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2022

Université du Luxembourg  
Maison des Sciences Humaines  
11 Portes des sciences  
L-4366 Esch-sur-Alzette

# Country-level Variation of Dementia Prevalence in Europe

## Comparing OECD and SHARE Data

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<sup>5</sup> Institute of Gerontology, University of Michigan, Ann Arbor, MI, USA  
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□ FACULTY OF HUMANITIES,  
EDUCATION AND  
SOCIAL SCIENCES





# Background

Dementia Ascertainment in Cohort Studies

# Background

## Rationale

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- No Harmonized Cognitive Assessment
- Dementia Classification Algorithms Exist in HRS<sup>1</sup>
- Country-level Variation
  - Cognitive Performance
  - Reported IADLs
  - Underdiagnosis

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<sup>1</sup> Gianattasio KZ, Wu Q, Glymour MM, Power MC. Comparison of Methods for Algorithmic Classification of Dementia Status in the Health and Retirement Study. *Epidemiol Camb Mass.* 2019;30(2):291-302. doi:10.1097/EDE.0000000000000945

# Classification Algorithms

Health and Retirement Study

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- **Score Cutoff-based Algorithms**

Herzog-Wallace<sup>1</sup>

**Langa-Kabeto-Weir<sup>2,3</sup>**

- **Regression-based Algorithms**

Crimmins<sup>3</sup>

Hurd<sup>4</sup>

Wu<sup>5</sup>

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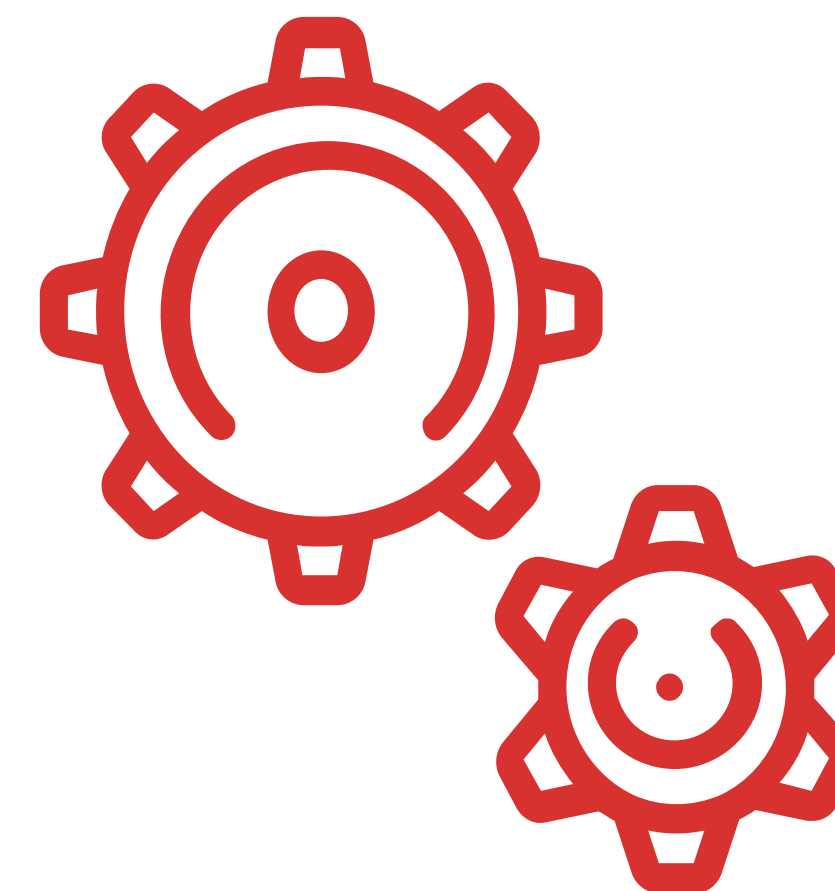
1 Herzog AR, Wallace RB. Measures of Cognitive Functioning in the AHEAD Study. *Journals Gerontol SerB*, 1997;52B:37–48.

2 Alzheimer's Association. 2010 Alzheimer's disease facts and figures. *Alzheimer's Dement* 2010;6:158–194. [PubMed: 20298981]

3 Crimmins EM, Kim JK, Langa KM, Weir DR. Assessment of Cognition Using Surveys and Neuropsychological Assessment: The Health and Retirement Study and the Aging, Demographics, and Memory Study. *Journals Gerontol Ser B Psychol Sci Soc Sci* 2011;66B(Supplement 1):i162– i171.

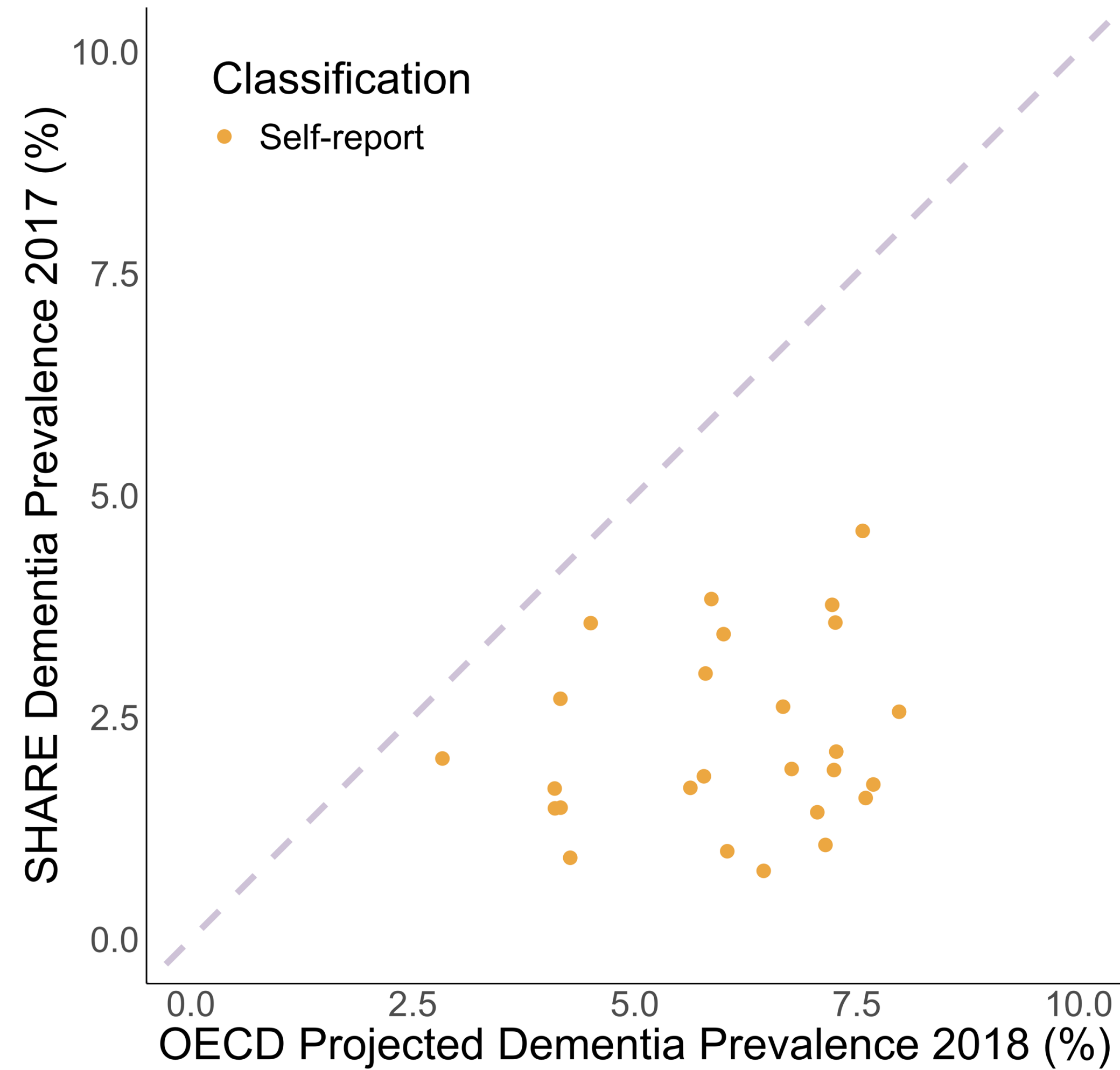
4 Hurd MD, Martorell P, Delavande A, Mullen KJ, Langa KM. Monetary Costs of Dementia in the United States. *N Engl J Med* 2013;368(14):1326–1334. doi:10.1056/NEJMsa1204629 [PubMed: 23550670]

5 Wu Q, Tchetgen Tchetgen EJ, Osypuk TL, White K, Mujahid M, Maria Glymour M. Combining Direct and Proxy Assessments to Reduce Attrition Bias in a Longitudinal Study. *Alzheimer Dis Assoc Disord* 2013;27(3):207–212. [PubMed: 22992720]



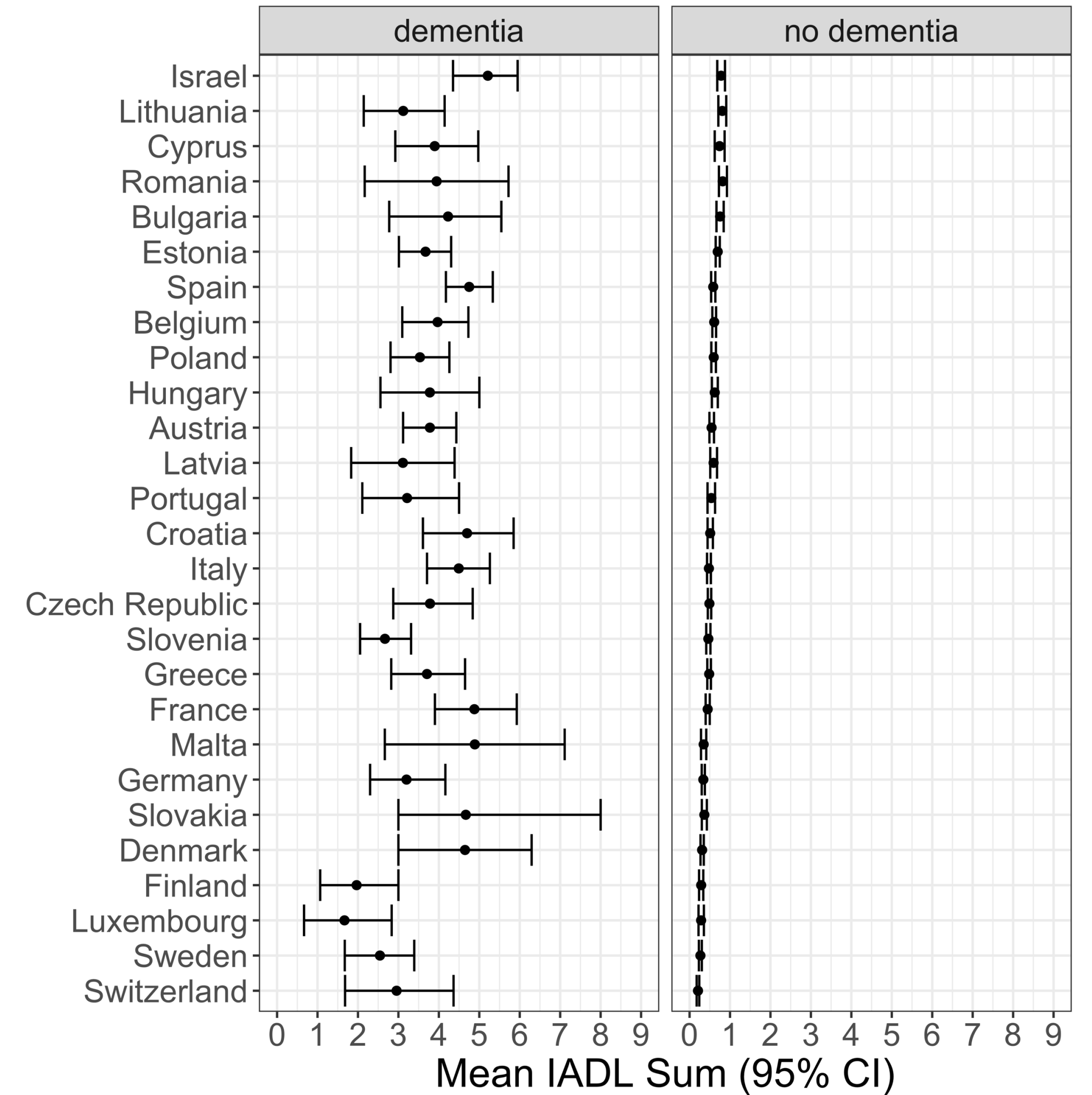
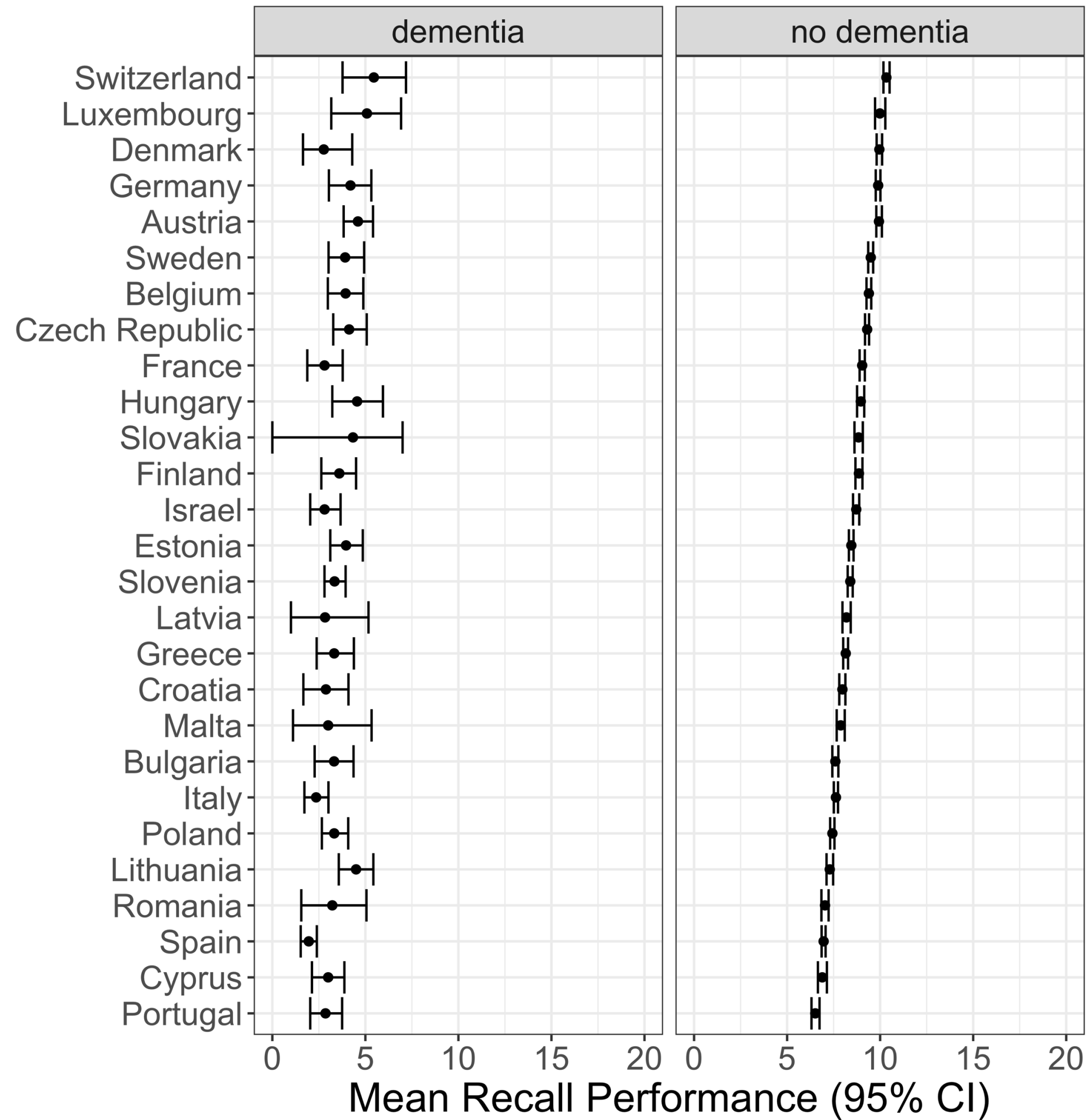
# Background

