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# Beyond the "European health divide": Functional limitation disparities among older adults in Central and Eastern Europe

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#### HIGHLIGHTS

• Country rates of functional limitation varied widely across physical, sensory, and cognitive domains.

• The Baltic States had unaccounted higher odds of near vision and hearing difficulty.

• There were no observed regional disparities in episodic memory.

• Socioeconomic factors mainly shaped regional disparities in functional limitation.

• Health and long-term care solutions will vary based on country-level older adult functional limitation profiles.

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ABSTRACT

*Objectives:* Countries in Central and Eastern Europe (CEE) generally have worse health outcomes than the rest of Europe, commonly referred to as the "European health divide". Regional specificities and historical pathways can shape health outcomes later in life, although variance of older adult functional limitation *within* CEE is understudied.

*Methods*: We used wave 9 (2021–2022) data (n = 18,903) from the Survey of Health, Ageing and Retirement in Europe (SHARE) with mixed effects regression models to analyze difficulty with mobility, near vision, hearing, and episodic memory among those ages 65+ in the Baltic States (Estonia; Latvia; Lithuania), Visegrád Group (Czechia; Hungary; Poland; Slovakia), Former Yugoslavia (Croatia; Slovenia), and the Black Sea (Bulgaria; Romania) while accounting for demographic, socioeconomic, health, and social tie indicators.

*Results:* Age-adjustments showed the highest difficulty rates of: mobility in Romania and Hungary, near vision in Latvia and Bulgaria, hearing in Estonia and Poland, and episodic memory in Poland and Croatia. Compared to the Baltic States, odds of reporting mobility difficulty were greater in the Black Sea but accounted for by socioeconomic factors. Fully adjusted odds of reporting near vision difficulty were lower in Visegrád Group and Former Yugoslavia. Fully adjusted odds of reporting hearing difficulty were lower in Visegrád Group, Former Yugoslavia, and the Black Sea. There were no regional differences in episodic memory.

*Discussion:* Functional limitation disparities, which were largely shaped by socioeconomic factors, varied throughout CEE. These findings highlight the heterogenous health and long-term care needs of older adults throughout CEE.

# 1. Introduction

The European health divide argues that health and mortality outcomes are worse in Central and Eastern Europe (CEE) compared to the rest of Europe (Carlson, 1998; Vågerö & Illsley, 1992). This disadvantage is extended to older adults (Ahrenfeldt et al., 2024; Bíró & Branyiczki, 2020; Gómez-Costilla et al., 2022; Hansen et al., 2024; Rueda-Salazar et al., 2022; Sakkeus, Schwanitz, Abuladze, & Rudissaar, 2023; Scheel-Hincke et al., 2020; Solé-Auró & Gumà, 2023) and is largely attributable to the public policies and health lifestyle practices that were characteristic of CEE during the Cold War (1947–1991) (Cockerham, 2002). These countries have since taken divergent

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economic and political paths to transition to democratic governments. As such, the confluence of political transition and rapid aging generate unique challenges for this region, particularly the development of health and long-term care systems (Botev, 2012). Integral to health, aging, and provision of care are functional limitations (Verbrugge & Jette, 1994). Therefore, we aim to examine disparities and indicators of physical, sensory, and cognitive functional limitation among older adults in CEE.

#### 1.1. Central and Eastern Europe

The health environment throughout CEE during the socialist period often influenced poor health outcomes. Health care throughout CEE was generally not a national priority, thus such systems were largely underfunded, had low quality care, provided unequal access, and prioritized secondary care (Cockerham, 2002). Heavy drinking and smoking as well as high fat diets were commonplace which contributed to the region's notably high mortality rates for many years, particularly among men (Aburto & Van Raalte, 2018; Meslé, 2004; Watson, 1995). Industrialization was integral to economic development in CEE during the socialist period which led to environmental devastation and air pollution that threatened population health (Little, 1998). Also, mental health care was largely underdeveloped and informed by political ideology instead of scientific practice (Tomov et al., 2007). This was magnified by the social stress that permeated CEE when momentous economic, political, and social changes emerged during the transition period, particularly reduced health care spending (Cockerham, 2002).

Despite their shared socialist histories, CEE is quite diverse in terms of their economies, politics, and cultures, as suggested in prior aging research (Bíró & Branyiczki, 2020). Below, we describe four unique regions within CEE:

The *Baltic States* (i.e., Estonia; Latvia; Lithuania) gained independence from the Russian Empire shortly after World War I but were then annexed by the Soviet Union during World War II. The Soviet Union prioritized the collectivization of peasant farms and industrialization which led to in-migration of ethnic groups with limited ties to the region, particularly in Estonia and Latvia (Sakkeus, 1994). After Stalin's death in 1953, these republics saw the secularization of social norms and heightened dissent toward the Soviet Union (Kasekamp, 2011). Since the Soviet Union's collapse in 1991, the Baltic States have taken similar political trajectories, all joining the European Union (EU) in 2004 (Lukić et al., 2019).

The Visegrád Group is a political and economic cooperation, founded in 1991, between four countries (i.e., Czechia; Hungary; Poland; Slovakia) to facilitate European integration (Káčerová & Ondačková, 2015). Dissolvement of Austria-Hungary after World War I led to unification of the Czech and Slovak lands (i.e., Czechoslovakia) (Teichova, 2013), Hungary losing much of its industrial territories (Tomka, 2020), and agricultural Poland reunifying with its southern territories (Roszkowski, 2008). After World War II, these countries experienced Soviet influence, but all showed discontent toward the Soviet Union, had failed uprisings, and left the Soviet sphere before its collapse (Cottey, 1995).

