

Racial and Ethnic Disparities in MCI and Dementia and Social Determinants in a Multi-ethnic US Cohort: A Machine Learning Approach

Huairui Wang, MS¹, Bei Wu, PhD², William T. Hu, MD, PhD^{3,4}, Xiang Qi, PhD¹

¹Rory Meyers College of Nursing, New York University, New York, NY 10010, USA; ² NYU Shanghai, Shanghai 200124, China; ³ Department of Neurology, Rutgers-Robert Wood Johnson Medical School and Center for Healthy Aging Research, USA; ⁴ Rutgers Institute for Health, Health Care Policy, and Aging Research, Rutgers Health, New Brunswick, USA

Background

Mild cognitive impairment (MCI) and dementia are common in older adults, but their prevalence and associated social determinants of health (SDOH) often differ across racial and ethnic groups. Examining these disparities and their underlying social risk factors is essential for understanding and addressing inequities in cognitive aging. In this study, we leveraged a large, multi-ethnic US cohort and validated EHR phenotypes to investigate how SDOH contribute to racial/ethnic differences in MCI and dementia.

Purpose

Aims 1: Quantify Prevalence Differences: Describe and compare the prevalence of MCI and dementia across 17 disaggregated racial and ethnic subgroups.

Aim 2: Assess SDOH Associations: Evaluate the associations between key SDOH factors and cognitive outcomes (MCI or dementia) in a diverse older adult population.

Aim 3: Identify Subgroup-Specific Predictors:

Determine how the importance of individual SDOH predictors varies across racial/ethnic subgroups, using a machine-learning model with SHAP (Shapley Additive Explanations) analysis to interpret subgroup-specific risk factor importance.

Methods

Population:

Data were analyzed from **104,955** participants aged ≥50 years in the *All of Us* Research Program. This cohort included individuals self-identifying into 17 disaggregated racial and ethnic categories.

Measurements:

MCI and dementia were ascertained using validated EHR phenotypes. **SDOH** included education, income, neighborhood disorder, perceived stress, and religiosity/spirituality, capturing socioeconomic, environmental, psychosocial, and cultural factors.

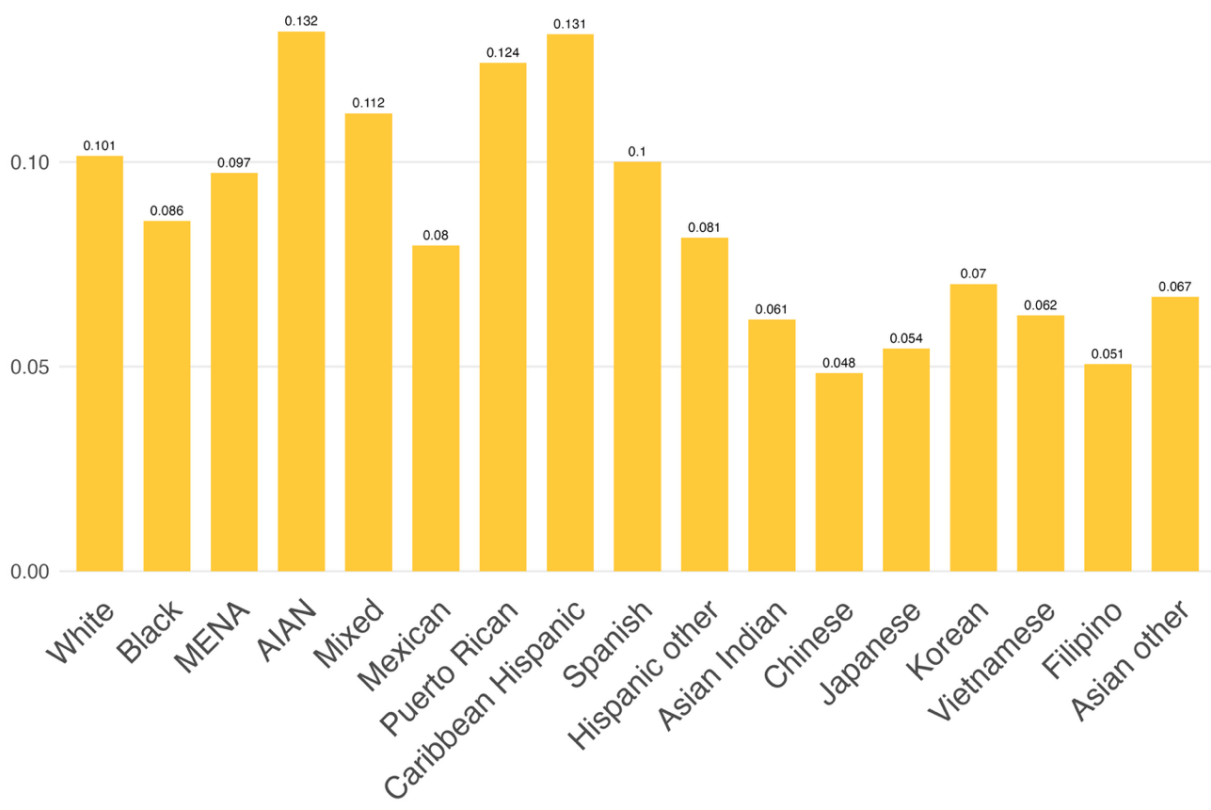
Analytical Approach:

