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Income-related inequalities in chewing ability of Europeans aged 50 and above

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Objective: To describe income-related inequalities in chewing ability of the elderly populations residing in different European countries. ***Basic research design:*** This study investigates income-related inequalities on basis of cross-sectional data from the Survey of Health, Ageing and Retirement in Europe (SHARE Wave 2). ***Participants:*** SHARE contains information on chewing abilities of 33,411 individuals aged 50+ from 14 different countries. ***Main outcome measures:*** Income-related inequalities in chewing ability were identified by means of Concentration Indices (CI) and Slope Indices of Inequality (SII). ***Results:*** Disproportionate concentration of chewing ability among the rich elderly populations was evident for all countries except Ireland (relative inequality according to CI). Moreover, chewing abilities were significantly better amongst individuals from the highest income groups, compared with the lowest, for all countries except Italy, Switzerland, Czechia, Poland and Ireland (absolute inequality according to SII). Denture status explained some proportion of absolute but not of relative inequalities. ***Conclusion:*** There is considerable income-related inequality in chewing ability for several elderly populations residing in Europe.

Key words: *socioeconomic status, chewing, inequalities, Europe, middle aged, aging, oral health*

Introduction

The elderly have recently received more attention in health policy as population ageing is often considered an increasing factor in oral health care expenditures. Although it is essential for the identification of treatment needs and an optimised management of health care delivery, little is known about socioeconomic inequalities in the oral wellbeing of elderly generations across European countries. Previous evidence suggests that a socioeconomic gradient in oral health exists, i.e. individuals from lower socioeconomic groups usually have worse oral health than individuals further up the scale (Marmot and Bell, 2011). While there still remains dispute about the causation of such a socioeconomic gradient in oral health (Sisson, 2007), chewing ability has frequently been suggested as an important determinant of elderly persons' oral wellbeing (Locker, 2002). Due to lack of suitable data sources, inequalities in the chewing ability of elderly populations were not directly comparable between European countries. The purpose of this paper is, therefore, to describe such socioeconomic disparities for persons aged 50 and above based on a single data source encompassing different European countries.

Method

The present analysis is based on data from Wave 2 of the Survey of Health, Ageing and Retirement in Europe (SHARE). The survey is modelled closely on the US Health and Retirement Study and produced the first European dataset to combine extensive cross-national information on socioeconomic status, health and family conditions of the elderly. Data were collected in 2006-2007 from household members aged 50 and over, via computer-assisted personal interviews and self-completion paper questionnaires. The questionnaire and details of data collection process are available on the SHARE website (www.share-project.org). SHARE Wave 2 contains information on chewing abilities of 33,411 individuals from 14 different countries. A descriptive overview of cross-country variations in chewing ability on basis of SHARE is given by Listl (2011a).

In SHARE, the measure for chewing ability is a binary variable which reports whether an individual has responded "yes" or "no" to the question "Can you bite and chew on hard foods such as a firm apple without difficulty?" Our measure of socioeconomic status is respondents' average net equalised income (in € per month) as specified according to the equivalence scale of the Organisation for Economic Co-operation and Development, OECD (Haagenars *et al.*, 1994). This scale takes account of household size and age of household members, i.e. children aged 14 years or younger are assumed to contribute less to household consumption than older household members and also less than the household head (see Appendix: formula F.1).

Income-related inequality in chewing ability is identified using the Concentration Index (CI) (Kakwani, 1977; 1980) and the Slope Index of Inequality (SII). The SII (Appendix: formula F.2) quantifies the degree of *absolute* inequality in a health variable (Pamuk, 1985). It has been

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used, for example, to measure inequalities in dental caries among adolescents (Perera and Ekanayake, 2008). In the present study, the SII is measured on basis of individual level data and describes the absolute difference in chewing ability between the lowest and highest decile of equalised income. For example, a SII of 0.2 indicates that the proportion of individuals who can bite and chew on hard foods is 20 percentage points higher within the highest income decile compared to the lowest income decile. The CI (formula F.3 in the Appendix) quantifies the degree of *relative* inequality in a health variable and is derived from the "concentration curve" (Kakwani *et al.*, 1997). It has been used to measure the degree of socioeconomic-related inequality in childhood caries (Do *et al.*, 2010) and oral health care utilisation (Somkotra and Detsomboonrat, 2009; Somkotra and Vachirarojpisan, 2009). In the present study, the CI is measured using individual level data as follows: a CI of zero indicates no income-related inequality regarding chewing ability; a positive (negative) value of the CI indicates disproportionate concentration of better chewing ability among the rich (poor). This is also referred to as "pro-rich" ("pro-poor") income-related inequality. The index ranges between -1 (maximum pro-poor inequality) and +1 (maximum pro-rich inequality). In the present study, the CI reflects the extent of deviation from perfect equality (CI = 0), i.e. identical chewing abilities irrespective of the position within the income ranking. Note that, as the CI is designed to detect the correlation between socioeconomic rank and health rank (i.e. *relative* health), it captures a different dimension of inequality than the SII, the latter measuring the association between socioeconomic rank and health status (i.e. *absolute* health).