The *Former Yugoslavia*, now seven independent countries (i.e., Bosnia and Herzegovina; Croatia; Kosovo; Montenegro; North Macedonia; Serbia; Slovenia), included multiethnic republics ruled by the Kingdom of Serbia after World War I (Štiblar, 2018). Demands for republic equality led to Yugoslavia becoming a socialist state in 1945 that, shortly after, declared self-determination from the Soviet Union (Hasani, 2013). Subsequent was a unique relationship with the West that led to notable economic and social development (Lagendijk & Schipper, 2016). In the 1980s, Serbian nationalism and Western support for Croatian and Slovenian separatists contributed to Yugoslavia's dissolution (Dragović-Soso, 2007). To date, only Croatia and Slovenia have joined the EU (Bojinović Fenko et al., 2023).

The Black Sea region were ideologically split during World War I, as Bulgaria was part of the Central Powers and Romania sided with the Allied Powers (Basciani, 2020). Despite pressure to industrialize after World War I, Bulgaria and Romania maintained their agricultural economies then developed stronger ties, via socialist ideology, after World War II (Shumanova, 2019). Starting in the 1960s, the Ceausescu regime in Romania pursued emancipation from the Soviet Union, effectively weakening ties with neighboring Bulgaria and leading to further country disagreement about economic and cultural identity. Though in the post-socialist era, both countries have maintained strong agricultural practices, exhibit minimalist welfare regimes, and joined the EU in 2007 (Tache & Neesham, 2011).

In Fig. 1, we provide a map of CEE that illustrates what countries belong to these four regions. In Table 1, we provide economic (2025) and health (Eurostat, 2024c) characteristics by country and year since 1992. As such, these important distinctions throughout CEE dispel monolithic viewpoints about this uniquely diverse region and thus provide theoretical basis for potential segmented health outcomes.

## 1.2. The European health divide

The European health divide, which argues that CEE has poorer health outcomes than the rest of Europe (Carlson, 1998; Vågerö & Illsley, 1992), predates the transition period because older adults in CEE report worse health and greater rates of hospitalization during childhood than other older adults in Europe (Bíró & Branyiczki, 2019). Moreover, CEE older adults with adverse childhood health experiences (ACHEs) are at high risk of reporting frailty later in life (Van Der Linden et al., 2020). Older adults in CEE generally have greater morbidity risk (Nielsen et al., 2017), higher large muscle functional limitation risk (Burns, Ailshire, & Crimmins, 2024), more difficulty with instrumental and basic activities of daily living (IADLs/ADLs) (Rueda-Salazar et al., 2022; Scheel-Hincke et al., 2020), higher disability risk (GALI) (Sakkeus, Schwanitz, Abuladze, & Rudissaar, 2023), and lower life expectancy (Aburto & Van Raalte, 2018; Meslé, 2004) than their other European counterparts. In 2022, the average life expectancy at age 65 for the EU was 19.0 years, although it was 17.2 years for its CEE members and 20.2 years for the other members (Eurostat, 2024a). Also, national income, in terms of gross domestic product (GDP) per capita, is linked to life expectancy, especially in CEE (Mackenbach, 2013).

Prior research suggests that older adults in Eastern Europe have higher IADL limitation rates, which often require walking, than the rest of Europe (Scheel-Hincke et al., 2020). Throughout Europe, older adults in CEE have the highest rates of hearing and vision impairment as well as the lowest rates of using hearing aid and glasses/contacts (Ahrenfeldt et al., 2024; Hansen et al., 2024; Laureyns, Bisgaard, Best, & Zimmer, 2024). Also, the prevalence of dual sensory (i.e., vision *and* hearing) impairment is higher among older adults in CEE than the rest of Europe (Ahrenfeldt et al., 2024). Although some research indicates that older adults in CEE have a slight cognitive (i.e., episodic memory) advantage in Europe that is speculatively due to selective survivability through repression and war (Sakkeus, Schwanitz, Abuladze, & Rudissaar, 2023).

This predominant health disadvantage among older adults in CEE is attributed to various factors. Some research points to the education gradient (Solé-Auró & Gumà, 2023) which speaks to early life course implications. Difficulty accumulating socioeconomic resources in adulthood is a strong indicator of CEE's poor health (Sakkeus, Schwanitz, Abuladze, & Rudissaar, 2023). Moreover, those throughout CEE most affected by the transition period, when many experienced widespread stress, financial strain, and job loss, report particularly poor physical and mental health in older adulthood (Bíró & Branyiczki, 2020). Also, the gender health gap is more pronounced in CEE (Schmitz & Lazarevič, 2020; Meslé, 2004) than the rest of Europe. Although, while women report worse physical functioning (Fors et al., 2022; Rueda-Salazar et al., 2022; Scheel-Hincke et al., 2020), men have worse cognitive functioning (Sakkeus, Schwanitz, Abuladze, & Rudissaar, 2023). It is also known that morbidities are associated with functioning (Marventano et al., 2014), while health care availability varies across



Fig. 1. Map of Central and Eastern Europe with regions.

# Table 1 Economic and Health Characteristics by Country and Year.

		GDP per capita, PPP (\$)					LE at Age 65					HLE at Age 65		
Region	Country	<u>1992</u>	<u>2002</u>	<u>2012</u>	<u>2022</u>		<u>1992</u>	<u>2002</u>	<u>2012</u>	<u>2022</u>		<u>2012</u>	<u>2022</u>	
	Estonia	5,868	11,667	26,243	47,802		14.4	15.6	18.1	18.3		5.5	7.6	
Baltic States	Latvia	4,760	9,756	20,494	39,965		N/A	15.1	16.6	16.6		6.0	4.3	
States	Lithuania	7,022	10,497	24,578	50,498		15.7	15.9	17.1	17		5.9	7.1	
	Czechia	11,924	18,344	29,466	51,710		14.4	15.8	17.6	18		8.7	7.4	
Visegrád	Hungary	8,252	14,526	23,267	43,702		14.0	15.4	16.5	16.4		6.4	7.1	
Group	Poland	6,189	11,841	23,728	46,077		14.7	16.2	17.9	17.7		7.6	8.2	
	Slovakia	7,266	13,292	27,023	41,112		14.4	15.3	16.8	17.1		2012           5.5           6.0           5.9           8.7           6.4           7.6           3.2           7.8           7.0           9.2           5.4	4.8	
Former	Croatia	7,321	12,775	21,620	41,960		N/A	15.5	17	17.1		7.8	5.4	
Yugoslavia	Slovenia	12,287	20,004	28,787	51,079		15.6	17.1	19.3	19.7		7.0	11.4	
Black	Bulgaria	6,915	7,786	16,327	34,856		14.2	14.4	15.8	15.4		9.2	10.1	
Sea	Romania	4,512	7,162	19,807	42,218		13.9	14.4	16.2	16.3		5.4	3.9	