We compared the prevalence of MCI and dementia across racial/ethnic groups. **XGBoost** were then used to model cognitive outcomes, and **SHAP** values were applied to assess the relative importance of individual SDOH predictors within each racial/ethnic subgroup.

Table 1. Means of SDOH and demographic characteristics for the whole sample and each Race and Ethnicity group (17 disaggregated groups).

Variable	White	Black	MENA	AIAN	Mixed	Mexican	Puerto Rican	Caribbean Hispanic	Spanish	Hispanic other	Asian Indian	Chinese	Japanese	Korean	Vietnamese	Filipino	Asian other
SDOH																	
Religious Attendance	1.932	3.236	1.714	2.332	2.010	2.804	2.239	2.439	2.449	2.497	1.811	1.431	1.180	2.218	2.333	2.871	2.036
Housing Quality	0.154	0.280	0.198	0.270	0.282	0.233	0.236	0.287	0.209	0.198	0.105	0.180	0.209	0.198	0.264	0.202	0.205
Housing Instability	0.080	0.140	0.088	0.138	0.126	0.100	0.141	0.094	0.153	0.122	0.096	0.068	0.063	0.100	0.055	0.102	0.119
Food Insecurity	0.084	0.294	0.104	0.330	0.233	0.286	0.329	0.329	0.317	0.225	0.043	0.041	0.061	0.044	0.103	0.127	0.178
PANES - Walking & Bicycling	2.729	2.947	3.024	2.798	2.870	3.100	3.107	3.117	3.091	3.130	2.971	3.103	3.180	3.061	3.202	3.234	3.201
PANES - Crime & Safety	1.368	1.988	1.375	1.730	1.624	1.939	1.939	1.856	1.734	1.651	1.350	1.475	1.465	1.518	1.712	1.604	1.593
Daily spiritual experiences	3.253	4.680	3.435	4.077	3.663	4.274	4.077	4.100	4.037	4.187	3.346	2.601	2.595	3.234	3.466	4.194	3.490
Neighborhood physical disorder	1.509	1.860	1.543	1.793	1.688	1.866	1.836	1.833	1.673	1.663	1.432	1.547	1.540	1.570	1.746	1.590	1.581
Neighborhood social disorder	1.520	1.901	1.580	1.860	1.733	1.877	1.888	1.870	1.707	1.711	1.496	1.556	1.581	1.621	1.743	1.621	1.661
Social cohesion	3.934	3.547	3.821	3.658	3.694	3.620	3.486	3.619	3.676	3.599	3.920	3.842	3.907	3.793	3.727	3.872	3.741
Everyday discrimination	0.616	1.147	0.703	1.020	1.006	0.677	0.828	0.648	0.853	0.672	0.750	0.844	0.837	0.896	0.627	0.780	0.990
Discrimination in medical settings	0.482	0.747	0.555	0.702	0.682	0.445	0.542	0.447	0.584	0.482	0.532	0.549	0.529	0.629	0.452	0.576	0.622
Perceived stress	2.175	2.365	2.360	2.409	2.439	2.356	2.474	2.426	2.424	2.317	2.260	2.153	2.200	2.390	2.346	2.342	2.382
Social support (total)	3.961	3.677	3.618	3.699	3.746	3.771	3.488	3.553	3.896	3.680	3.670	3.776	3.937	3.851	3.635	3.858	3.693
Loneliness	14.658	15.275	14.928	15.206	15.744	13.842	15.458	14.421	14.262	13.905	14.764	14.942	14.599	14.893	14.705	13.920	15.089
Demographic																	
Age	66.461	62.014	64.821	62.432	61.668	60.503	60.273	60.864	61.816	60.208	61.825	62.860	65.812	57.884	59.595	60.017	60.143
Birthplace	0.960	0.948	0.385	0.939	0.870	0.431	0.752	0.161	0.605	0.253	0.107	0.362	0.714	0.140	0.113	0.285	0.369
Partner	0.681	0.349	0.710	0.480	0.562	0.602	0.477	0.513	0.615	0.622	0.814	0.729	0.704	0.728	0.744	0.683	0.738
Income	0.747	0.411	0.768	0.399	0.591	0.391	0.430	0.436	0.474	0.506	0.895	0.852	0.837	0.835	0.808	0.801	0.738
Education	0.664	0.400	0.818	0.300	0.516	0.234	0.345	0.458	0.357	0.486	0.940	0.896	0.839	0.833	0.692	0.791	0.722
Employment	0.417	0.410	0.531	0.332	0.466	0.434	0.384	0.514	0.520	0.575	0.664	0.543	0.454	0.619	0.658	0.618	0.526
Insurance	0.989	0.949	0.994	0.958	0.972	0.888	0.969	0.979	0.900	0.923	0.993	0.993	0.997	1.000	0.975	0.984	0.977
Neighborhood deprivation	0.437	0.788	0.373	NA	0.564	0.735	0.622	0.869	0.757	0.708	0.331	0.404	0.388	0.430	0.562	0.498	0.391
Sex (male)	0.400	0.311	0.493	0.392	0.348	0.312	0.342	0.312	0.383	0.343	0.581	0.417	0.374	0.307	0.380	0.412	0.434
MCI	0.101	0.086	0.097	0.132	0.112	0.080	0.124	0.131	0.100	0.081	0.061	0.048	0.054	0.070	0.062	0.051	0.067
Dementia	0.051	0.045	0.046	0.062	0.057	0.034	0.068	0.074	0.035	0.047	0.033	0.034	0.020	0.044	0.038	0.027	0.017