Underdiagnosis Varies Across Countries



# Background

## Cognitive Performance & IADL Sums Vary Across Countries





# Methods

Dementia Status Classification Algorithms

# Data

SHARE Wave 7 (2017)



- Survey of Health, Ageing and Retirement in Europe<sup>1,2</sup>

140,000 Respondents Age 50+, 28 Countries

More Information: <http://www.share-project.org/>

Age 60+  
No Missing Data  
26 Countries



1 Börsch-Supan A, Brandt M, Hunkler C, Kneip T, Korbmacher J, Malter F, et al. Data Resource Profile: The Survey of Health, Ageing and Retirement in Europe (SHARE). *Int J Epidemiol* 2013;42:992–1001.

2 Börsch-Supan A. Survey of Health, Ageing and Retirement in Europe (SHARE) Wave 7 2020.

# Classification Algorithms

Adapted to SHARE



- Langa-Weir Classification<sup>1</sup>

- Competitive Algorithms

- Logistic Regression (weighted)

- Random Forest

- set of individual decision trees
    - prediction based on majority votes

- XGBoost<sup>2</sup>

- gradient boosting machine
    - sequential ensemble of individual decision trees

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<sup>1</sup> Crimmins EM, Kim JK, Langa KM, Weir DR. Assessment of cognition using surveys and neuropsychological assessment: the Health and Retirement Study and the Aging, Demographics, and Memory Study. *J Gerontol B Psychol Sci Soc Sci.* 2011;66 Suppl 1:i162-171.

<sup>2</sup> Chen T, Guestrin C. XGBoost: A Scalable Tree Boosting System. In: *Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining.* KDD '16. Association for Computing Machinery; 2016:785-794.

Langa-Weir Classification						
Characteristics	HRS	SHARE Recall	SHARE Recall/IADLs	Logistic Regression	Random Forest	XGBoost
<b>Cognitive Function</b>						
Immediate Recall	SR	SR	SR	SR	SR	SR
Delayed Recall	SR	SR	SR	SR	SR	SR
Serial 7's	SR	-	-	-	-	-
Backward Counting	SR	-	-	-	-	-
<b>Instrumental Activities of Daily Living</b>						
Preparing Meals	Proxy	-	SR	SR	SR	SR
Shopping Groceries	Proxy	-	SR	SR	SR	SR
Making Phone Calls	Proxy	-	SR	SR	SR	SR
Taking Medication	Proxy	-	SR	SR	SR	SR
Managing Money	Proxy	-	SR	SR	SR	SR
Using a Map	-	-	SR	SR	SR	SR
Doing Housework	-	-	SR	SR	SR	SR
Leaving Independently	-	-	SR	SR	SR	SR
Doing Laundry	-	-	SR	SR	SR	SR
<b>Activities of Daily Living</b>						
Dressing	-	-	-	SR	SR	SR
Walking	-	-	-	SR	SR	SR
Bathing	-	-	-	SR	SR	SR
Eating	-	-	-	SR	SR	SR
Getting out of Bed	-	-	-	SR	SR	SR
Using the Bathroom	-	-	-	SR	SR	SR
<b>Sociodemographic Indicators</b>						
Age	-	-	-	SR	SR	SR
Gender	-	-	-	SR	SR	SR
Educational Level	-	-	-	SR	SR	SR
<b>Interviewer Variables</b>						
Proxy Presence	-	-	-	Proxy	Proxy	Proxy
Needed Help Reading	-	-	-	Proxy	Proxy	Proxy
Willingness to Answer	-	-	-	Proxy	Proxy	Proxy
Asked for Clarification	-	-	-	Proxy	Proxy	Proxy
Comprehension	-	-	-	Proxy	Proxy	Proxy
Interviewer Rating	Proxy	-	-	-	-	-
Memory Rating	Proxy	-	-	-	-	-

# Characteristics Across Algorithms – Overview

## LW

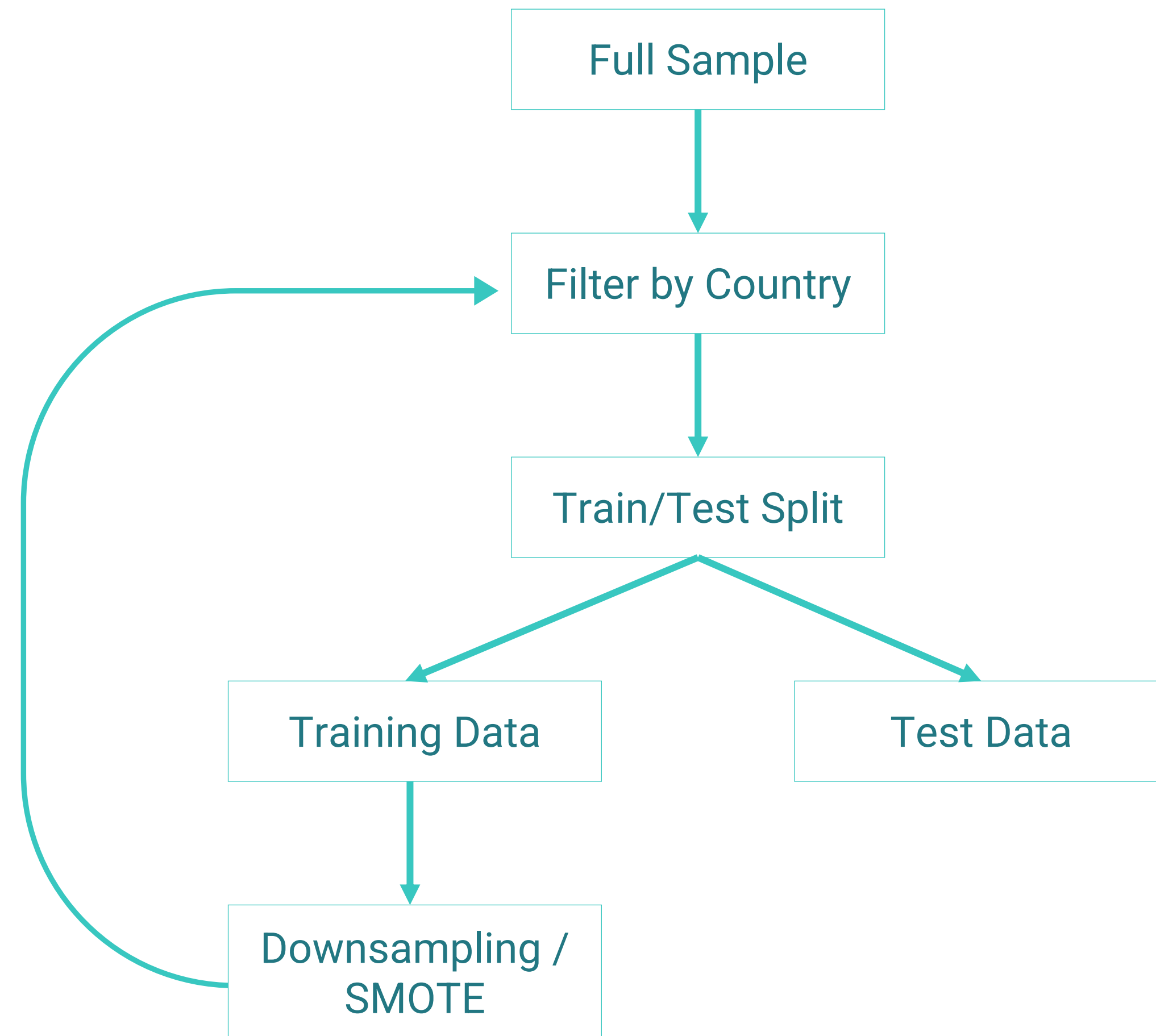
- 2 (Recall vs Recall/IADL) \*
- 2 Tresholds Based on Percentiles:
  - 2.5th (Recall) / 97.5th (IADL)
  - 1 - Prevalence

## Competition

- 3 (GLM, RF, XGBoost) \*
- 3 Sampling Strategies for Training Data (30:70, Downsampling, SMOTE<sup>1</sup>)

<sup>1</sup> Chawla, N. V., Bowyer, K. W., Hall, L. O., and Kegelmeyer, W. P. (2002). Smote: Synthetic minority over-sampling technique. Journal of Artificial Intelligence Research, 16:321-357.