*Notes*: GDP = Gross Domestic Product; PPP = Purchasing Power Parity; \$ = United States Dollars; LE = Life Expectancy; HLE = Healthy Life Expectancy; N/A = Not Available; Red Cells = Lower GDP/LE/HLE by Year; Green Cells = Higher GDP/LE/HLE by Year; HLE at Age 65 data was not available for 1992 and 2002.

CEE (Romaniuk & Szromek, 2016). Social ties are importantly related to older adult functioning in Europe, as widowhood (Sakkeus, Schwanitz, Abuladze, & Rudissaar, 2023), living in larger households (Rueda-Salazar et al., 2022), and being foreign-born (Solé-Auró & Crimmins, 2008) are all known risk factors.

# 1.3. The disablement process

The disablement process refers to the influence health conditions have on functioning and ability to participate in self-care and social life (Verbrugge & Jette, 1994). The main pathway of the disablement process indicates that disease or injury (i.e., pathology) result in abnormalities of the body (i.e., impairment) that restrict normal bodily function (i.e., functional limitation) and thus influence difficulty with self-care and social participation (i.e., disability). Identifying associations with functional limitation risk can mitigate the onset of disability. Risk factors (e.g., demographic characteristics; lifestyles) and 'extra-individual factors' (e.g., medical care; support systems; built, physical, & social environment) can influence this process. Thus, the factors that inform the disablement process are consistent with those that influence the European health divide. As such, the disablement process is integral to understanding functional limitation disparities in CEE since poor health outcomes are commonplace (Ahrenfeldt et al., 2024; Bíró & Branyiczki, 2020; Gómez-Costilla et al., 2022; Hansen et al., 2024; Rueda-Salazar et al., 2022; Sakkeus, Schwanitz, Abuladze, & Rudissaar, 2023; Scheel-Hincke et al., 2020; Solé-Auró & Gumà, 2023), although economic, political, and cultural contexts differ within this region (Hasani, 2013; Káčerová & Ondačková, 2015; Lukić et al., 2019; Tache & Neesham, 2011).

# 1.4. The current study

Most of the population health and gerontological literature about CEE is in comparison to the rest of Europe and seldom considers the various sociopolitical histories, economies, and health care systems throughout CEE (Hasani, 2013; Káčerová & Ondačková, 2015; Lukić et al., 2019; Romaniuk & Szromek, 2016; Tache & Neesham, 2011) that can differently shape health outcomes. Thus, we provide a comprehensive analysis of physical, sensory, and cognitive functional limitation disparities among older adults in CEE while accounting for various demographic, socioeconomic, health, and social indicators related to the disablement process (Verbrugge & Jette, 1994). We hypothesize that: (1) Country-level reports of physical, sensory, and cognitive functional limitation will be notably high in the Baltic States and Black Sea -and-(2) Regional disparities in functional limitation will be accounted for by variations in demographic, socioeconomic, health, and social characteristics. We expect our study to highlight the heterogeneity of older adult functional limitation in CEE and thus inform pertinent health and long-term care interventions in this historically and demographically unique region of the world.

# 2. Methods

# 2.1. Data

We used wave 9 (2021–2022) data from the Survey of Health, Ageing and Retirement in Europe (SHARE), a panel survey that collects health, economic, and social information on older adults from Europe. While the response rate in SHARE is higher than other European surveys, nonresponse and attrition may contribute to selection bias and representativeness (Börsch-Supan et al., 2013); thus, we include person-level weights from SHARE to account for data collection issues and complex survey design. We restricted our sample to respondents ages 65+ (n =19,069) and excluded those who were missing any covariate responses (n = 166), leading to an analytical sample of n = 18,903.

# 2.2. Dependent variables

*Mobility difficulty* is a dichotomous variable that measures if the respondent has no difficulty walking 100 m (reference) or has difficulty walking 100 m.

*Near vision difficulty*, which was chosen since SHARE has no general vision question, is a dichotomous variable derived from a self-rated 5-point Likert-type item (i.e., excellent; very good; good; fair; poor) that considered use of glasses or contact lenses and was recoded into the following categories: good/very good/excellent near vision (reference) and fair/poor near vision.

*Hearing difficulty* is a dichotomous variable derived from a self-rated 5-point Likert-type item (i.e., excellent; very good; good; fair; poor) that

considered use of hearing aids and was recoded into the following categories: good/very good/excellent hearing (reference) and fair/poor hearing.

*Episodic memory* is a composite count variable (range: 0–20) that includes both the immediate (range: 0–10) and delayed (range: 0–10) word recall scores. For immediate word recall, respondents had 10 words displayed on a screen and were given one minute to name as many words as possible. After completing the verbal fluency and numerical competency questions, respondents conducted the delayed word recall in which they were given one minute to verbally recall as many of the words possible from the immediate word recall.

