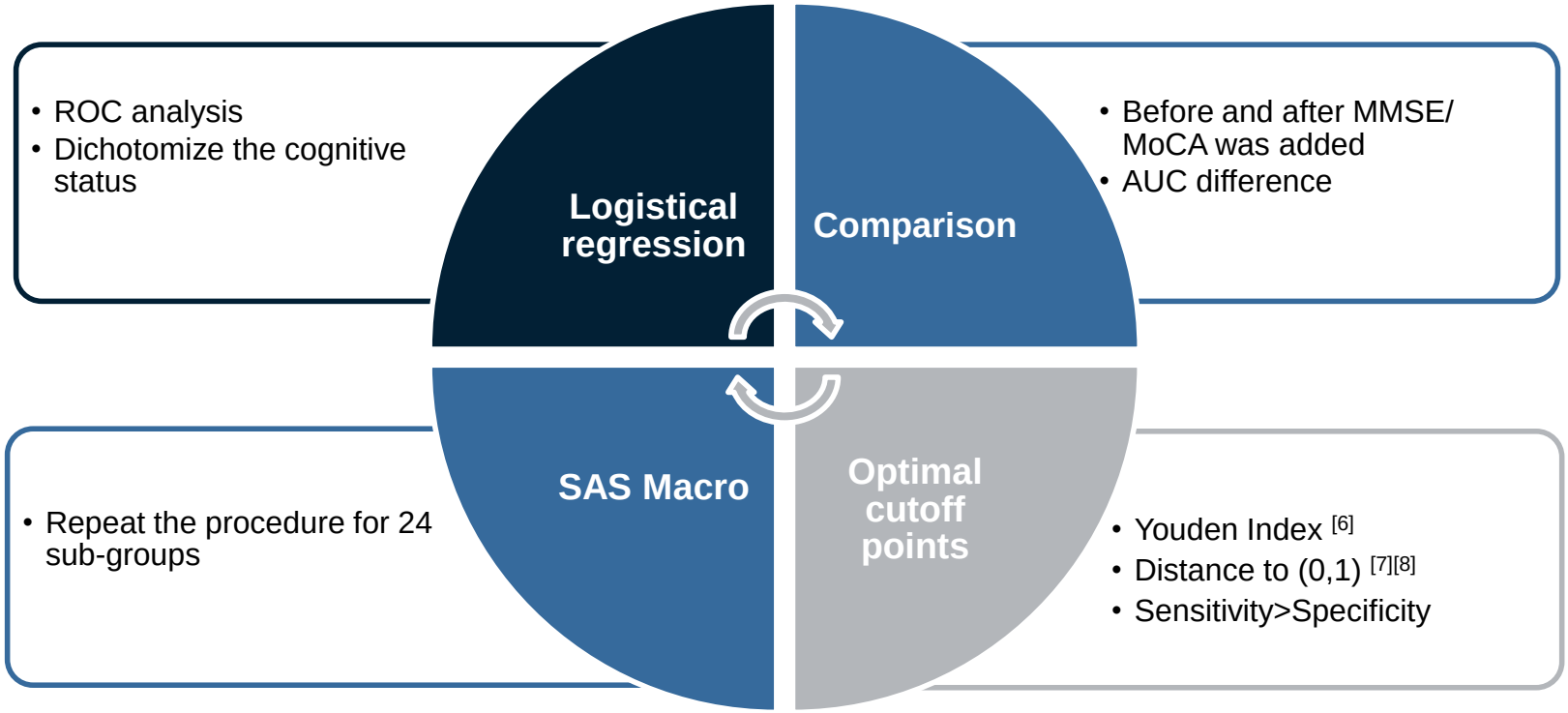


Table of Contents

1 TERMS & INTRODUCTION

2 DATA & DATA VALIDATION

3 ANALYSIS

4 RESULTS & VISUALIZATION

5 CONCLUSION & GENERALIZATION

6 SUGGESTIONS FOR FUTURE STUDIES

Summary of Study Subject's Characteristics in the NACC database

Table I	Total Frequency 120,099	Normal 58,886 (49.03%)	Impaired-not-MCI 5,871 (4.89%)	MCI 22,256 (18.53%)	Dementia 33,086 (27.55%)
MMSE 25.57 (5.97)	86,348	28.91 (1.46)	28.03 (2.20)	27.07 (2.52)	19.27 (7.04)
MoCA 23.33 (5.80)	33,752	26.37 (2.75)	24.73 (3.36)	22.57 (3.50)	14.92 (6.17)
Age 75.80 (7.37)	120,099	75.20 (7.25)	75.26 (7.14)	76.33 (7.24)	76.61 (7.59)
Education Years 15.42 (3.31)	119,721	15.89 (3.00)	15.20 (3.63)	15.36 (3.36)	14.69 (3.64)
Sex: Female 69,394 (57.78%)	120,099	20,299 (34.47%)	2,550 (43.43%)	11,045 (49.63%	16,811 (50.81%)
Diabetes 5,418 (14.26%)	37,982	2,862 (13.42%)	276 (14.79%)	1,276 (17.65%)	1,004 (13.82%)
Smoking History 40,920 (46.63%)	87,762	18,922 (47.11%)	2,256 (52.39%)	7,883 (47.00%)	11,859 (44.72%
Alcohol Abuse 5,104 (5.65%)	90,322	1,568 (3.82)	371 (8.47%)	1,025 (5.96%)	2,140 (7.73%)
Hypertension 19,620 (51.58%)	38,037	10,689 (49.33%	1,096 (58.61%)	4096 (56.54%)	3739 (51.54%)
Hypercholesterolemia 21,083 (55.87%)	37,734	11,669(54.28%)	1,036 (55.55%)	4,285 (59.68%)	4093 (56.90%)

*Mean, Standard Deviation, and Frequency (percentage) are reported for continuous and categorical variables, respectively

Models with Age, Education and Sex, and MMSE/MoCA Added

Table II	Independent Variables	I	II	III
MMSE	**Age, Education, Sex**	63.77%	63.68%	62.92%
	Age, Education, Sex, MMSE	86.61%	88.19%	93.98%
	Difference in AUC	**+22.84%**	**+24.51%**	**+31.06%**
MoCA	**Age, Education, Sex**	62.33%	62.56%	62.28%