# Sampling



## Train/Test Split

- Country-specific
- Random; 30:70

## Downsampling

- Random Undersampling of Majority Class

## Synthetic Minority Over-Sampling Technique<sup>1</sup>

- Generates New Instances of Minority Class
- Majority Class is Undersampled

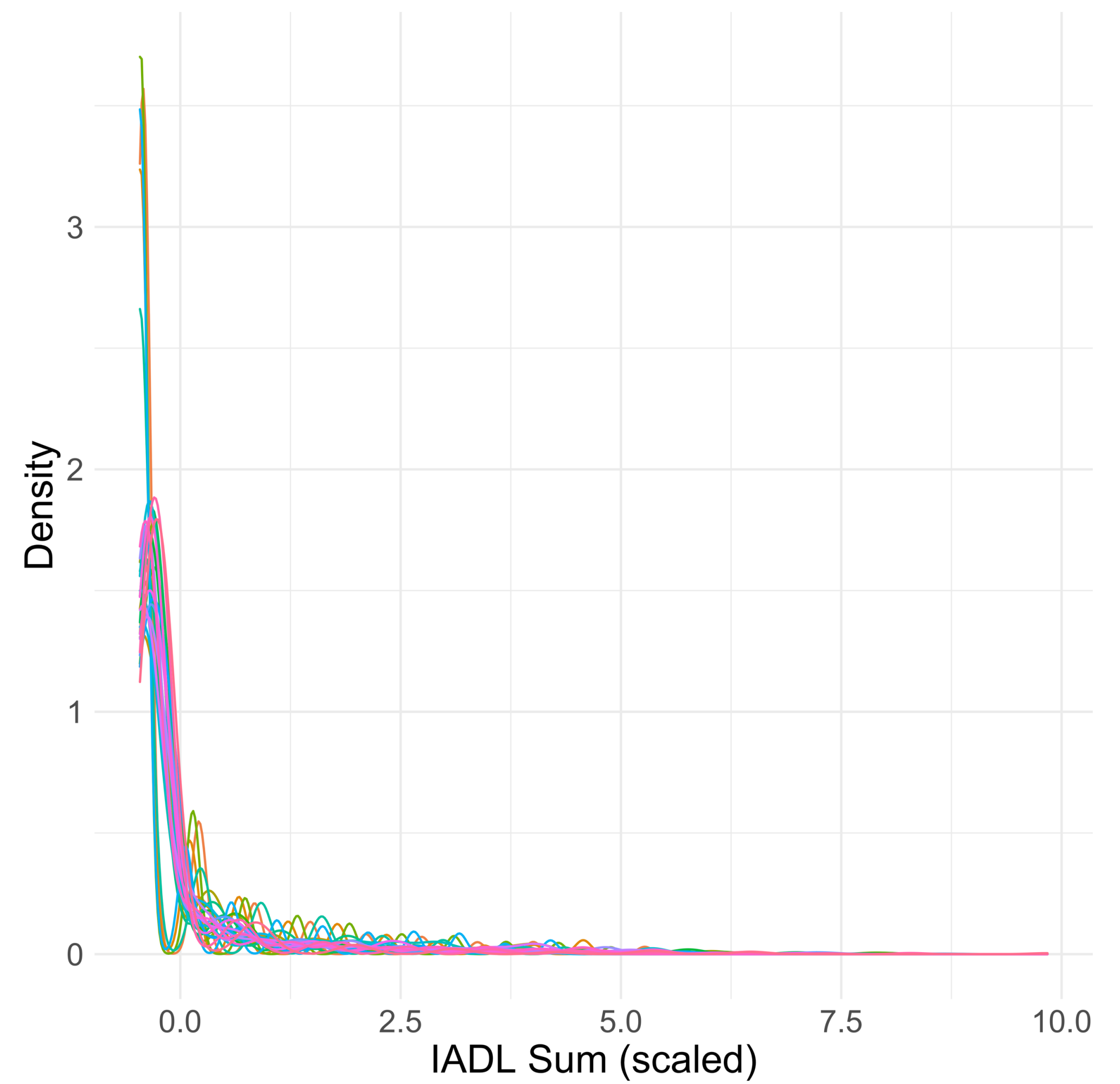
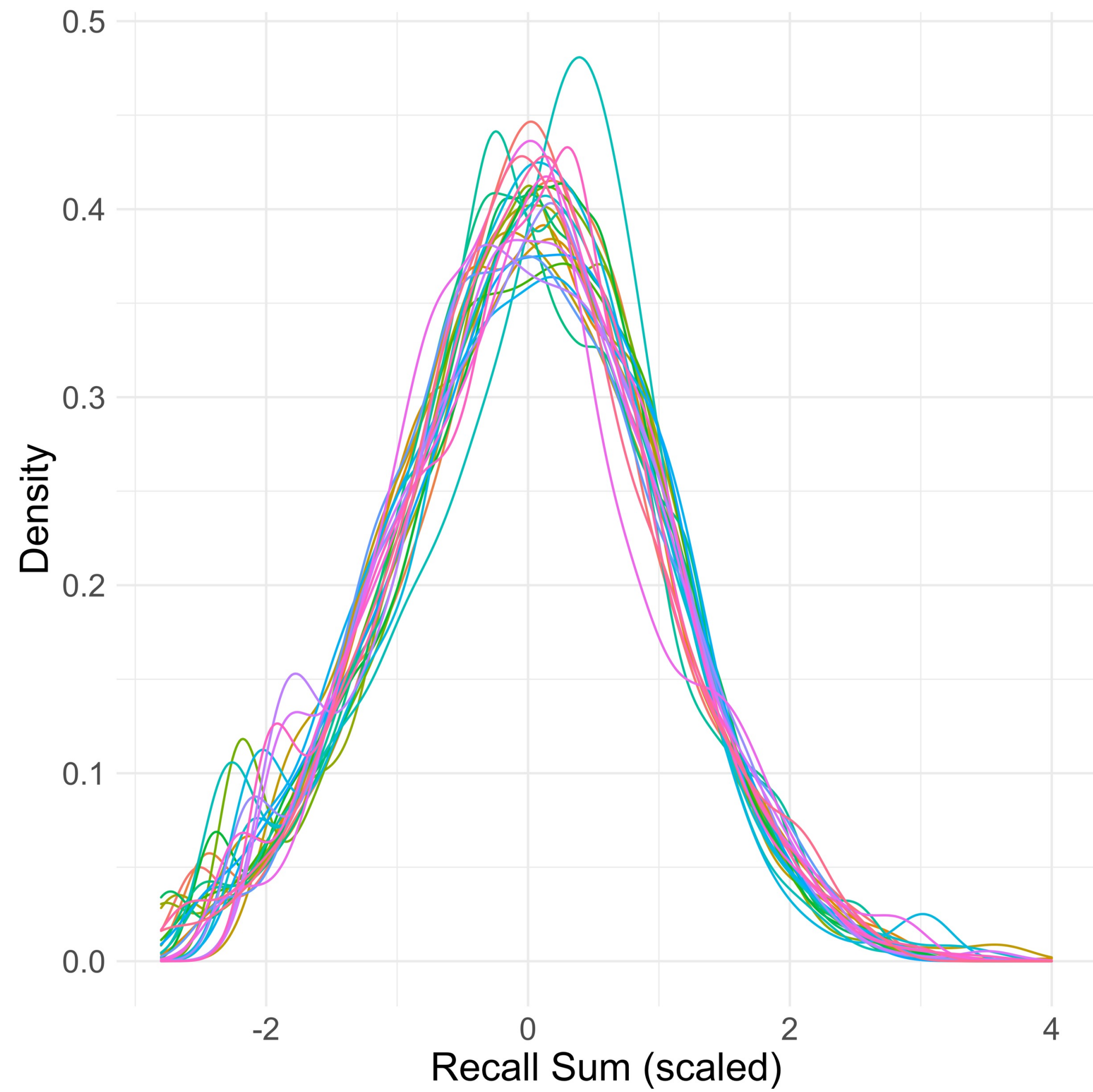
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# Methods

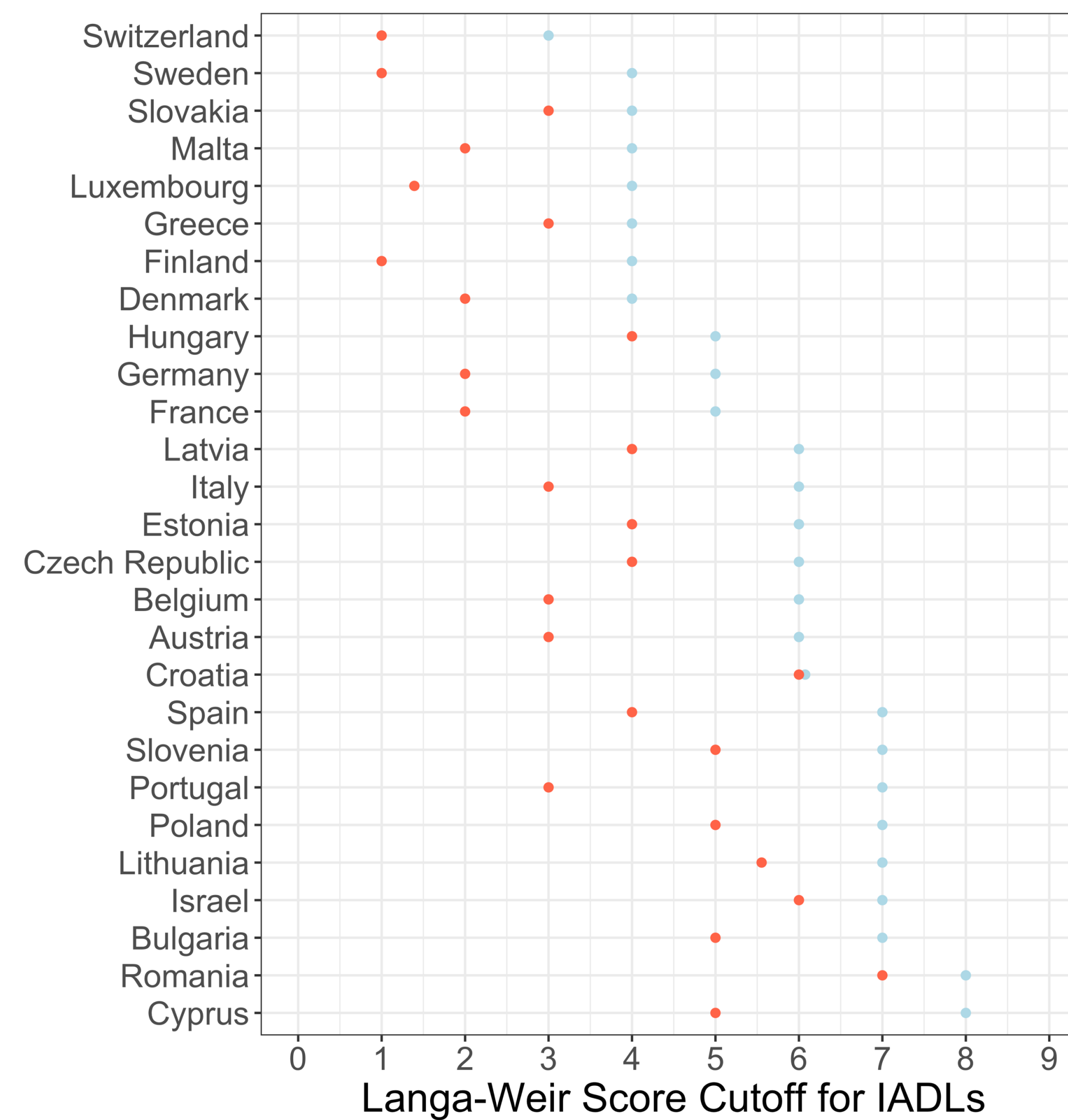
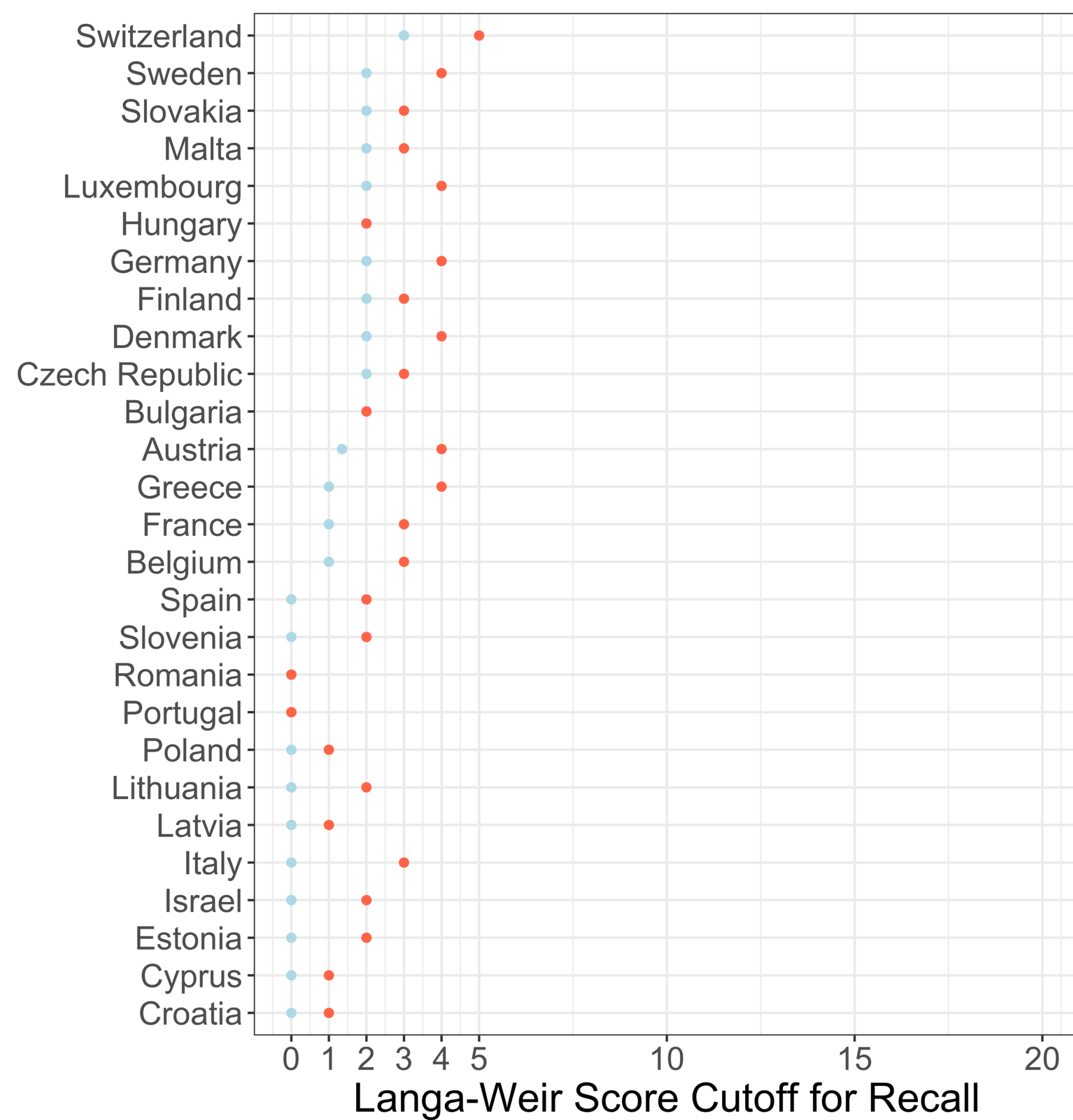
No Normal Distribution for Recall or IADL Sum