a). MCI



b). Dementia

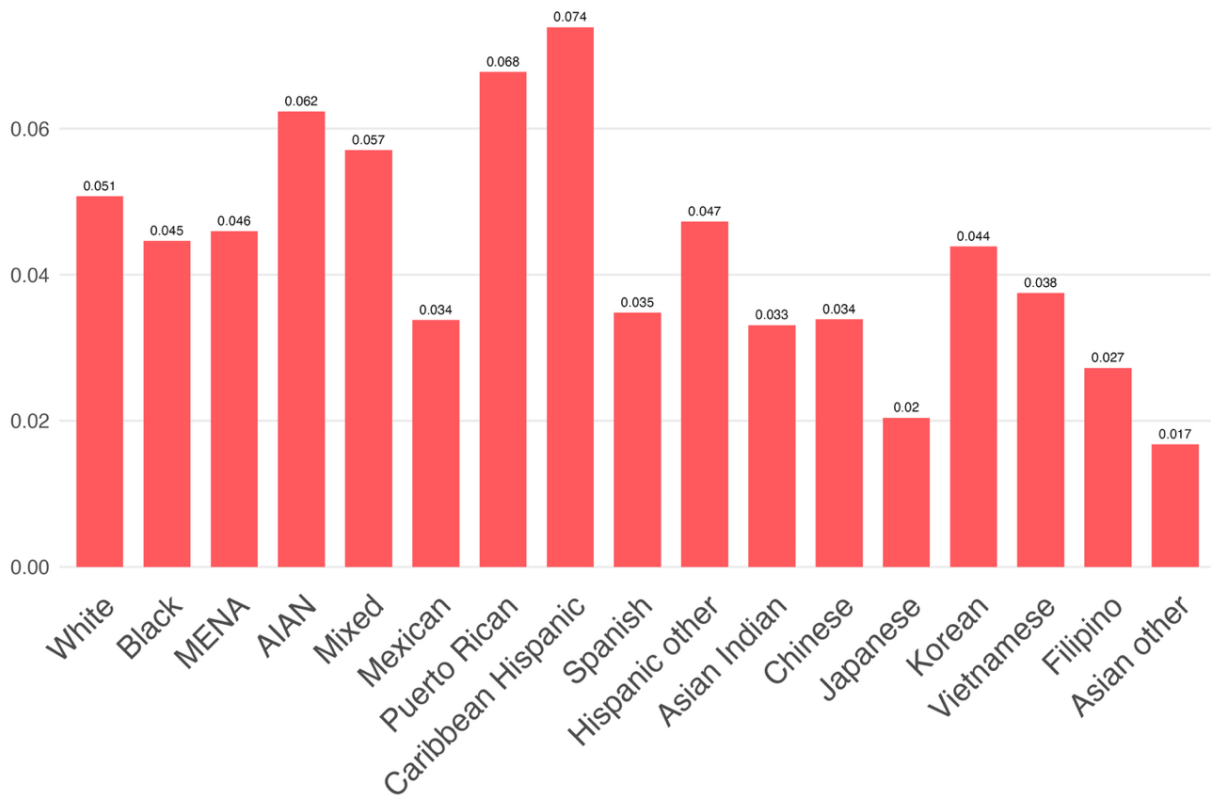


Fig. 1. Prevalence of MCI and dementia among 17 Race and Ethnicity groups.