	Age, Education, Sex, MoCA	86.65%	88.74%	94.10%
	Difference in AUC	**+24.32%**	**+26.18%**	**+31.82%**

* I: normal vs. cognitively impaired, MCI, or dementia; II: normal or cognitively impaired vs. MCI or dementia; III: normal, cognitively impaired, or MCI vs. dementia

Performance of MMSE and MoCA in different cognitive statuses

Table III	MMSE				MOCA			
Cognitive Status	I	II	III	Mean	I	II	III	Mean
Sensitivity	73.0%	76.1%	85.4%	78.2%	76.1%	79.4%	86.3%	80.6%
Specificity	82.2%	82.1%	87.4%	83.9%	79.1%	79.0%	85.5%	81.2%
AUC	84.6%	86.5%	93.3%	88.2%	84.9%	86.9%	93.1%	88.3%

* I: Normal vs. Cognitively Impaired, MCI, or Dementia;
* II: Normal vs. MCI or Dementia;
* III: Normal, Cognitively Impaired, or MCI vs. Dementia

The MMSE and MoCA optimal cutoff points in different subgroups

Table IV		Male			Female		
	AGE (years)	61-70	71-80	81-90	61-70	71-80	81-90
MMSE	High School or Below	26/26/24	26/25/24	25/25/24	27/27/25	26/26/24	25/25/24
	Bachelor degree or equivalent	28/27/26	27/27/26	27/27/25	28/28/26	28/28/26	27/27/26
	Master degree or equivalent	28/28/27	28/28/26	27/27/26	28/28/27	28/28/27	28/28/26
	Doctoral degree or above	28/28/27	28/27/27	27/27/26	28/28/28	28/28/27	28/28/26
MOCA	High School or Below	24/24/19	22/22/19	20/20/18	23/23/19	22/22/19	20/20/18
	Bachelor degree or equivalent	24/23/22	23/23/21	22/22/20	24/24/22	24/23/21	23/23/20
	Master degree or equivalent	25/25/23	24/24/22	24/24/21	25/25/23	25/25/23	24/24/21
	Doctoral degree or above	26/25/23	25/25/22	24/24/22	26/25/24	25/25/22	25/25/23

* The numbers in each cell refers to the optimal cutoff point to differentiate I: normal vs. cognitively impaired, MCI, or dementia; II: normal or cognitively impaired vs. MCI or dementia; III: normal, cognitively impaired, or MCI vs. dementia.