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# Methods

## Cut Points for IADL or Recall Criterion



Prevalence-based cutoff  
Statistically Informed cutoff



# Results

Underdiagnosis in SHARE

## Table 1.

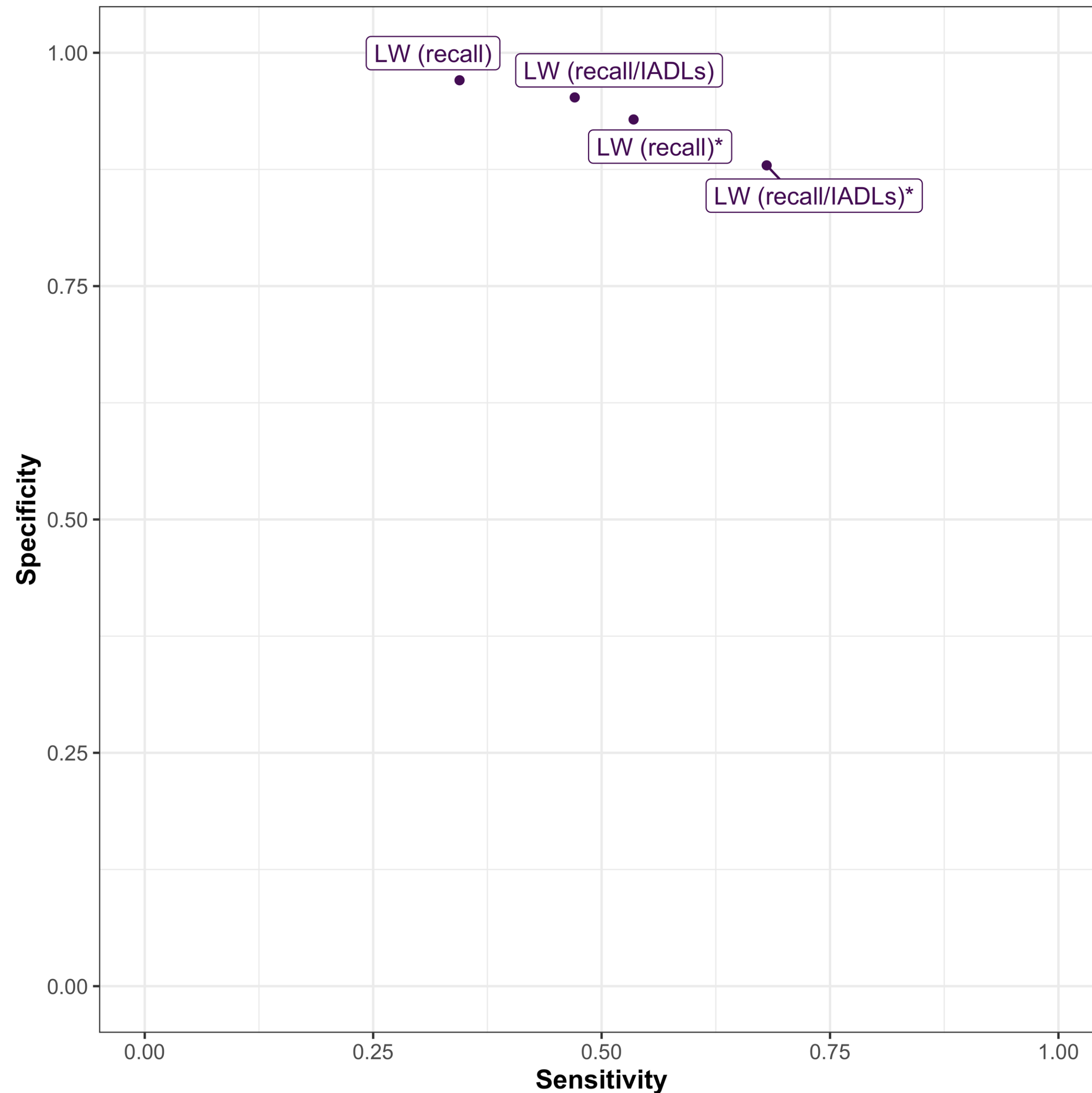
### Baseline Characteristics of Participants in the Training and Test Set

	Test Set	Training Set	P Value
<b>Age</b>			
Mean (SD)	71.8 (8.09)	71.7 (8.06)	.31
<b>Gender</b>			
Female	9,560 (56.2%)	22,324 (56.3%)	.92
Male	7,436 (43.8%)	17,328 (43.7%)	
<b>Educational Level (ISCED 1997)</b>			
Lower Secondary	6,841 (40.3%)	15,968 (40.3%)	.81
Tertiary	4,402 (25.9%)	10,358 (26.1%)	
Upper Secondary	5,753 (33.8%)	13,326 (33.6%)	
<b>Dementia Status</b>			
Dementia	357 (2.1%)	829 (2.1%)	.97
No dementia	16,639 (97.9%)	38,823 (97.9%)	

# Specificity vs. Sensitivity of Algorithms

## Langa-Weir Classification

\*Score Cutoff Threshold Accordig to OECD Prevalence<sup>1,2,3</sup>



**Inclusion of IADLs and Prevalence-informed Cutoff Thresholds Improve Sensitivity**

1 Prince M, Wimo A, Guerchet M, Ali GC, Wu YT, Prina M. World Alzheimer Report 2015. The Global Impact of Dementia. An Analysis of Prevalence, Incidence, Cost and Trends. Alzheimer's Disease International; 2015.

2 OECD/European Union (2018), "Dementia prevalence", in Health at a Glance: Europe 2018: State of Health in the EU Cycle, OECD Publishing, Paris/European Union, Brussels.

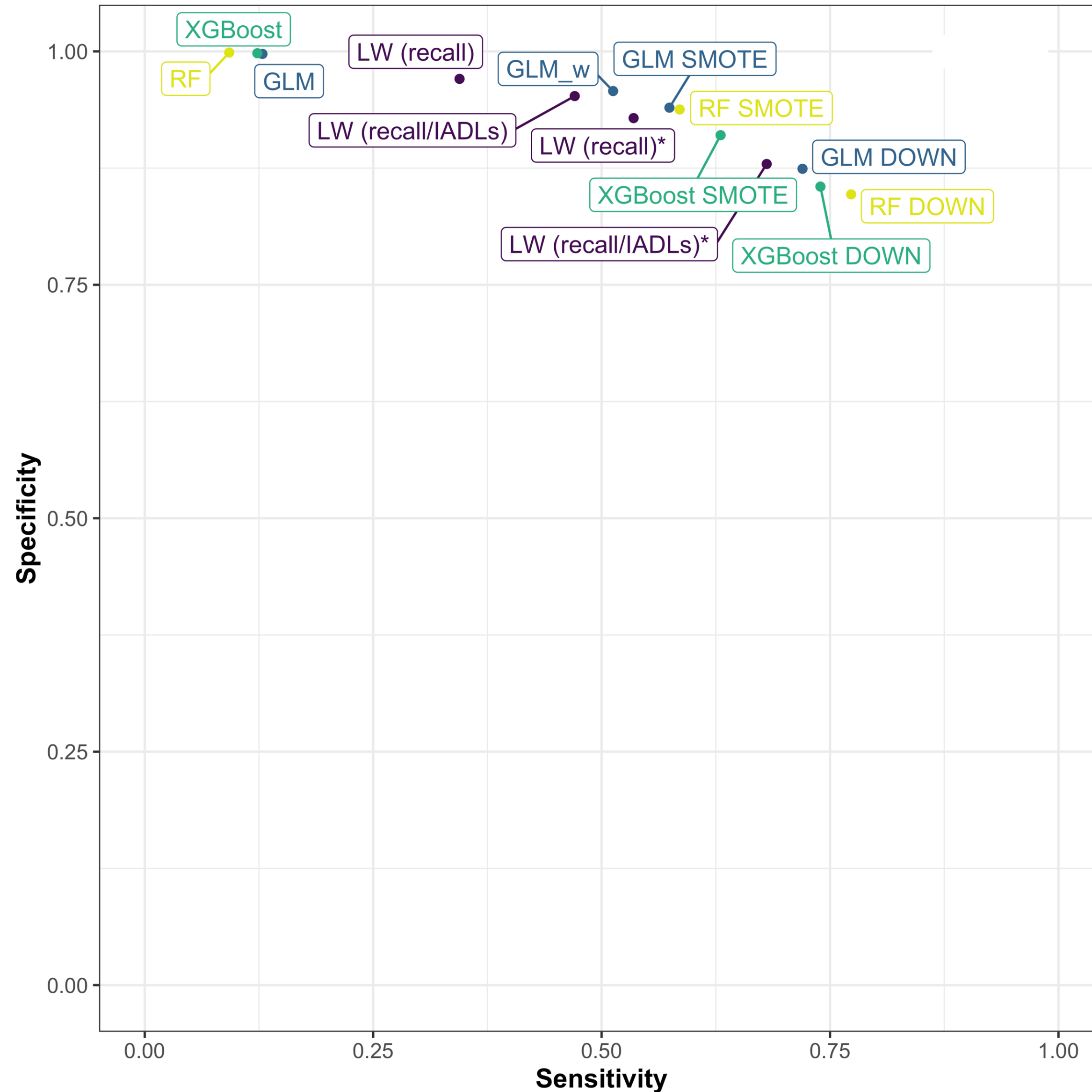
3 Kodesh A. Prevalence and comorbidities of dementia in Israel: A nationally representative cohort study. *Int Psychogeriatr.* 2019;31(7):1059-1063.

## Table 2.

Classifications Due IADL or Recall Criterion in Full Sample

	Dementia	No Dementia	% Correct
<b>Due IADLs</b>	177	1,087	14.0
<b>Due Recall</b>	402	1,696	19.2

# Specificity vs. Sensitivity of Algorithms



Langa-Weir Classification

\*Score Cutoff Threshold Accordig to OECD Prevalence<sup>1,2,3</sup>

Logistic Regression

Random Forest

XGBoost



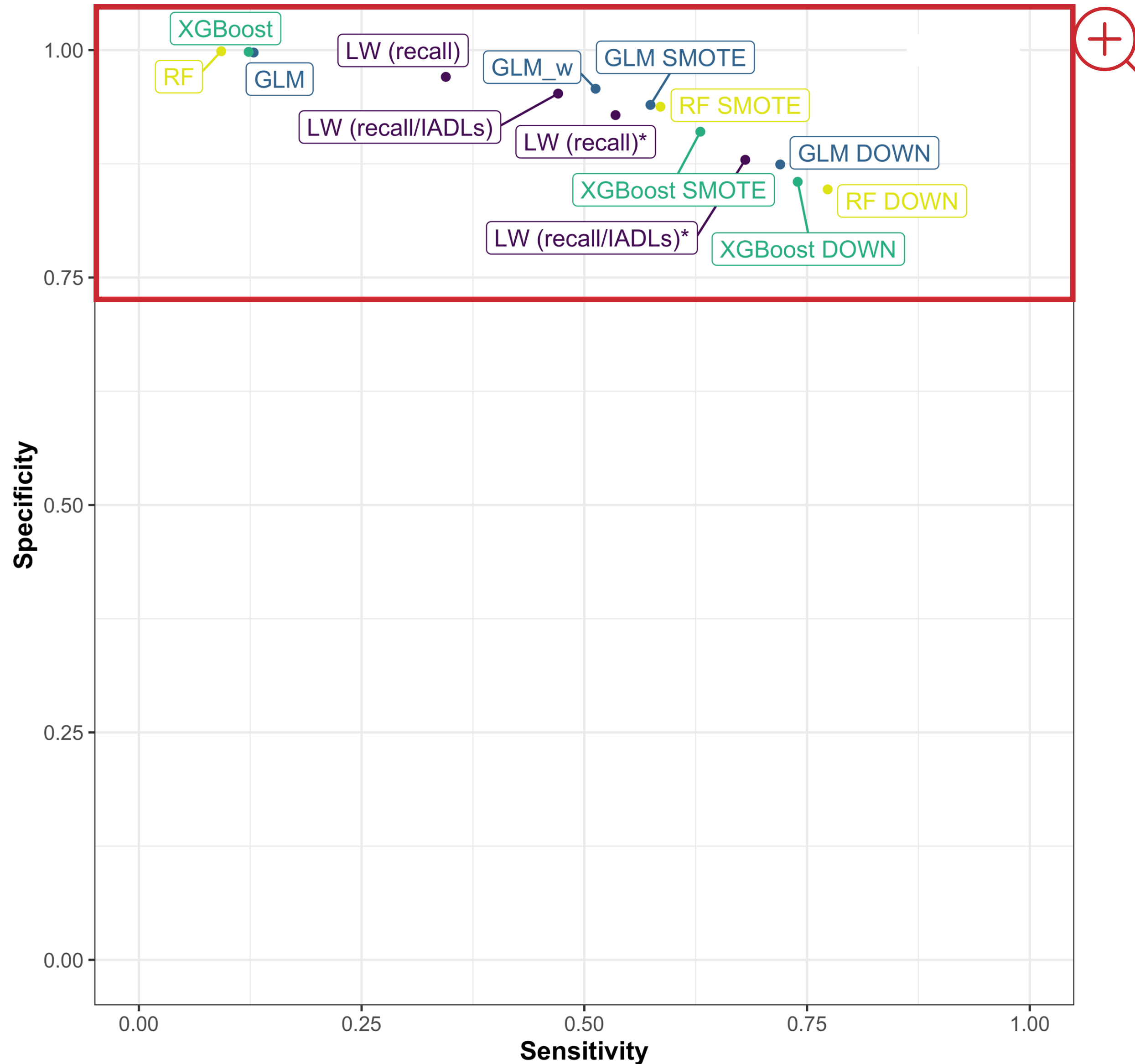
**Competitive Algorithms Align  
According to Sampling Strategy**

1 Prince M, Wimo A, Guerchet M, Ali GC, Wu YT, Prina M. World Alzheimer Report 2015. The Global Impact of Dementia. An Analysis of Prevalence, Incidence, Cost and Trends. Alzheimer's Disease International; 2015.

2 OECD/European Union (2018), "Dementia prevalence", in Health at a Glance: Europe 2018: State of Health in the EU Cycle, OECD Publishing, Paris/European Union, Brussels.

3 Kodesh A. Prevalence and comorbidities of dementia in Israel: A nationally representative cohort study. *Int Psychogeriatr.* 2019;31(7):1059-1063.