Table 2. Top three SDOH predictors identified by SHAP-based feature importance for MCI and dementia across racial/ethnic subgroups

Outcome	Race/Ethnicity	Top 1 SHAP-ranked predictor		Top 2 SHAP-ranked predictor		Top 3 SHAP-ranked predictor	
		SDOH	SHAP Value	SDOH	SHAP Value	SDOH	SHAP Value
MCI	All	Perceived stress	0.219	Employment	0.162	Loneliness	0.112
	White	Perceived stress	0.222	Employment	0.162	Loneliness	0.111
	Black	Perceived stress	0.276	Employment	0.230	Daily spiritual experiences	0.162
	MENA	Daily spiritual experiences	0.739	Religious Attendance	0.735	Everyday discrimination	0.729
	AIAN	Loneliness	0.893	Social support (total)	0.828	Neighborhood social disorder	0.671
	Mixed	Perceived stress	0.331	Loneliness	0.293	Social support (total)	0.290
	Mexican Mainland	Education	0.332	Employment	0.328	Social support (total)	0.293
	Spanish	Social cohesion	1.664	Daily spiritual experiences	0.914	Neighborhood physical disorder	0.835
	Caribbean Hispanic	Perceived stress	0.539	PANES - Walking & Bicycling	0.426	Daily spiritual experiences	0.365
	Hispanic Other	Neighborhood social disorder	0.546	Perceived stress	0.482	Daily spiritual experiences	0.473
	East Asian	Perceived stress	0.856	Loneliness	0.679	PANES - Crime & Safety	0.632
	Southeast Asian	Neighborhood physical disorder	1.222	Everyday discrimination	0.664	PANES - Walking & Bicycling	0.537
	South Asian	Social support (total)	0.869	Everyday discrimination	0.789	Discrimination in medical settings	0.746
	Asian Other	Social cohesion	1.974	Religious Attendance	0.973	Neighborhood physical disorder	0.789
Dementia	All	Employment	0.192	Perceived	0.182	Loneliness	0.073
	White	Perceived stress	0.190	Employment	0.187	Income	0.074
	Black	Everyday discrimination	0.271	Social support (total)	0.264	Daily spiritual experiences	0.261
	MENA	Social support (total)	1.559	PANES - Walking & Bicycling	0.974	Loneliness	0.599
	AIAN	Loneliness	1.323	Perceived stress	0.835	Housing Quality	0.782
	Mixed	Perceived stress	0.429	PANES - Walking & Bicycling	0.387	PANES - Crime & Safety	0.337
	Mexican Mainland	PANES - Walking & Bicycling	0.602	Perceived stress	0.515	Employment	0.401
	Spanish	Food Insecurity	1.992	PANES - Walking & Bicycling	1.536	Social support (total)	0.637
	Caribbean Hispanic	PANES - Walking & Bicycling	0.676	Neighborhood social disorder	0.504	Discrimination in medical settings	0.466
	Hispanic Other	PANES - Walking & Bicycling	0.755	Neighborhood social disorder	0.702	Loneliness	0.658
	East Asian	Daily spiritual experiences	1.007	Social support (total)	0.629	Neighborhood physical disorder	0.621
	Southeast Asian	PANES -Walking & Bicycling	1.199	Neighborhood physical disorder	1.000	Social cohesion	0.961
	South Asian	Everyday discrimination	1.659	Discrimination in medical settings	0.864	Perceived stress	0.838

Results

- In this large, diverse cohort (N = 104,955), MCI prevalence ranged from 5% (Chinese) to 13% (American Indian/Alaska Native [AI/AN]), and dementia prevalence ranged from 2% (Japanese) to 7% (Caribbean Hispanic) (Figure 1).
- Racial and ethnic subgroups also exhibited distinct SDOH profiles: college graduation rates ranged from approximately 15% in some Hispanic and AI/AN subgroups to over 50% in several Asian subgroups, while historically disadvantaged groups reported lower incomes and higher perceived stress (Table 1).
- SHAP analysis of XGBoost models demonstrated substantial heterogeneity in the relative importance of SDOH predictors across subgroups (Figure 2).

Implications

- Our disaggregated analysis revealed distinct social risk profiles among racial/ethnic subgroups, demonstrating that a “one-size-fits-all” approach to cognitive health risk assessment is inadequate.
- Differences in which SDOH factors most strongly predict cognitive impairment across subgroups underscore the need for screening and intervention strategies that are culturally and contextually tailored.
- Addressing factors such as neighborhood conditions, educational opportunities, and psychosocial resources may require approaches adapted to each community’s context.