Table of Contents

1 TERMS & INTRODUCTION

2 DATA & DATA VALIDATION

3 ANALYSIS

4 RESULTS & VISUALIZATION

5 CONCLUSION & GENERALIZATION

6 SUGGESTIONS FOR FUTURE STUDIES

Conclusion: Better Diagnosis in Dementia

- MMSE and MoCA are helpful in testing cognitive status based on the substantial change in AUC.
- The sensitivity and specificity of MMSE and MoCA can vary depending on subject's characteristics, thus using a personalized test cutoff may be more effective in the diagnosis of cognitive function than a single universal cutoff.
- Better Diagnosis in Dementia: The tests demonstrated greatest increase in AUC, sensitivity and specificity for the outcome of dementia; Most of the cutoff-points are similar for diagnosing impaired and MCI; These tests may be not sensitive in cognition impairment or MCI screening, and may serve as a more efficient diagnostic tool for dementia.

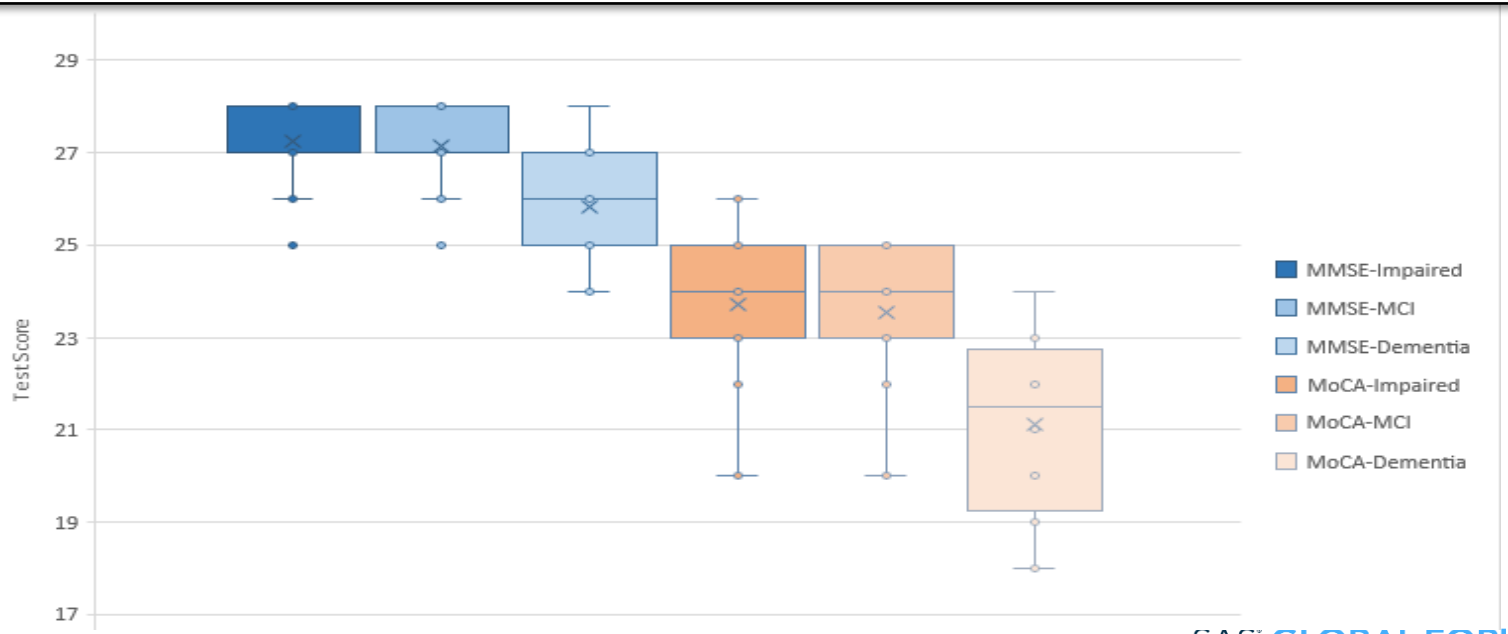


Table of Contents

1 TERMS & INTRODUCTION

2 DATA & DATA VALIDATION

3 ANALYSIS

4 RESULTS & VISUALIZATION

5 CONCLUSION & GENERALIZATION

6 SUGGESTIONS FOR FUTURE STUDIES

Suggestions for Future Studies

Comparisonss & Advantages

Tan et al. (2015) & Ng A et al. (2013)
- Relatively small sample size
- Study population: Chinese, Singapore