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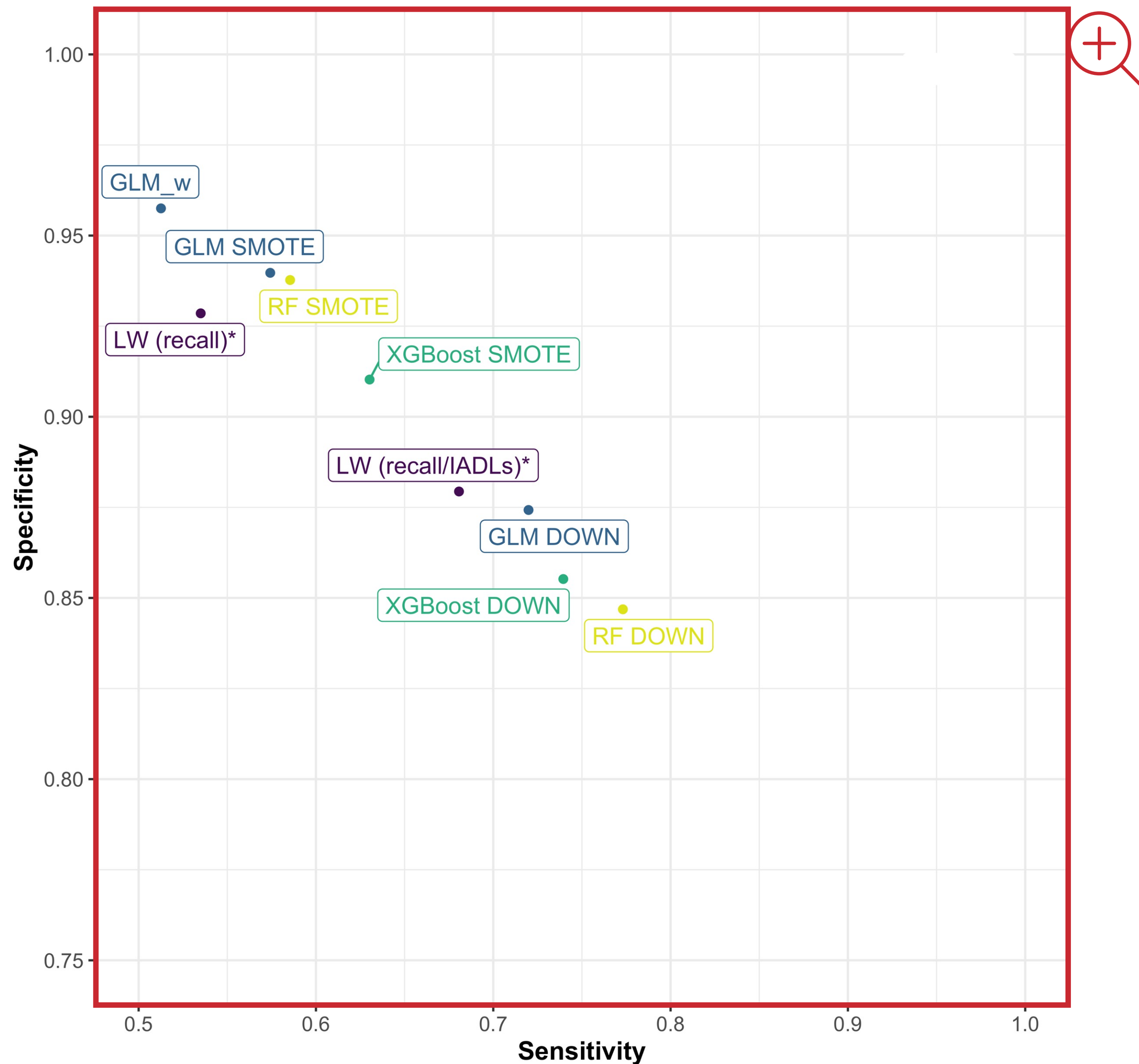
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2 OECD/European Union (2018), "Dementia prevalence", in Health at a Glance: Europe 2018: State of Health in the EU Cycle, OECD Publishing, Paris/European Union, Brussels.

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# Specificity vs. Sensitivity of Algorithms



Langa-Weir Classification

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Logistic Regression

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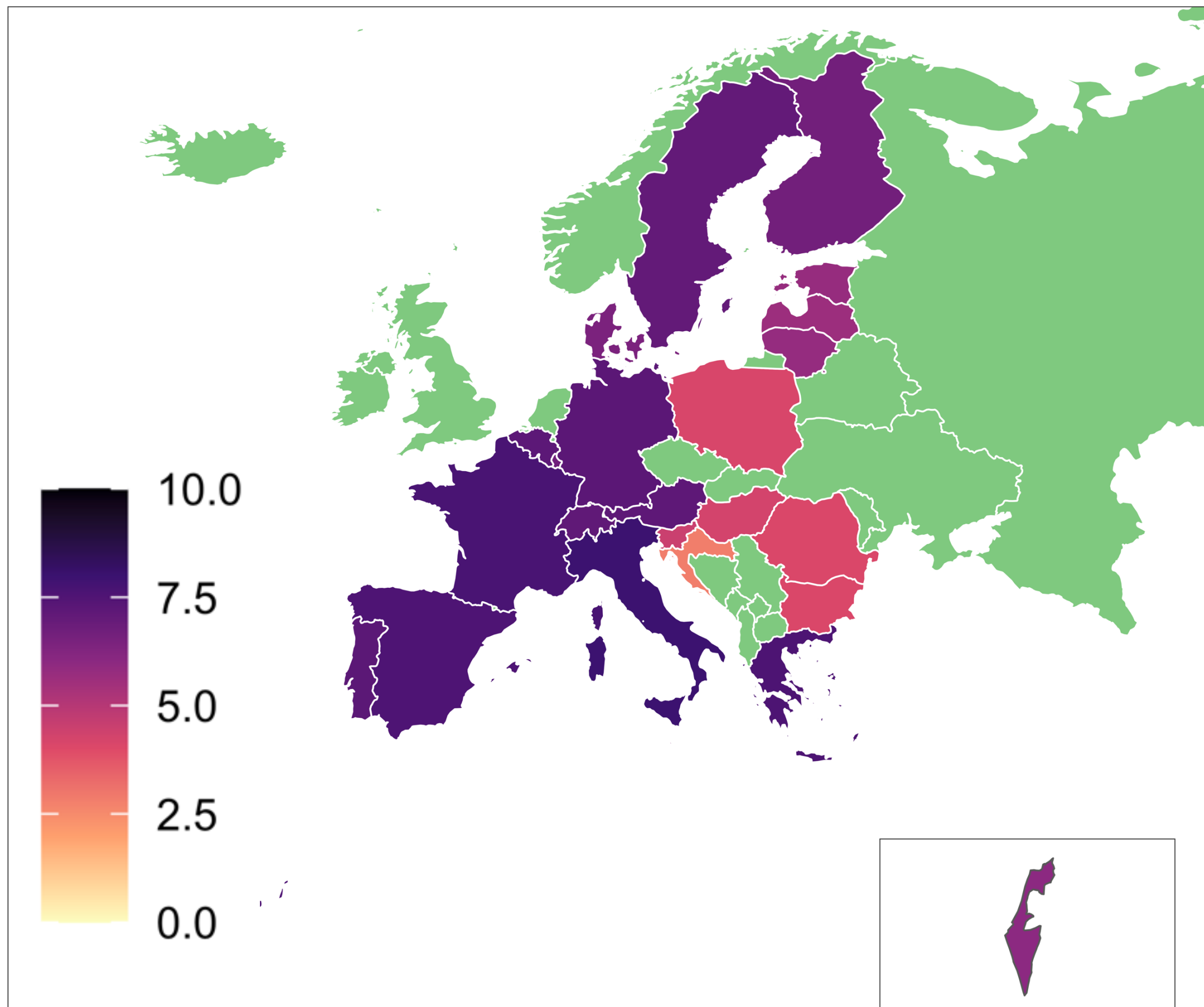


**Favorable Performance of Competitive Algorithms Holds With AUCs between .87 and .89**

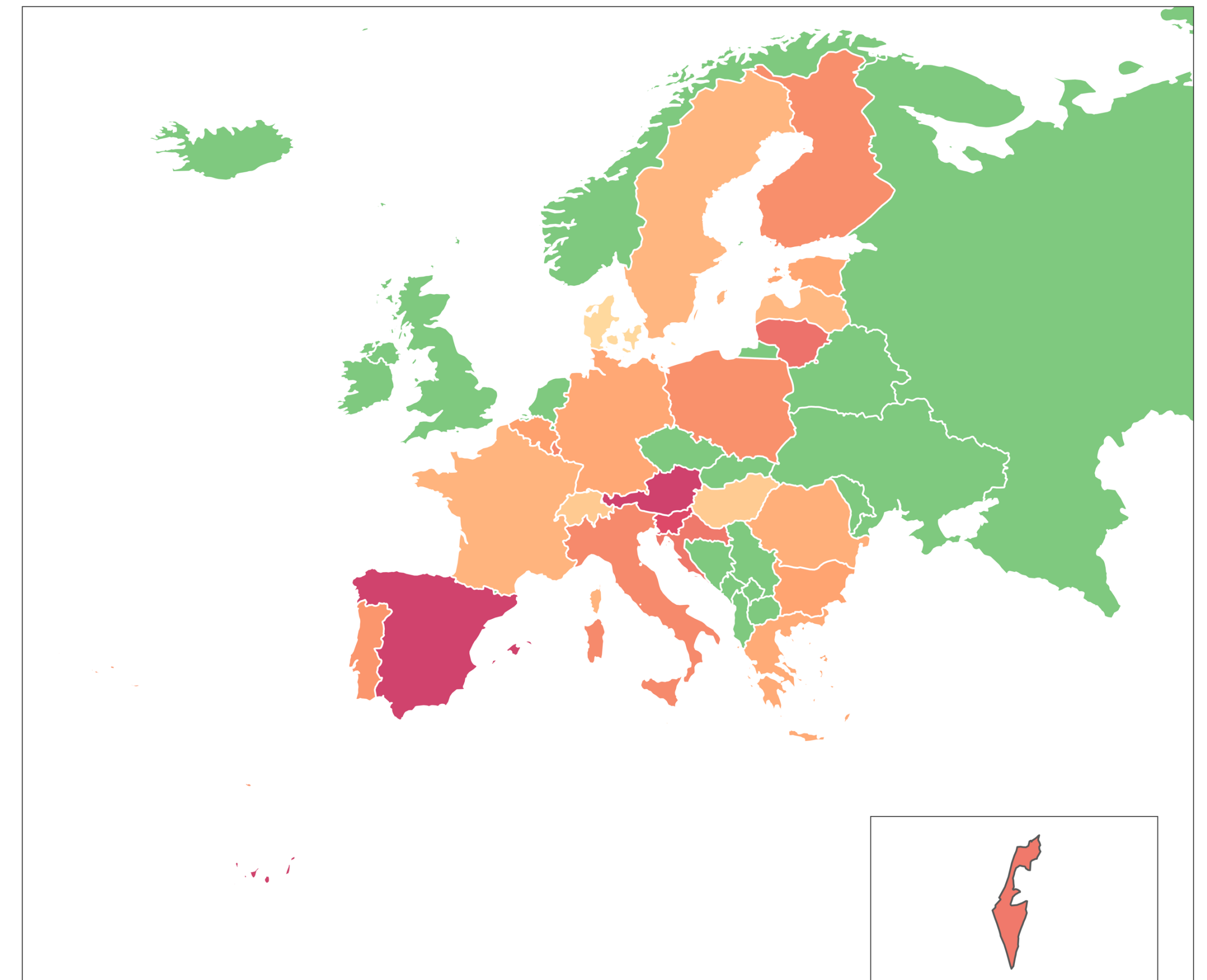
1 Prince M, Wimo A, Guerchet M, Ali GC, Wu YT, Prina M. World Alzheimer Report 2015. The Global Impact of Dementia. An Analysis of Prevalence, Incidence, Cost and Trends. Alzheimer's Disease International; 2015.

2 OECD/European Union (2018), "Dementia prevalence", in Health at a Glance: Europe 2018: State of Health in the EU Cycle, OECD Publishing, Paris/European Union, Brussels.

3 Kodesh A. Prevalence and comorbidities of dementia in Israel: A nationally representative cohort study. *Int Psychogeriatr.* 2019;31(7):1059-1063.