#### 2.3. Covariates

Region is a categorical variable that organizes countries from CEE into four politically, economically, and culturally distinct groups, an approach that has been practiced in similar aging research (Bíró & Branyiczki, 2020). The four regions are the Baltic States (i.e., Estonia; Latvia; Lithuania), Visegrád Group (i.e., Czechia; Hungary; Poland; Slovakia), Former Yugoslavia (i.e., Croatia; Slovenia), and the Black Sea (i.e., Bulgaria; Romania). The Baltic States were set as the main reference group in this variable due to their intermediate position in health system outcomes (Romaniuk & Szromek, 2016). Age Group (range: 65-105) was recoded into three categories: 65-74, 75-84, and 85+. Gender is a dichotomous variable derived from the sex question that we renamed "male" as men (reference) and "female" as women. Education is a categorical variable based on the 1997 International Standard Classification of Education (ISCED-97) that assigns educational attainment into seven unique categories (OECD, 2004) which we collapsed into three groups: less than upper secondary (ISCED 0-2) was renamed "low education" (reference), upper secondary (ISCED 3-4) was named "moderate education", and tertiary education (ISCED 5-6) was renamed "high education". Household Net Worth is an imputed continuous variable measured in nominal Euros (€) that we adjusted for 2021 and 2022 purchasing power parity (PPP), depending on the response year, and was divided by the square root of household members which is a known calculation for household income distribution (OECD, 2013). Comorbidities is a count variable that measures if respondents reported any variation of the six following diagnoses: hypertension, diabetes, cancer, lung condition, heart condition, and stroke (range: 0-3+). Health Care Barriers is a dichotomous variable in SHARE that measures if the respondent had to forgo health care of any type due to unavailability -"No" (reference) and "Yes". Marital Status is a categorical variable that was recoded to measure three groups: married/partnered (reference), separated/divorced/never married, and widowed. We consolidated the separated/divorced and never married respondents together due to the particularly small number of respondents who reported the latter option. Household Size is a count variable that includes the number of people in the respondent's residence (range: 1-4+). Origin is a dichotomous variable that measures whether the respondent is native-born (reference) or foreign-born in relation to the country of the interview.

# 2.4. Analytic strategy

First, we computed weighted descriptive statistics by country. Second, using weighted age-adjusted logistic regression (i.e., mobility difficulty; near vision difficulty; hearing difficulty) and linear regression (i. e., episodic memory), we computed weighted margins command estimates for each dependent variable by country and presented the prevalence/means in a colored scaled map. Finally, we computed weighted adjusted mixed effects logistic regression with odds ratios (i.e., mobility difficulty; near vision difficulty; hearing difficulty) and mixed effects linear regression (i.e., episodic memory) models to test for regional differences (random intercept = country). Informed by the factors that influence the disablement process (Verbrugge & Jette, 1994), each model was progressively adjusted as follows: Model 1 controlled for demographic risk factors (i.e., age group; gender), Model 2 added socioeconomic risk factors (i.e., education; household net worth), Model 3 incorporated health measures that relate to the disablement process main pathway (i.e., comorbidities) and 'built, physical & social environment' (i.e., health care barriers), and Model 4 employed social ties related to 'external supports' (i.e., marital status; household size; origin). All analyses were conducted using Stata, release 18.5 SE and accounted for complex survey design using the SHARE wave 9 individual-level sample weight.

# 3. Results

# 3.1. Descriptive statistics by country

The sample characteristics by country are presented in Table 2 (n =18,903). Respondents ages 65–74 represented the largest group in all countries, although the proportion was notably high in Slovakia (65.1 %) and lower in the Baltic States (49.8 % -53.4 %). Those ages 75–84 were most prominent in Czechia (36.3 %) but smallest in Poland (26.3 %). Among those ages 85+, the three Baltic States (33.9 % -34.1 %) were among the top four highest rates but lowest in Slovakia (5.6 %) and Hungary (5.9%). Women were the majority in all 11 countries, although their largest share were in the Baltic states (64.9 % - 66.5 %). Low education was highest among those from Romania (59.2 %), and it was lower in the Baltic States (18.8 % - 24.9 %). Moderate education was highest among those from Slovakia (75.8 %), it was lowest in Romania (36.5 %). High education was highest among those in the Baltic States (23.7 % - 36.3 %). Median household net worth, per household size, was highest among those in Czechia (€126,558) and Slovenia (€120,136) but lowest in Latvia (€24,595) and Bulgaria (€35,763). Mean number of comorbidities was highest in Lithuania (1.3) while lowest in Slovakia (1.0). Health care barriers were most prevalent in Slovakia (18.5 %) and lowest in Slovenia (7.4 %) and Croatia (7.6 %). Reports of being married/partnered were highest in Slovenia (68.2 %) and lowest in Bulgaria (47.0 %). Being divorced/separated/never married was most common in Estonia (24.0 %) and lowest in Romania (4.4 %). Widows were most prevalent in Bulgaria (46.6 %) and lowest in Estonia (21.4 %). The largest mean household sizes were in Romania (2.2) and lowest in Estonia (1.6). The proportion of those being foreign-born was highest in Estonia (22.4 %) and lowest in Slovakia (0.2 %).

#### 3.2. Age-adjusted functional limitation prevalence by country

Fig. 2 shows age-adjusted color scaled prevalence maps of mobility difficulty, near vision difficulty, hearing difficulty, and episodic memory by country. Darker shades indicate higher functional limitation prevalence, except for episodic memory (i.e., darker shade = lower mean). Age-adjusted rates for each country by dependent variable are provided in Supplemental Table 1. For mobility difficulty, age-adjusted rates were highest in Romania (26.3 %) and Hungary (23.0 %) while lowest in Latvia (8.3 %) and Slovakia (12.3 %). For near vision difficulty, age-adjusted rates were highest in Latvia (48.7 %) and Bulgaria (38.9 %) while lowest in Czechia (9.0 %) and Slovenia (15.6 %). For hearing difficulty, age-adjusted rates were highest in Estonia (31.7 %) and Poland (29.9 %) while lowest in Slovakia (12.6 %) and Czechia (16.4 %). For episodic memory, age-adjusted means were lowest in Poland (6.9) and Croatia (7.1) while highest in Hungary (9.9) and Czechia (9.6).