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- Huge sample size
- Study population: American

Chapman et al (2016)
- Considered population characteristics separately
- Treated MCI and dementia as two distinct diseases

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- Considered age, education, and sex as covariates and created subgroups
- Considered impaired, MCI and dementia as an ordinal variable

Limitation & Future Works

Parallel data

- Few subjects had both MMSE and MoCA data
- Not directly comparable between MMSE and MoCA

Depression

- Interaction with Alzheimer
- Misdiagnosis in dementia [12]

Impairment

- Relatively small sample size with impaired cognitive function
- Difficulty in diagnosis impaired

Reference

- [1] World Health Organization. 2020. “Dementia.” Accessed March 10, 2021 https://www.who.int/news-room/fact-sheets/detail/dementia
- [2] Petersen, R. C., Lopez, O., Armstrong, M. J., Getchius, T., Ganguli, M., Gloss, D., Gronseth, G. S., Marson, D., Pringsheim, T., Day, G. S., Sager, M., Stevens, J., & Rae-Grant, A., 2018, "Practice guideline update summary: Mild cognitive impairment: Report of the Guideline Development, Dissemination, and Implementation Subcommittee of the American Academy of Neurology.” Neurology, 90(3), 126–135.
- [3] Folstein, M.E, Folstein, S.E., and McHugh, P.R. 1975 “'Mini-mental state': A practical method for grading the cognitive state of patients for the clinician.” Journal of psychiatric research, 12(3):189-198.
- [4] Nasreddine, Z.S., Phillips, N.A., Bedirian, V., Charbonneau, S., Whitehead, V., Collin, I., Cummings, J.L., Chertkow, H. 2005 “The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment.” Journal of the American Geriatrics Society 2005, 53(4):695-699.
- [5] Kukull, Walter A., 2015. “NACC Uniform Data Set: Researchers Data Dictionary Version 3.0.” National Alzheimer’s Coordinating Center. Accessed March 14, 2021, https://naccdata.org/data-collection/forms-documentation/uds-3
- [6] Youden, W.J., 1950. “Index for rating diagnostic tests.” Cancer 3.1, 32-35.
- [7] Goddard, M.J., Hinberg, I., 1990. “Receiver operator characteristic (ROC) curves and non-normal data: an empirical study.” Statistics in Medicine 9(3), 325–337.
- [8] Perkins, N.J. and Schisterman, E.F., 2006. “The inconsistency of ‘optimal’ cut points obtained using two criteria based on the receiver operating characteristic curve.” American Journal of Epidemiology, 163(7), 670-675.
- [9] Tan, J.P., Li, N., Gao, J., Wang, L.N., Zhao, Y.M., Yu, B.C., Du, W., Zhang, W.J., Cui, L.Q, Wang, Q.S., Li, J. J, Yang, J.S., Yu, J.M., Xia, X.N. and Zhou, P.Y. 2015. “Optimal cutoff scores for dementia and mild cognitive impairment of the Montreal Cognitive Assessment among elderly and oldest-old Chinese population.” Journal of Alzheimer's Disease, 43(4), 1403-1412.
- [10] Ng, A., Chew, I., Narasimhalu, K., and Kandiah, N. 2013. “Effectiveness of Montreal Cognitive Assessment for the diagnosis of mild cognitive impairment and mild Alzheimer’s disease in Singapore.” Singapore Med J, 54(11), 616-619.
- [11] Chapman, K. R., Bing-Canar, H., Alosco, M. L., Steinberg, E. G., Martin, B., Chaisson, C., Kowall, N., Tripodis, Y., and Stern, R. A. 2016. “Mini Mental State Examination and Logical Memory scores for entry into Alzheimer’s disease trials.” Alzheimer's research & therapy, 8(1), 1-11.
- [12] Andersen, K., Lolk, A., Kragh-Sørensen, P., Petersen, N. E., & Green, A. 2005.“Depression and the risk of Alzheimer disease.” Epidemiology, 233-238.

Thank you!

Contact Information
abc@email.com