OECD Projections



SHARE Data

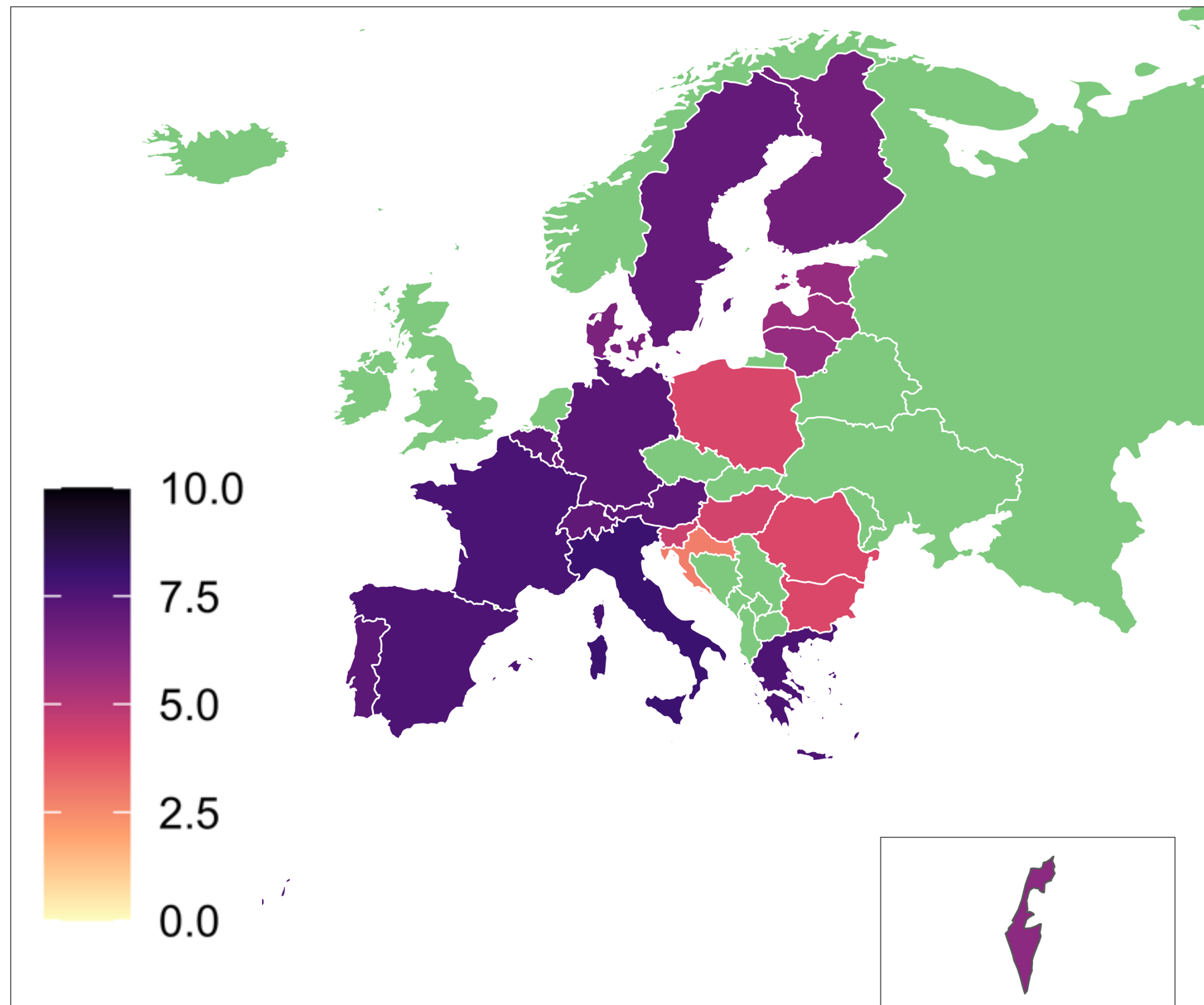
Dementia Prevalence According to OECD Projections<sup>1,2,3</sup>.

Dementia Prevalence According to SHARE Self-reported Dementia Diagnosis in Wave 7.

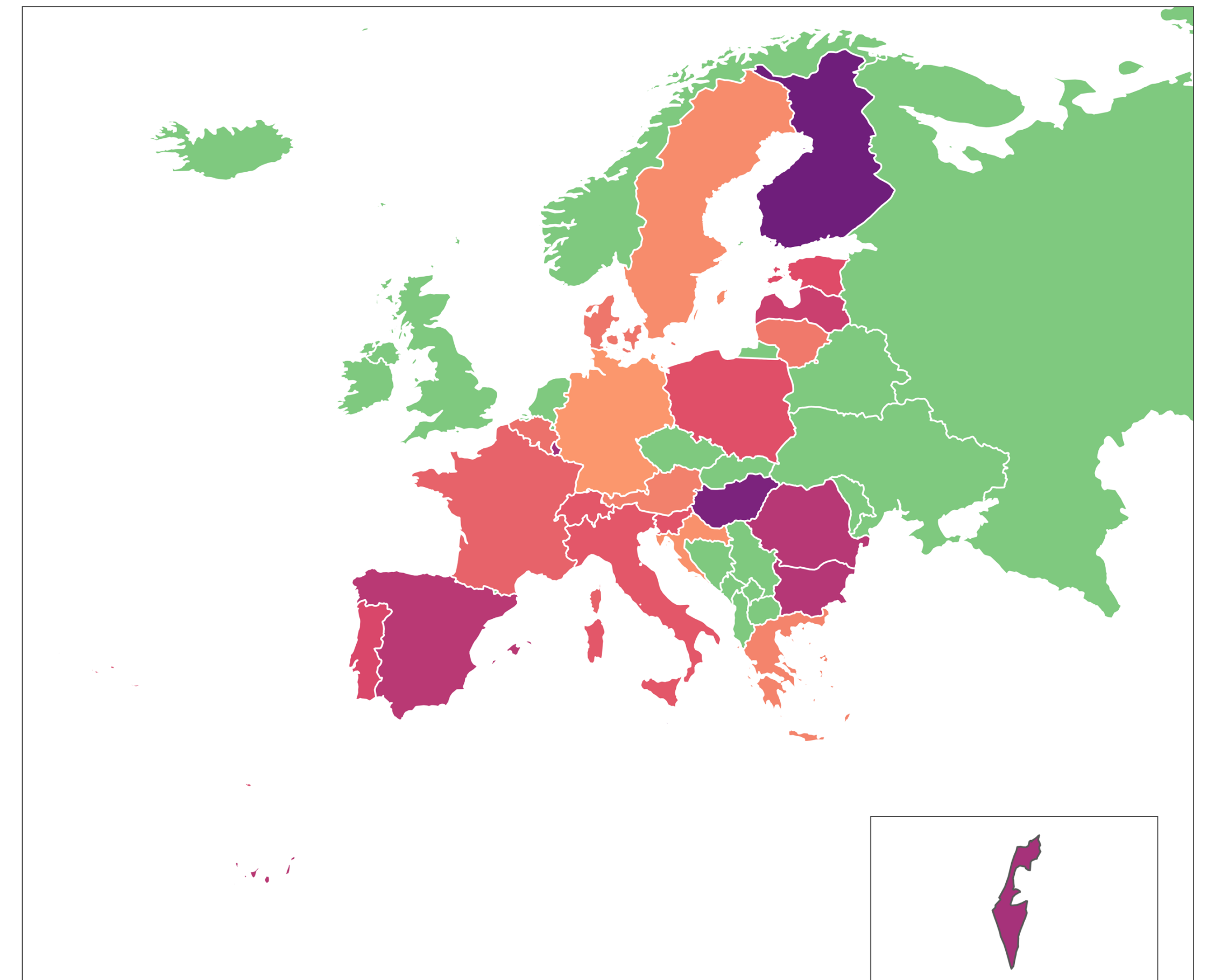
1 Prince M, Wimo A, Guerchet M, Ali GC, Wu YT, Prina M. World Alzheimer Report 2015. The Global Impact of Dementia. An Analysis of Prevalence, Incidence, Cost and Trends. Alzheimer's Disease International; 2015.

2 OECD/European Union (2018), "Dementia prevalence", in Health at a Glance: Europe 2018: State of Health in the EU Cycle, OECD Publishing, Paris/European Union, Brussels.

3 Kodesh A. Prevalence and comorbidities of dementia in Israel: A nationally representative cohort study. *Int Psychogeriatr.* 2019;31(7):1059-1063. doi:10.1017/S1041610218001461



OECD Projections



Langa-Weir (Recall)

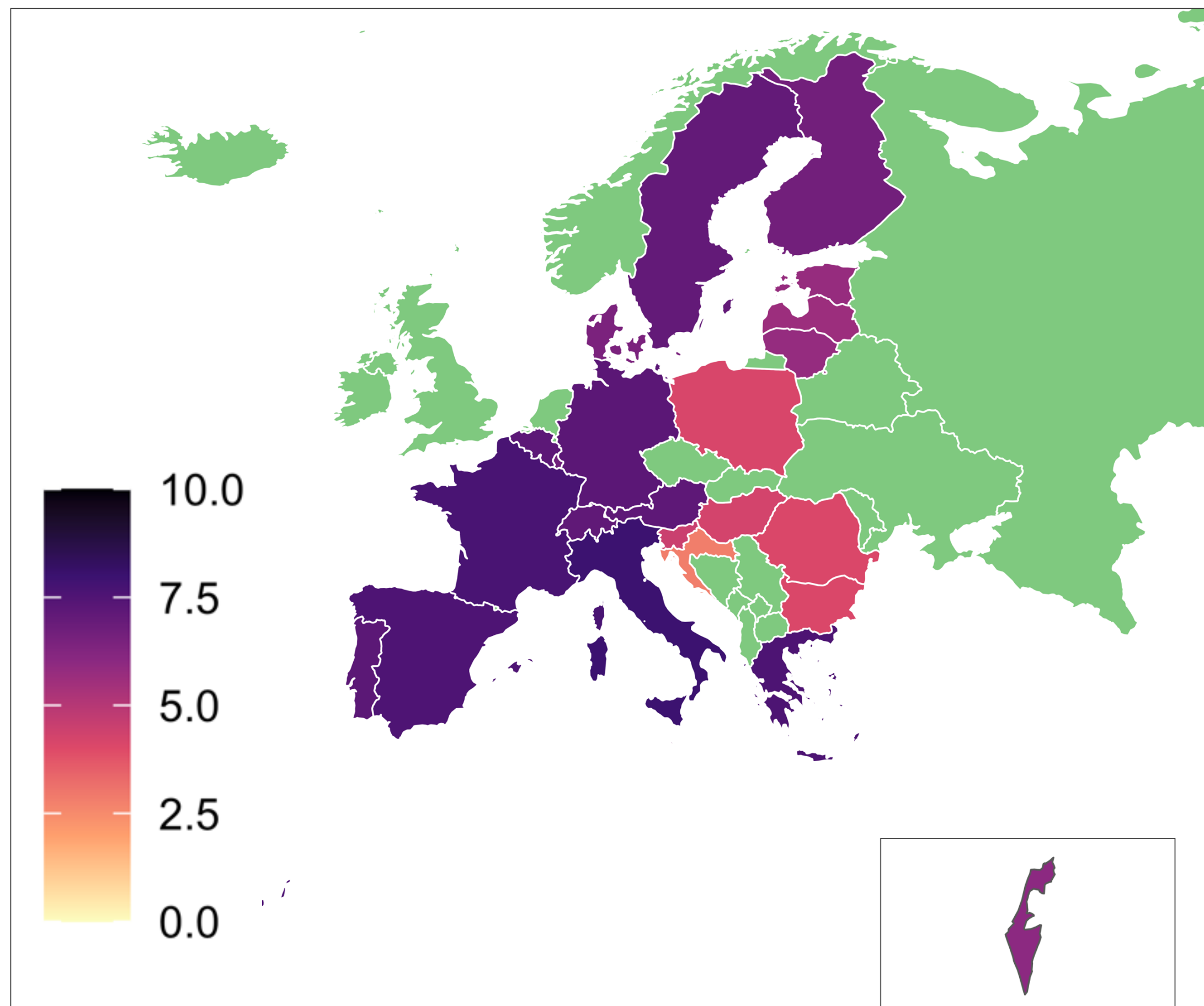
Dementia Prevalence According to OECD Projections<sup>1,2,3</sup>.

Dementia Prevalence According to Langa-Weir Classifications based on Recall.

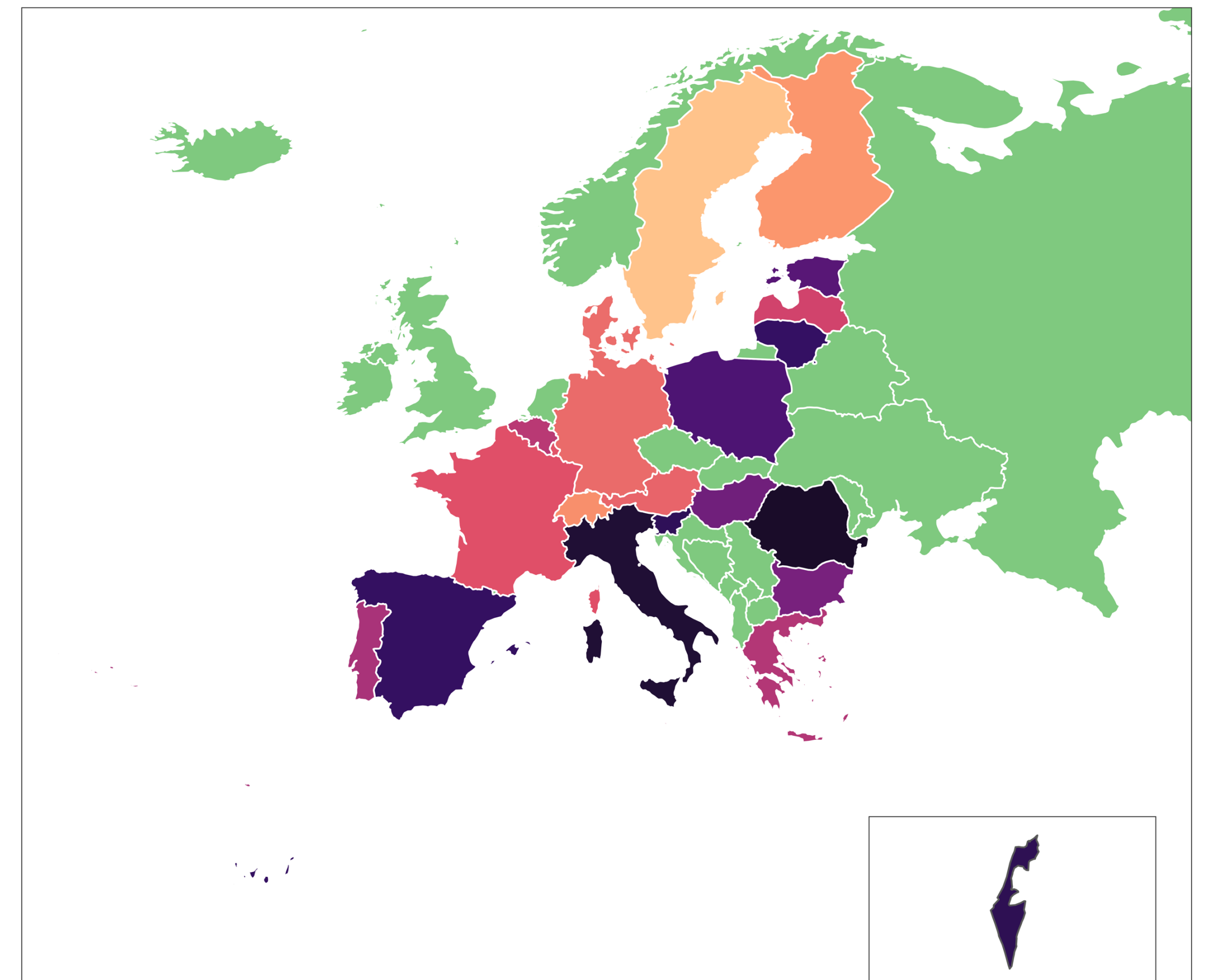
1 Prince M, Wimo A, Guerchet M, Ali GC, Wu YT, Prina M. World Alzheimer Report 2015. The Global Impact of Dementia. An Analysis of Prevalence, Incidence, Cost and Trends. Alzheimer's Disease International; 2015.