CIs and SIIs are first provided for the full sample. In an attempt to adjust for oral health status, separate inequality measures are then reported according to individual's denture status. Denture wearing is reported as a binary variable (respondent wears a denture or not). This does not distinguish between complete and partial dentures, upper and lower jaw, or one or two dentures per patient so may be considered only a proxy variable, however, it is the only available measure of dental conditions, other than chewing ability, within SHARE.

Statistically significant differences between those with and without dentures are identified by means of pairwise t-tests. A recent paper (Listl, 2011b) has used SHARE to investigate income-related inequalities in dental service utilisation. The present paper applies a similar method but focuses on inequalities in chewing ability. To obtain results demographically representative of each population, a statistical adjustment was made by weighting according to variables included in the SHARE database (release 2.3.1). All data analyses were carried out using STATA/SE 10.1 (StataCorp, College Station, Texas, USA) with the level of statistical significance generally set at 5%.

Results

Table 1 shows responses to the question "Can you bite and chew on hard foods…", denture wearing and average monthly equalised income by respondent's country of residence.

For all countries except Ireland the CI is positive and statistically significant, indicating pro-rich inequality in chewing ability (Table 2). In decreasing order of inequality, the countries rank as follows: Austria, Greece, Spain, Denmark, Germany, Poland, Czechia (Czech Republic), Sweden, the Netherlands, Belgium, France, Italy, Switzerland.

Considering absolute inequalities, Table 2 shows SIIs for the full sample. For the following countries, a significantly higher proportion of individuals could bite and chew on hard food if belonging to upper instead of lower income groups (in decreasing order of inequality): Austria, Denmark, Sweden, Germany, Greece, the Netherlands, Spain, Belgium and France. The SIIs for Ireland, Poland, Switzerland, Italy and Czechia are positive (i.e. indicating higher chewing abilities of individuals located in the highest in relation to the lowest income group) but not statistically significant.

Table 1. Probability of 'being able to bite and chew on hard foods', net monthly equivalence income, and population proportion of denture wearing by respondents' country of residence

Country	*Number of observations*	*OECD equalised income*		*Ability to bite and chew on hard foods*	*Wearing dentures*
	n	*€/month*	*(Std. Dev.)*	*% of population*	*% of population*
Sweden	2707	2419	(3785)	92	14
Switzerland	1415	4758	(8723)	88	31
Netherlands	2592	2925	(5527)	85	46
Germany	2520	3941	(7117)	82	48
Denmark	2522	4020	(7760)	81	28
Ireland	1099	4261	(7773)	80	54
Austria	1323	1277	(573)	80	61
Greece	3075	1987	(3977)	79	26
Spain	2174	1970	(4457)	79	42
France	2821	2962	(5561)	79	33
Italy	2914	4390	(5998)	74	32
Belgium	3081	2360	(4289)	74	54
Czechia	2750	1937	(3178)	74	42
Poland	2418	619	(1396)	67	56

Table 2. Concentration indices and Slope Indices of Inequality for income-related inequalities in chewing ability

Country	*Concentration Index (95% Conf. Interval)*	*Slope Index of Inequality (95% Conf. Interval)*
Sweden	**0.025** (0.018, 0.033)	**0.234** (0.174, 0.294)
Switzerland	**0.017** (0.005, 0.029)	0.043 (-0.040, 0.125)
Netherlands	**0.024** (0.013, 0.035)	**0.144** (0.076, 0.211)
Germany	**0.034** (0.021, 0.046)	**0.180** (0.108, 0.250)
Denmark	**0.035** (0.023, 0.047)	**0.254** (0.167, 0.339)
Ireland	0.010 (-0.012, 0.031)	0.061 (-0.031, 0.153)
Austria	**0.050** (0.033, 0.067)	**0.363** (0.233, 0.492)
Greece	**0.042** (0.028, 0.055)	**0.169** (0.103, 0.236)
Spain	**0.035** (0.019, 0.052)	**0.114** (0.039, 0.189)
France	**0.020** (0.008, 0.031)	**0.108** (0.042, 0.174)
Italy	**0.018** (0.004, 0.031)	0.033 (-0.022, 0.088)
Belgium	**0.023** (0.010, 0.036)	**0.108** (0.031, 0.186)
Czechia	**0.026** (0.011, 0.041)	0.023 (-0.046, 0.092)
Poland	**0.033** (0.016, 0.050)	0.044 (-0.040, 0.127)

Note: age- and gender-adjusted results; values in bold indicate statistical significance at the 5% level.