#### 3.3. Multivariate analyses

Full tables with odds ratios (i.e., mobility difficulty; near vision difficulty; hearing difficulty) or beta coefficients (i.e., episodic memory) for the covariates are in Supplemental Tables 2–5. For ease of interpretability, Table 3 provides adjusted mixed effects regression region differences by functional limitation:

In the first panel, the odds of reporting mobility difficulty are shown (n = 18,881). In the demographic characteristics model (Model 1), compared to the Baltic States, greater odds of mobility difficulty were reported among those from the Black Sea (OR=2.04; 95 % CI: 1.10, 3.78). After adjusting for socioeconomic factors (Model 2), the Black Sea no longer had significantly different odds of mobility difficulty. Accounting for health factors (Model 3) and social ties (Model 4) did not result in any significant changes to the regional differences.

In the second panel, the odds of reporting near vision difficulty are shown (n = 18,853). In the demographic characteristics model (Model 1), compared to the Baltic states, lower odds of near vision difficulty were reported among those from Former Yugoslavia (OR=0.39; 95 % CI: 0.22, 0.70). After adjusting for socioeconomic factors (Model 2), Former Yugoslavia had significantly lower odds of reporting near vision difficulty (OR=0.35; 95 % CI: 0.20, 0.60). After adjusting for health factors (Model 3), the Visegrád Group had significantly lower odds of reporting near vision difficulty (OR=0.45; 95 % CI: 0.20, 1,00). Adjusting for social ties (Model 4) did not result in any significant changes to the

Table 2

Sample characteristic	(percentage or mean,	<pre>/standard deviation)</pre>	by country	(N = 18,903).
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	Estonia	Latvia	Lithuania	Czechia	Hungary	Poland	Slovakia	Croatia	Slovenia	Bulgaria	Romania
Mobility Difficulty	20.0 %	9.1 %	17.3 %	12.7 %	21.6 %	17.1 %	10.9 %	21.9 %	17.6 %	18.7 %	26.7 %
Near Vision Difficulty	30.8 %	50.5 %	29.0 %	8.9 %	26.9 %	31.9 %	21.1 %	19.9 %	16.1 %	38.9 %	32.4 %
Hearing Difficulty	33.7 %	29.0 %	26.8 %	16.3 %	20.9 %	29.8 %	11.3 %	20.7 %	24.9 %	21.2 %	23.4 %
Episodic Memory <sup>†</sup>	8.7 (3.7)	8.4 (3.3)	7.1 (3.5)	9.5 (3.5)	10.0 (3.4)	6.9 (3.2)	7.5 (3.6)	7.1 (3.5)	8.0 (3.5)	8.3 (3.4)	7.2 (3.6)
65–74	53.4 %	53.0 %	49.8 %	55.3 %	61.8 %	62.0 %	65.1 %	56.6 %	58.0 %	57.0 %	58.0 %
75–84	34.1 %	33.9 %	34.1 %	36.3 %	32.3 %	26.3 %	29.3 %	32.9 %	29.3 %	34.2 %	30.4 %
85+	12.5 %	13.1 %	16.1 %	8.5 %	5.9 %	11.8 %	5.6 %	10.5 %	12.7 %	8.8 %	11.6 %
Women	64.9 %	65.8 %	66.5 %	58.3 %	61.8 %	60.2 %	59.4 %	58.9 %	56.2 %	60.3 %	58.2 %
Low Education	24.9 %	18.8 %	23.2 %	29.6 %	30.2 %	33.9 %	19.2 %	40.9 %	32.4 %	38.9 %	59.2 %
Moderate Education	51.4 %	55.2 %	40.6 %	53.5 %	56.9 %	54.6 %	75.8 %	44.1 %	51.7 %	49.1 %	36.5 %
High Education	23.7 %	26.0 %	36.3 %	16.9 %	12.9 %	11.5 %	5.0 %	15.0 %	15.9 %	12.0 %	4.3 %
Household Net Worth <sup><math>\epsilon</math></sup>	65,294	24,595	48,631	126,558	46,563	65,021	79,428	80,913	120,136	35,763	45,334
Comorbidities <sup>†</sup>	1.1 (0.9)	1.1 (0.8)	1.3 (0.9)	1.2 (0.9)	1.2 (0.9)	1.2 (1.0)	1.0 (0.9)	1.2 (0.9)	1.1 (0.9)	1.2 (0.8)	1.1 (0.9)
Health Care Barriers	13.7 %	15.4 %	13.6 %	8.8 %	15.0 %	10.9 %	18.5 %	7.6 %	7.4 %	9.7 %	8.3 %
Married/Partnered	54.6 %	51.8 %	49.8 %	61.7 %	53.5 %	58.7 %	58.8 %	55.1 %	68.2 %	47.0 %	61.9 %
Divorced/Separated/NM	24.0 %	14.3 %	11.9 %	15.8 %	15.1 %	8.3 %	10.1 %	9.1 %	10.0 %	6.5 %	4.4 %
Widowed	21.4 %	33.8 %	38.3 %	22.5 %	31.4 %	33.0 %	31.1 %	35.8 %	21.8 %	46.6 %	33.7 %
Household Size <sup>†</sup>	1.6 (0.7)	1.7 (0.7)	1.8 (0.8)	1.7 (0.7)	1.7 (0.8)	1.9 (0.9)	1.8 (0.8)	1.9 (0.9)	1.9 (0.8)	1.7 (0.8)	2.2 (1.0)
Foreign-Born	22.4 %	18.0 %	4.3 %	4.1 %	1.2 %	2.3 %	0.2 %	15.7 %	10.7 %	0.8 %	0.4 %
n=	2855	1000	848	2571	1181	3035	552	2692	2682	555	932

*Note:* ADL = Activities of Daily Living; IADL = Instrumental Activities of Daily Living; NM = Never Married;  $\dagger$  = Count mean;  $\pounds$  = Median in nominal Euros, adjusted for purchasing power parity (PPP) and divided by  $\sqrt{}$  of household size.