2 OECD/European Union (2018), "Dementia prevalence", in Health at a Glance: Europe 2018: State of Health in the EU Cycle, OECD Publishing, Paris/European Union, Brussels.

3 Kodesh A. Prevalence and comorbidities of dementia in Israel: A nationally representative cohort study. *Int Psychogeriatr.* 2019;31(7):1059-1063. doi:10.1017/S1041610218001461



OECD Projections



Logistic Regression

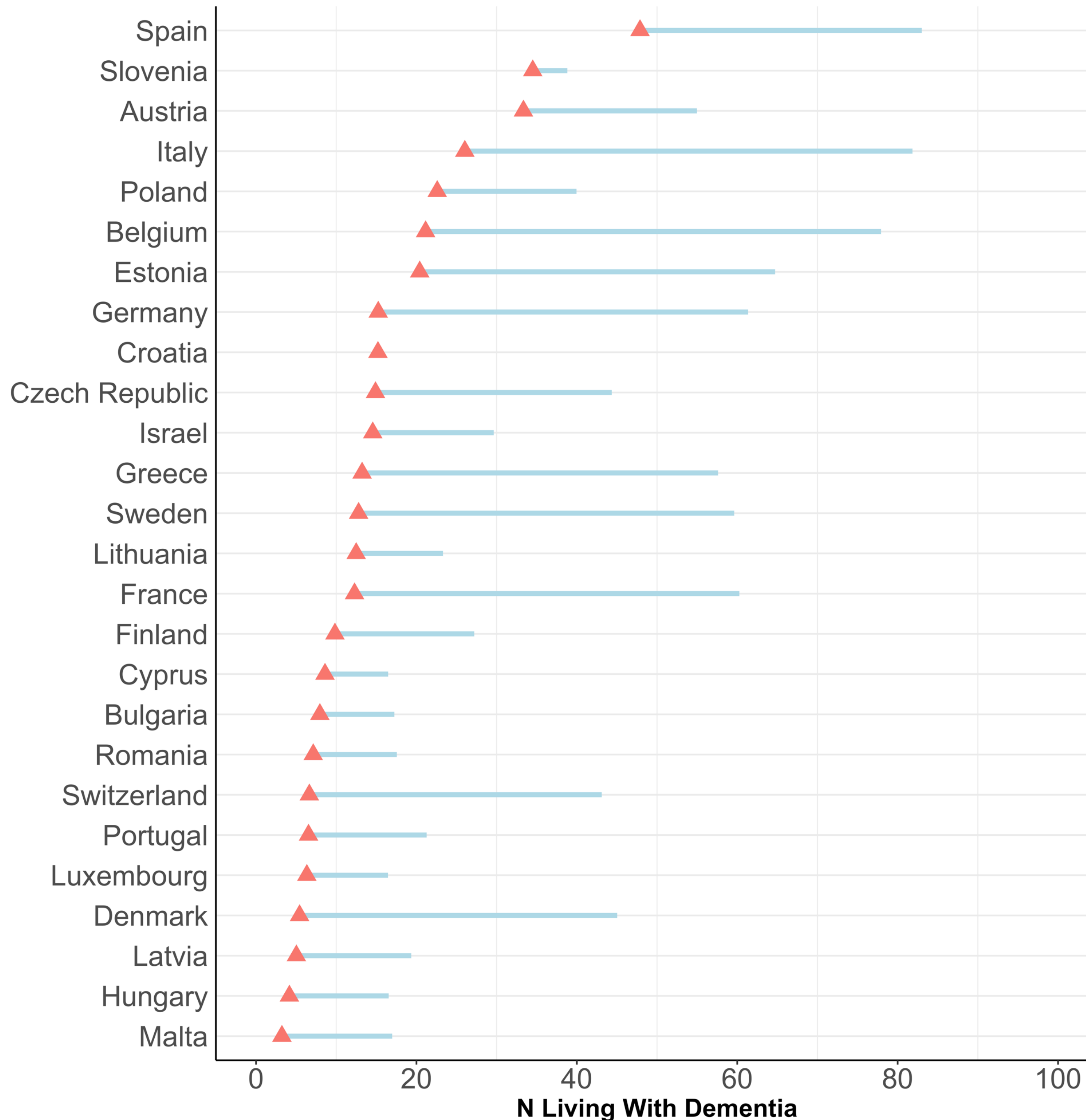
Dementia Prevalence According to OECD Projections<sup>1,2,3</sup>.

Dementia Prevalence According to Weighted Logistic Regression

1 Prince M, Wimo A, Guerchet M, Ali GC, Wu YT, Prina M. World Alzheimer Report 2015. The Global Impact of Dementia. An Analysis of Prevalence, Incidence, Cost and Trends. Alzheimer's Disease International; 2015.

2 OECD/European Union (2018), "Dementia prevalence", in Health at a Glance: Europe 2018: State of Health in the EU Cycle, OECD Publishing, Paris/European Union, Brussels.

3 Kodesh A. Prevalence and comorbidities of dementia in Israel: A nationally representative cohort study. *Int Psychogeriatr.* 2019;31(7):1059-1063. doi:10.1017/S1041610218001461



# Total N Classified Living With Dementia (SHARE)

Point range: N Factual (SHARE Self-report Dementia) to N Expected (ADI Projections<sup>1,2,3</sup>)

**N Factual SHARE**

Data: Test Set



**Mean Underdiagnosis (95% CI) =**

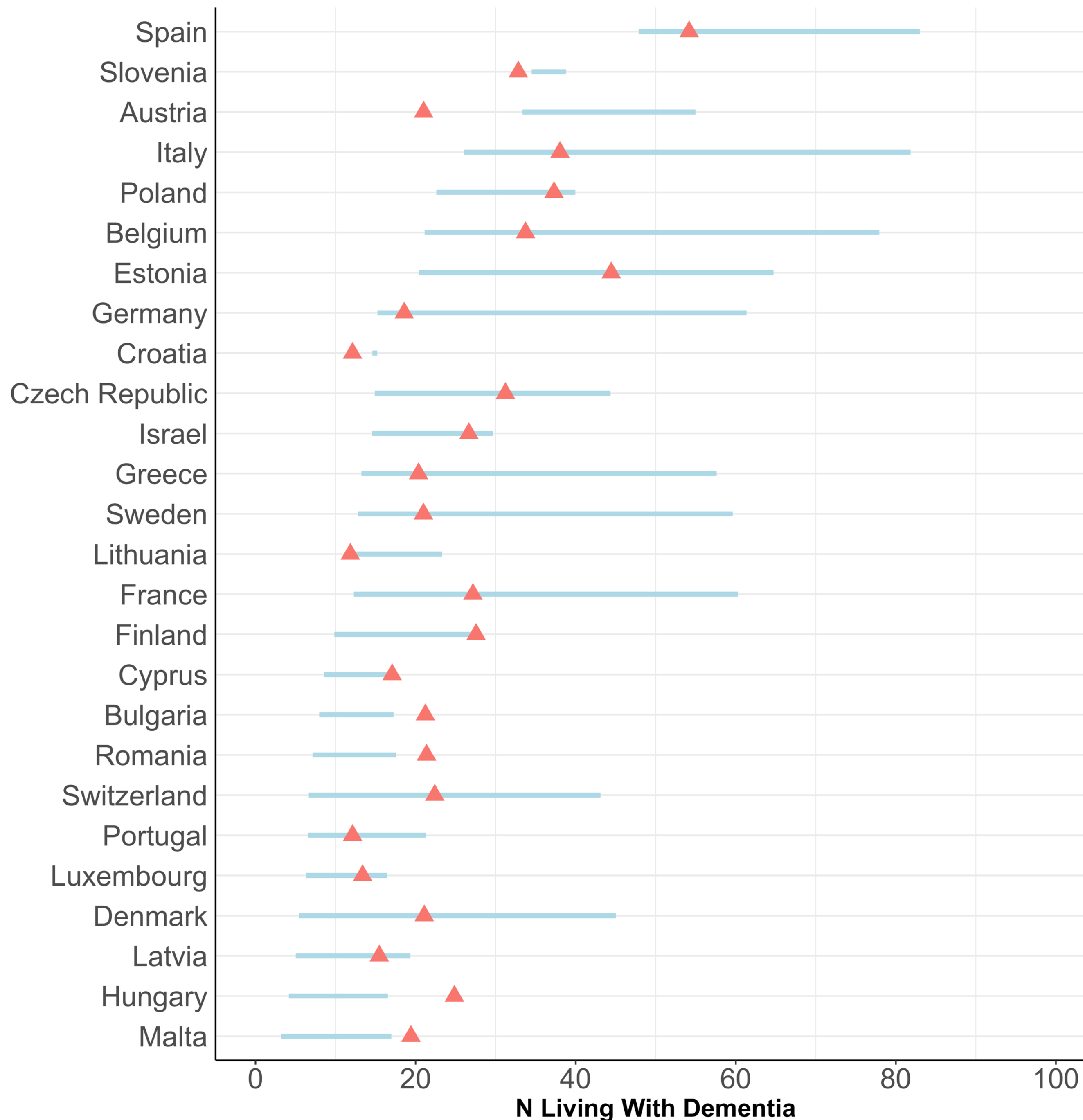
**60.5% (51.7%-69.3%)**

with: Underdiagnosis =  $1 - \frac{N_{factual}}{N_{expected}}$

1 Prince M, Wimo A, Guerchet M, Ali GC, Wu YT, Prina M. World Alzheimer Report 2015. The Global Impact of Dementia. An Analysis of Prevalence, Incidence, Cost and Trends. Alzheimer's Disease International; 2015.

2 OECD/European Union (2018), "Dementia prevalence", in Health at a Glance: Europe 2018: State of Health in the EU Cycle, OECD Publishing, Paris/European Union, Brussels.

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# Total N Classified Living With Dementia (SHARE)

Point range: N Factual (SHARE Self-report Dementia) to N Expected (ADI Projections<sup>1,2,3</sup>)

**N Classified with Langa-Weir (Recall)**

Data: Test Set

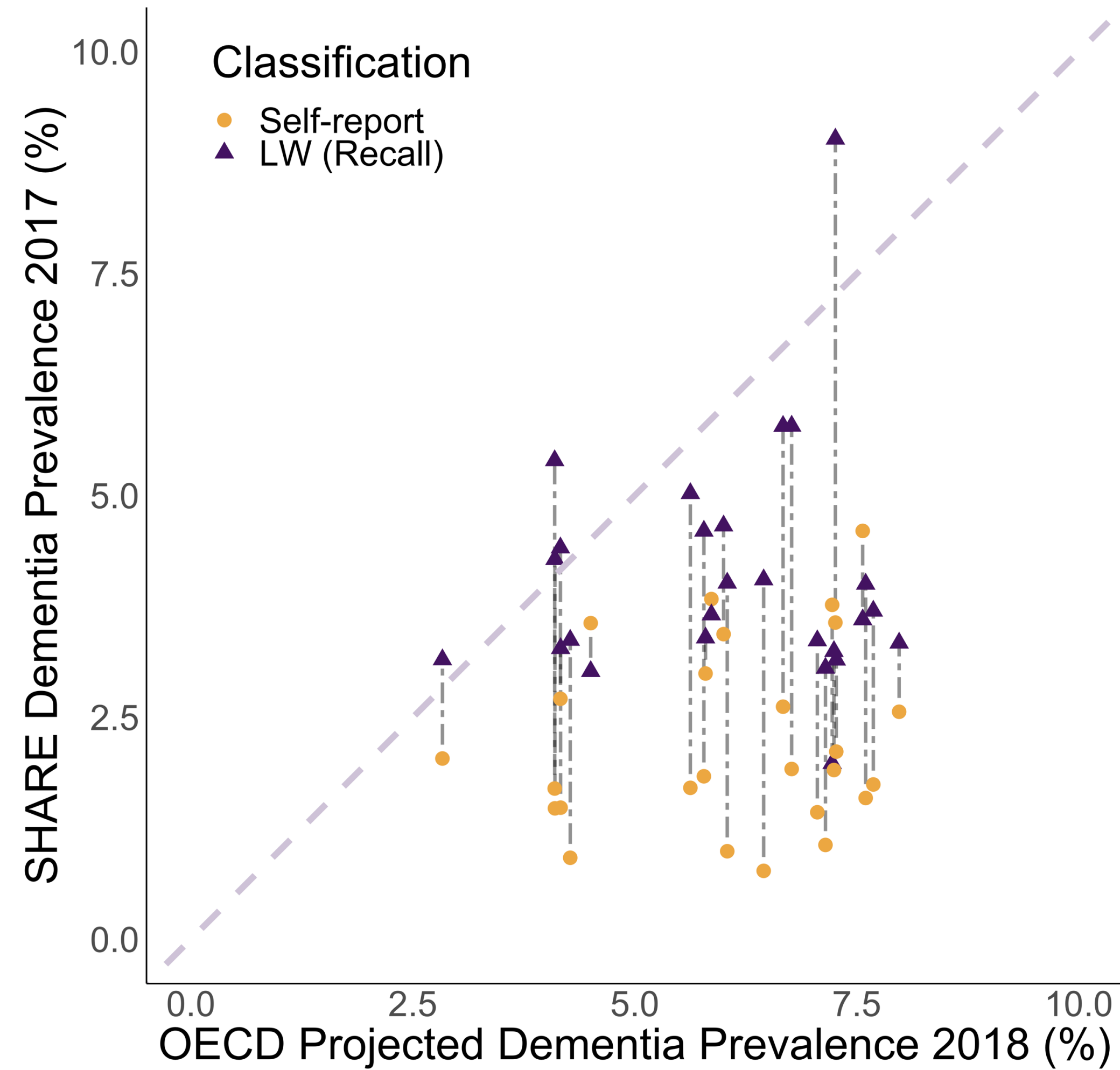
**i** **Mean Underdiagnosis (95% CI) = 26.5% (13.6%-39.4%)**

$$\text{with: Underdiagnosis} = 1 - \frac{N_{\text{factual}}}{N_{\text{expected}}}$$

1 Prince M, Wimo A, Guerchet M, Ali GC, Wu YT, Prina M. World Alzheimer Report 2015. The Global Impact of Dementia. An Analysis of Prevalence, Incidence, Cost and Trends. Alzheimer's Disease International; 2015.  
 2 OECD/European Union (2018), "Dementia prevalence", in Health at a Glance: Europe 2018: State of Health in the EU Cycle, OECD Publishing, Paris/European Union, Brussels.  
 3 Kodesh A. Prevalence and comorbidities of dementia in Israel: A nationally representative cohort study. *Int Psychogeriatr.* 2019;31(7):1059-1063.