Note: † = Count mean

Fig. 2. Age-adjusted color scaled prevalence/mean maps of functional limitation in Central and Eastern Europe.

#### Table 3

Adjusted mixed effects regression region differences by functional limitation.

Mobility Difficulty	obility Difficulty Model 1: Demographic		Model 2: Socioeconomic			Model 3: H	Iealth		Model 4: Social Ties			
n = 18,881	OR	95 % CI		OR	95 % CI		OR	95 % CI		OR	95 % CI	
(Baltic States) Visegrád Group Former Yugoslavia Black Sea	1.28 1.64 2.04*	0.71 0.96 1.10	2.32 2.82 3.78	1.13 1.53 1.69	0.60 0.88 0.91	2.13 2.68 3.13	1.13 1.64 1.81	0.60 0.93 0.95	2.14 2.88 3.45	1.11 1.63 1.74	0.58 0.92 0.90	2.11 2.90 3.35
Near Vision Difficulty	Model 1:	Demographi	с	Model 2: Socioeconomic			Model 3: Health			Model 4: Social Ties		
n = 18,853	OR	95 % CI		OR	95 % CI		OR	95 % CI		OR	95 % CI	
(Baltic States) Visegrád Group Former Yugoslavia Black Sea	0.50 0.39** 1.05	0.21 0.22 0.58	1.17 0.70 1.90	0.45 0.35*** 0.86	0.20 0.20 0.47	1.00 0.60 1.58	0.45* 0.36*** 0.88	0.20 0.21 0.48	1.00 0.62 1.62	0.44* 0.36*** 0.87	0.20 0.21 0.48	0.97 0.63 1.57
Hearing Difficulty	Model 1: Demographic			Model 2: Socioeconomic			>Model 3: Health			>Model 4: Social Ties		
n = 18,881	OR	95 % CI		OR	95 % CI		OR	95 % CI		OR	95 % CI	
(Baltic States) Visegrád Group Former Yugoslavia Black Sea	0.62 0.71* 0.71**	0.38 0.54 0.57	1.02 0.94 0.90	0.57* 0.67** 0.62***	0.36 0.50 0.50	0.89 0.89 0.76	0.57* 0.68* 0.63***	0.36 0.50 0.50	0.89 0.94 0.79	0.57* 0.68* 0.62***	0.36 0.49 0.50	0.90 0.96 0.78
Episodic Memory	Model 1:	Demographi	c	Model 2: Socioeconomic			Model 3: Health			Model 4: Social Ties		
n = 18,331	β	95 % CI		β	95 % CI		β	95 % CI		β	95 % CI	
(Baltic States) Visegrád Group Former Yugoslavia Black Sea	0.14 -0.67 -0.43	$-1.42 \\ -1.71 \\ -1.54$	1.70 0.36 0.68	0.45 -0.38 0.19	$-1.10 \\ -1.43 \\ -0.84$	2.00 0.68 1.21	0.44 -0.40 0.17	$-1.10 \\ -1.43 \\ -0.85$	1.99 0.63 1.19	0.45 -0.40 0.19	-1.07 -1.40 -0.85	1.97 0.60 1.24
Constant	8.96	8.14	9.77	6.40	5.46	7.33	6.68	5.73	7.63	6.84	5.87	7.81

*Note*: Model 1 = adjusts for age group and gender; Model 2 = additionally adjusts for education and household net worth; Model 3 = additionally adjusts for comorbidities and health care barriers; Model 4 = additionally adjusts for marital status, household size, and origin; OR = Odds Ratio; CI = Confidence Interval;  $\beta$  = beta coefficient; \* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001.

regional differences.

In the third panel, the odds of reporting hearing difficulty are shown (n = 18,881). In the demographic characteristics model (Model 1), compared to the Baltic states, lower odds of hearing difficulty were reported among those from Former Yugoslavia (OR=0.71; 95 % CI: 0.54, 0.94) and the Black Sea (OR=0.71; 95 % CI: 0.57, 0.90). After adjusting

for socioeconomic factors (Model 2), the Visegrád Group had significantly lower odds of hearing difficulty (OR=0.57; 95 % CI: 0.36, 0.89), while the odds became significantly lower in Former Yugoslavia (OR=0.67; 95 % CI: 0.50, 0.89) and the Black Sea (OR=0.62; 95 % CI: 0.50, 0.76). Adjusting for health factors (Model 3) resulted in slightly attenuated, but still significantly lower, odds of hearing difficulty among

those from Former Yugoslavia (OR=0.68; 95 % CI: 0.50, 0.94). Adjusting for social ties (Model 4) did not result in any significant changes to the regional differences.

In the fourth panel, the beta coefficients for episodic memory are shown (n = 18,331). Compared to the Baltic States, there were no significant regional differences in episodic memory in another of the four model adjustments. Although the coefficients in the Visegrád Group and Former Yugoslavia were consistently positive and negative, respectively, while the coefficient in the Black Sea was negative, then become positive after adjusting for socioeconomic factors.

#### 4. Discussion and conclusions

This study investigated physical, sensory, and cognitive functional limitation disparities among older adults in CEE since much of the literature focuses on the European health divide (Ahrenfeldt et al., 2024; Bíró & Branyiczki, 2020; Gómez-Costilla et al., 2022; Hansen et al., 2024; Rueda-Salazar et al., 2022; Sakkeus, Schwanitz, Abuladze, & Rudissaar, 2023; Scheel-Hincke et al., 2020; Solé-Auró & Gumà, 2023). Age-adjusted rates of mobility, near vision, hearing, episodic memory limitations varied by country, with regularly higher rates in Romania and Poland. As such, we found partial support for our first hypothesis by observing that country-level rates of functional limitation were higher in certain countries of the Baltic States and Black Sea, although this depended on the type of functional limitation. Compared to the Baltic States, the odds of reporting mobility difficulty were greater in the Black Sea but accounted for by socioeconomic factors. Fully adjusted odds of reporting near vision difficulty were lower in the Visegrád Group and Former Yugoslavia. Fully adjusted odds of reporting hearing difficulty were lower in the Visegrád Group, Former Yugoslavia, and the Black Sea. There were no regional differences in episodic memory. Therefore, we found partial support for our second hypothesis by observing the important role socioeconomic factors had in influencing regional disparities in functional limitation. These results speak to the disablement process (Verbrugge & Jette, 1994) by highlighting the heterogenous physical, sensory, and cognitive functional limitation profiles of older adults throughout post-socialist CEE which were largely shaped by socioeconomic factors.