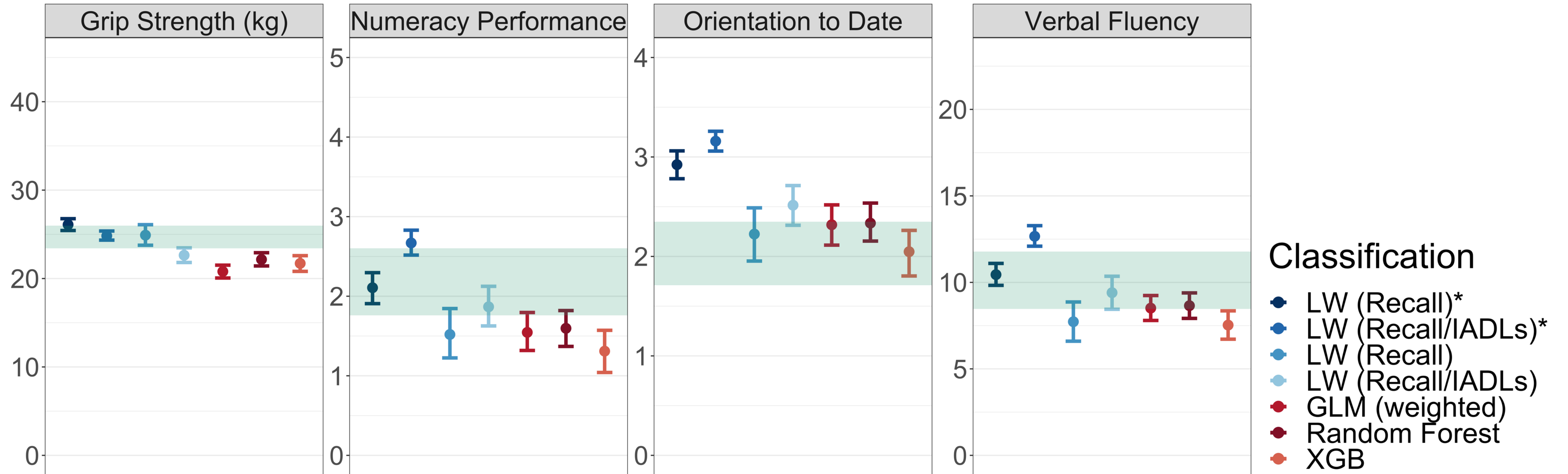
# Results

## Reduction in Underdiagnosis With LW



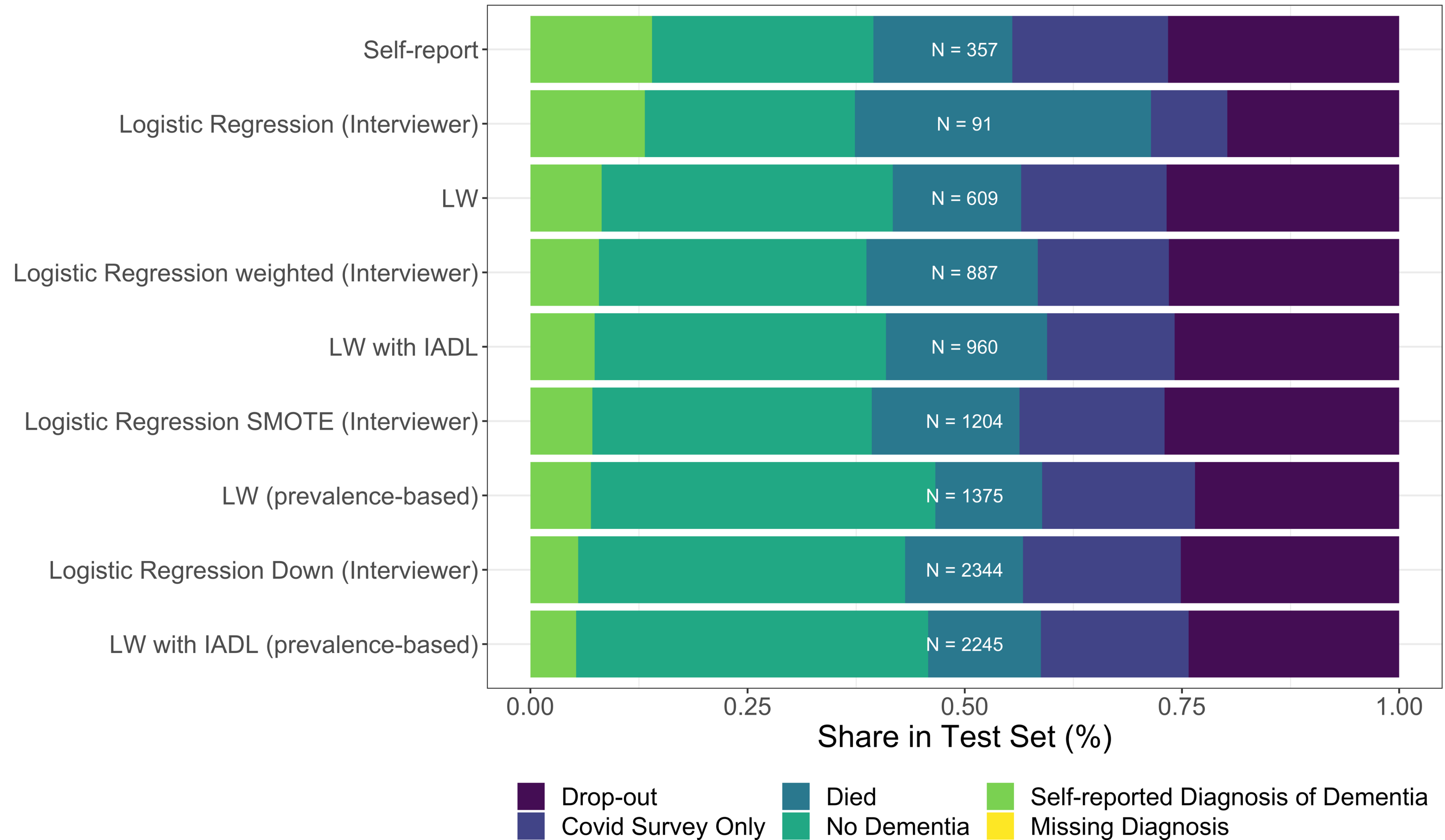
# Validation in Test Set

Examining Construct Validity of Classifications in Related Domains



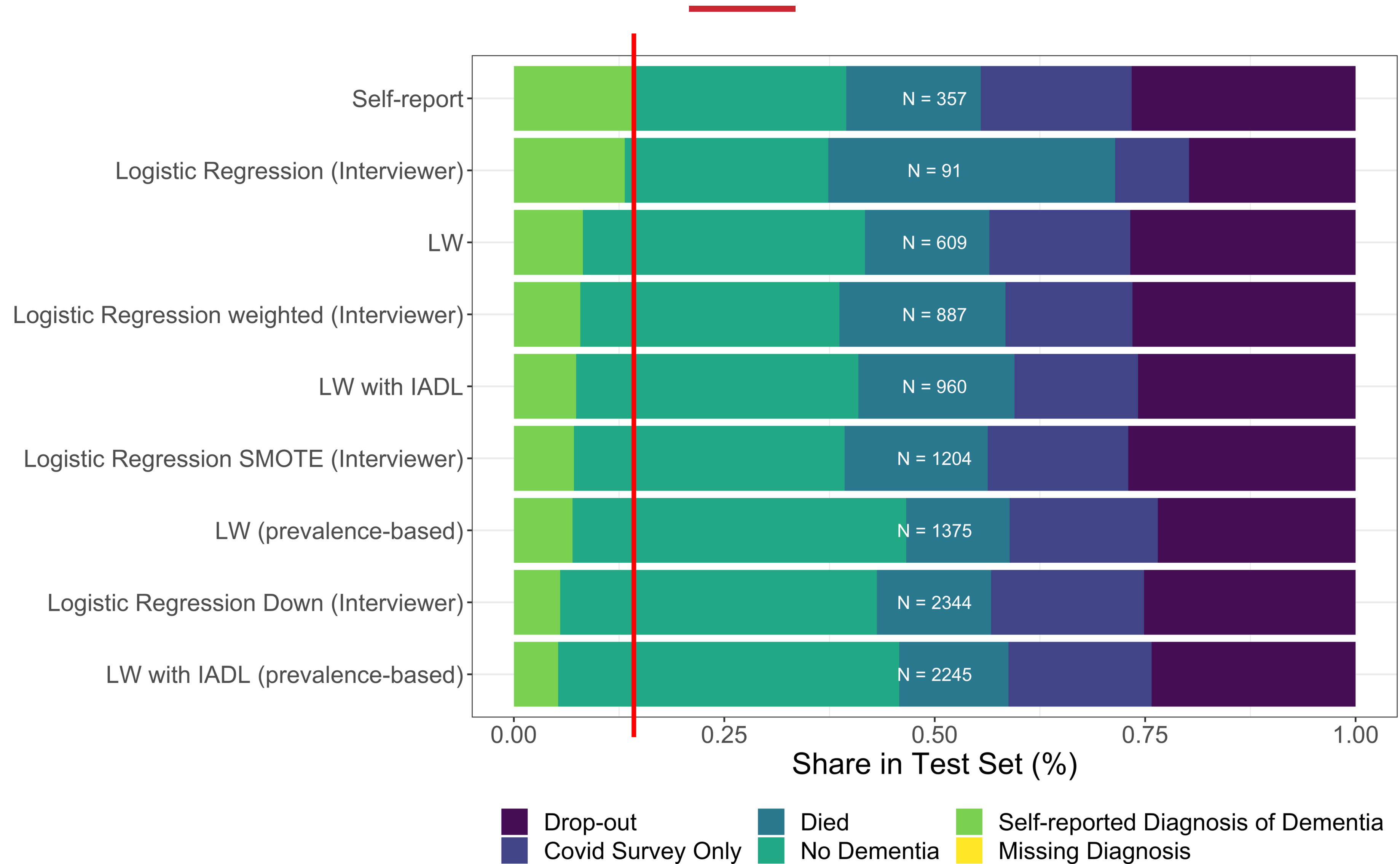
# Validation in Test Set

Examining Dementia Status 2 Years Later



# Validation in Test Set

Examining Dementia Status 2 Years Later





# Conclusions

Implications for Data Collection and Future Research

# Conclusions

## Dementia Classification in SHARE

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- Country Specific Langa-Weir Classification based on Recall With Most Preferable Sensitivity and Specificity Trade-Off Despite Much Lower Complexity
- Inclusion of Self-reported IADLs Improves Performance (at Expense of Sensitivity)
- Varying Performance Across Countries
- Further Validation

# Limitations

## Health and Retirement Study

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- Diversity<sup>1</sup>
- Power
- No Proxy Assessments
- Healthy Volunteers<sup>2</sup>
- Consistency in Dementia Status Over Time

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1 Gianattasio KZ, Ciarleglio A, Power MC. Development of Algorithmic Dementia Ascertainment for Racial/Ethnic Disparities Research in the US Health and Retirement Study. *Epidemiol Camb Mass* 2020;31:126–33.

2 Delgado-Rodriguez M, Llorca J. Bias. *J Epidemiol Community Health* 2004;58(8):635–641.

# Take Home Message

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Identifying probable dementia through dementia classification algorithms sheds new light on the magnitude of undiagnosed dementia in Europe. We provided a transportable classification algorithm that may increase statistical power, reduce underdiagnosis and improve validity in cross-national investigations.

The inclusion of proxy assessments and a broader range of cognitive tests is necessary for improvements in algorithmic classifications of probable dementia.

# Connect with Us



**Matthias Klee**

Institute for Research on Socio-Economic Inequality  
University of Luxembourg



Contact Info

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Web

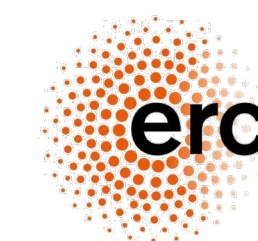
<https://cognitiveageing.uni.lu/>



Twitter

[@matthias\\_klee](https://twitter.com/matthias_klee)

# Funding Institution



European Research Council  
Established by the European Commission