Analyzing age-adjusted disability rates by country gave us a bird's eye view of the various functional limitation profiles across CEE. Romania and Poland regularly reported the poorest rates/means of functional limitation, especially mobility difficulty and episodic memory, respectively. Romania's notably high reports of age-adjusted mobility difficulty supports prior cross-national European research that shows this country has a high rate of older adult ADL disability (Bobak et al., 2011), a measure that is informed by mobility. On the other hand, Romania is not generally present in cross-national aging research on cognition. Research indicates that exposure to war-time death/injury, stressful living conditions, and displacement are associated with poor physical functioning and cognition in older adulthood (Zimmer et al., 2021); thus, Romania's notably poor mobility and cognition is potentially tied to its history with state repression and insurgent violence (Petrescu, 2014). Poland's uniquely low age-adjusted episodic memory draws parallel with research that shows this country has one of the highest age and gender standardized rates of memory impairment in Europe (Barbosa et al., 2021). While Poland had one of the highest rates of age-adjusted hearing difficulty, research on older adult hearing loss throughout Europe does not show particularly higher rates in Poland (Laureyns et al., 2024); although research on noise-induced hearing loss (NIHL) in CEE overwhelmingly comes from Poland (Pawlaczyk Luszczynska et al., 2013), suggesting noise exposure from machinery has been a particular concern in this country. Also, both Romania and Poland have comparatively low per capita health care budgets among CEE countries (Eurostat, 2024b) which might contribute to their higher risk of functional limitation. To the contrary, Czechia performed the best in terms of lower age-adjusted rates of disability.

This finding was anticipated because Czechia historically has one of the best GDP, PPP per capita (Table 1) and health care expenditures per capita (Eurostat, 2024b) in all of CEE as well as excelled in integrating people with disabilities (Eurostat, 2022; Mussida & Sciulli, 2016). This analysis suggests that, for older adults in CEE who lived through the socialist and transition periods, all functional limitations are not created equal. Although an important similarity throughout CEE is their low per capita health care expenditures (Eurostat, 2024b) which translate to underinvestment in primary and long-term care systems (Economist Impact, 2022) that prevent and treat older adult functional limitation.

Socioeconomic factors (i.e., education; household net worth) shaped various disability disparities throughout CEE; specifically, these factors accounted for greater odds of mobility difficulty in the Black Sea; in addition, these factors contributed to lower odds of near vision difficulty in Former Yugoslavia and lower odds of hearing difficulty in the Visegrád Group, Former Yugoslavia, and Black Sea. Thus, while research largely points to education as a key factor that contributes to CEE's especially poor health when compared to the rest of Europe (Bíró & Branyiczki, 2020; Sakkeus, Schwanitz, Abuladze, & Rudissaar, 2023; Solé-Auró & Gumà, 2023), it also shapes functional limitation disparities within CEE. This finding speaks to disablement process (Verbrugge & Jette, 1994) by demonstrating how education and household net worth serve as notable functional limitation risk factors in CEE. Descriptively, the Black Sea had the poorest education outcomes in the sample, while both the Baltic States and Black Sea had among the lowest reports of household net worth. Also, per Table 1, the Black Sea, and to a smaller extent the Baltic States, entered the transition period with the lowest GDP, PPP per capita in CEE and remain in a similar position as of 2022. Together, these various functional limitation disparities and socioeconomic gradients speak to more granular health divides within CEE. In future cohorts of older adults, these regional functional limitation disparities are subject to continue through socioeconomic factors, as recent out-of-school rates among those 15 years old are uniquely high in Bulgaria and Romania (Eurostat, 2024d). Moreover, in both the Baltic States and Black Sea, poverty risk is especially high among people with disabilities (Eurostat, 2022), while old-age and disability pension expenditures are lower in these regions than most of Europe (Eurostat, 2024e).

The greater odds of near vision and hearing difficulty in the Baltic States, net of covariates, might be accounted for by other factors not observable in our models, namely occupational conditions. Unfavorable sensory functioning in the Baltic States might have been influenced by deleterious workforce conditions in the Soviet Union that serve as 'extraindividual factors' (i.e., built, physical, & social environment) within the disablement process (Verbrugge & Jette, 1994). Specifically, Soviet-era production equipment and machinery was antiquated, noisy, and emitted debris, while industrial workers regularly disregarded safety measures (Semenov, 1978). Relatedly, industrial workers are at high risk of eyes injuries (Blais, 2005) and hearing loss (Pawlaczyk Luszczynska et al., 2013). Due to the harsh winters, agricultural labor activity in the Soviet Union was seasonal which included intolerable summer conditions, intense workloads, and machinery with low technical specifications (Smith, 1984). Among agricultural workers, ultraviolet radiation is a common threat to vision loss (Modenese et al., 2018), while hearing loss can be influenced chemical fume exposure (Campo et al., 2013). Thus, it is possible the 'hammer and sickle' produced poor sensory function outcomes in the Soviet-era Baltic States due to deleterious industrial and agricultural workplace conditions (Watson, 1998). This was likely compounded by the fact that, while the Soviet Union saw an increase in chronic health conditions during the mid-20th century, it remained focused on infectious diseases and did not prioritize detection and treatment of chronic conditions through primary care checkups until 1983 (Meslé, 2004; Tulchinsky & Varavikova, 1996). In present day, the exceptionally poor sensory functioning of older adults in the Baltic States requires special attention to audiology and ophthalmology care, namely diagnosis, treatment, and provision of assistive devices;

though, as each of the Baltic States have different health care expenditures and resources (Põlluste et al., 2013), programming and policy related to older adult sensory care is subject to vary and thus requires detailed research to better identify country-level needs.

While existing literature finds that episodic memory is better in CEE than Western Europe (Sakkeus, Schwanitz, Abuladze, & Rudissaar, 2023), we observed no regional differences in episodic memory within CEE. As such, this observed cognitive indifference within CEE might be due to a shared context. Existing cross-national research of older in Europe finds that education is a key indicator of cognition, specifically memory (Barbosa et al., 2021; Schneeweis et al., 2012). While our study accounted for educational level, such a variable does not encapsulate education quality which is related to older adult cognition, including memory (Crowe et al., 2013; Schneeweis, Skirbekk, & Winter-Ebmer, 2012; Walsemann et al., 2024). In socialist CEE, education was free and accessible but has also been characterized as poor quality (Silova, 2009). Many of the older adults included in our sample attended schooling during education reforms that made secondary and tertiary education more vocational (Mincu, 2016). This cognitive indifference might also be influenced by the varied number of compulsory schooling vears throughout CEE, even within our four typified regions (Gawlicz & Starnawski, 2018). As such, accounting for these variations and changes in education systems should be considered in future research that focuses on older adult cognition in CEE.

The disablement process suggests functional limitation, in conjunction with the influence of individual and external factors, result in disability (Verbrugge & Jette, 1994). As such, there are unique cultural, economic, and social factors among those living in CEE (Hasani, 2013; Káčerová & Ondačková, 2015; Lukić et al., 2019; Tache & Neesham, 2011) that could shape differential rates of functional limitation by country and region. Guided by this framework, our analysis found that socioeconomic factors (i.e., education; household net worth) primarily shaped functional limitation disparities in CEE. This socioeconomic marker of functional limitation disparities within CEE is parallel to the research that sees such factors account for the poorer health of older adults in CEE compared to Western Europe (Sakkeus, Schwanitz, Abuladze, & Rudissaar, 2023; Solé-Auró & Gumà, 2023). Per our findings, socioeconomic indicators were the most important factors that shaped the disablement process (Verbrugge & Jette, 1994) throughout subregions of CEE. Health factors played a small role in regional differences by contributing to the Visegrád Group's lower odds of near vision difficulty and partially accounting for Former Yugoslavia's lower odds of hearing difficulty; such findings are related to the main pathway (i.e., comorbidities) and 'extra-individual factors' (i.e., health care barriers) of the disablement process. While it did not account for any regional differences, widowhood was significantly associated with risk in all four functional limitations; this finding draws parallel with existing literature (Sakkeus, Schwanitz, Abuladze, & Rudissaar, 2023) as well as generates curiosity about the mechanisms that inform exceptional functional limitation risk among widows, a notable demographic in CEE (Botev, 2012). In pursuit of accounting for the remaining regional disparities, net of covariates, future research on the disablement process in CEE would benefit from analyzing the influence of other 'extra-individual factors' (e.g., environmental risks; occupational settings) and 'intra-individual factors' (e.g., health lifestyles; psychosocial characteristics). Specifically, we recommend further investigation into how industrial and agricultural work histories can inform poor sensory functioning. With shifting care dynamics in CEE being driven by demographic, economic, and political transition (Botev, 2012), health and long-term care provisions for older adults is crucial and subject to vary throughout the region, especially as it relates to the different diagnostic, assistive device, and care needs of people with physical, sensory, and/or cognitive limitations. Though strengthening such provisions in current conditions will likely be a challenge due to the exceptionally low expenditure on health care throughout CEE (Eurostat, 2024b). Lastly, the different environmental and societal barriers that allow physical, sensory, and

cognitive functional limitations to become disability highlights the social aspect of disability (Mouchaers et al., 2022; Verbrugge & Jette, 1994) which necessitates greater emphasis on accessible environments.

While this is the first known study to comprehensively analyze functional limitation disparities among older adults in post-socialist CEE, it is not without its limitations. First, our sample is informed by the selective survivability of those who lived through the socialist and transition periods as well as the COVID-19 pandemic. Second, due to data limitations, our Former Yugoslavia regional category only included two countries from the former republic. Third, since there was no general vision question in SHARE, we used the near vision measure because this outcome is associated with aging (He et al., 2012). Fourth, country-level variations in secondary and tertiary education reforms (Mincu, 2016) might not be fully reflected in our education variable that was informed by ISCED-97. Finally, while occupation type is associated with physical and cognitive functioning (Min et al., 2015), we did not include such a variable due to large missingness from coding and language discrepancies.

The European health divide posits that health and mortality outcomes are markedly worse in CEE than the rest of Europe (Carlson, 1998; Vågerö & Illsley, 1992). However, health disparities, particularly reports of functional limitation among older adults, within CEE have been largely unexplored. We found that age-adjusted rates of mobility, near vision, hearing, and episodic memory limitations varied greatly by country. Also, compared to the Baltic States, mobility difficulty odds were greater in the Black Sea but accounted for by socioeconomic factors, fully adjusted near vision difficulty odds were lower in the Visegrád Group and Former Yugoslavia, fully adjusted hearing difficulty odds were lower in the Visegrád Group, Former Yugoslavia, and Black Sea, and there were no regional differences in episodic memory. As such, there are pronounced functional limitation disparities among older adults in CEE that are largely shaped by socioeconomic factors and, thus, heterogenous health and long-term care needs of those aging in CEE.

# CRediT authorship contribution statement

Shane D. Burns: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. Liili Abuladze: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. Luule Sakkeus: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Conceptualization.

#### Declaration of competing interest

The authors declare that there is no conflict of interest.

#### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.archger.2025.105908.

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