Table 3. Concentration Indices and Slope Indices of Inequality by denture status

Country	*Concentration Index (95% Conf. Int.)*		*Slope Index of Inequality (95% Conf. Int.)*	
	respondent wears denture	*respondent wears no denture*	*respondent wears denture*	*respondent wears no denture*
Sweden	0.032 (-0.005, 0.069)	**0.012** (0.005, 0.018)	0.278 (-0.013, 0.569)	**0.102** (0.051, 0.153)
Switzerland	0.014 (-0.020, 0.049)	0.000 (-0.009, 0.009)	0.009 (-0.212, 0.230)	-0.027 (-0.096, 0.043)
Netherlands	-0.004 (-0.024, 0.016)	**0.021** (0.011, 0.031)	-0.021 (-0.149,0.101)	**0.144** (0.079, 0.210)
Germany	**0.039** (0.014, 0.064)	0.009 (-0.001, 0.019)	**0.169** (0.045, 0.294)	**0.061** (0.000, 0.121)
Denmark	0.009 (-0.025, 0.042)	-0.000 (-0.011, 0.010)	0.012 (-0.211, 0.235)	-0.005 (-0.088, 0.078)
Ireland	0.011 (-0.023, 0.045)	-0.008 (-0.032, 0.016)	0.051 (-0.051, 0.195)	0.012 (-0.113, 0.090)
Austria	**0.048** (0.022, 0.074)	**0.019** (0.002, 0.037)	**0.328** (0.143, 0.512)	**0.146** (0.009, 0.282)
Greece	**0.051** (0.004, 0.098)	**0.016** (0.005, 0.027)	0.112 (-0.070, 0.293)	**0.077** (0.017, 0.137)
Spain	0.022 (-0.007, 0.051)	**0.041** (0.022, 0.061)	0.049 (-0.080, 0.178)	**0.144** (0.051, 0.237)
France	-0.012 (-0.042, 0.017)	**0.012** (0.001, 0.022)	-0.046 (-0.190, 0.097)	**0.069** (0.003, 0.135)
Italy	0.024 (-0.010, 0.055)	0.011 (-0.003, 0.026)	0.074 (-0.037, 0.184)	0.006 (-0.054, 0.066)
Belgium	0.009 (-0.013, 0.031)	0.008 (-0.006, 0.022)	0.027 (-0.091, 0.146)	**0.029** (0.060, 0.118)
Czechia	**0.038** (0.012, 0.065)	0.003 (-0.014, 0.020)	**0.118** (0.003, 0.232)	**-0.070** (-0.152,-0.012)
Poland	**0.034** (0.011, 0.057)	**0.036** (0.011, 0.062)	0.048 (-0.059, 0.155)	0.045 (-0.083, 0.172)

Note: Age- and gender-adjusted results; values in bold indicate statistical significance at the 5% level.

Table 3 reports CIs and SIIs according to denture status. Based on these measures, Table 4 shows pairwise t-tests for differences with regard to denture status. While t-statistics for CIs are negative for some countries and positive for others, the inequalities do not differ significantly between persons with and without dentures. Table 4 also shows pairwise t-statistics for differences in SIIs according to denture status. Significant differences were observed for Austria, Germany, Sweden and Czechia (higher absolute inequalities amongst denture wearers compared to those without a denture) as well as for the Netherlands and France (lower absolute inequalities amongst denture wearers compared to those without a denture).

Discussion

On the basis of cross-sectional survey-based data (SHARE Wave 2), this paper describes income-related inequalities in chewing ability of Europeans aged 50 and older. The findings indicate a higher concentration of the ability to bite and chew on hard foods among the rich elderly populations in all 14 countries except Ireland (relative inequality according to CI). Moreover, significantly more individuals with chewing abilities were found in the highest compared with the lowest income group for all countries except Italy, Switzerland, Czechia, Poland and Ireland (absolute inequality according to SII). While the magnitude of both relative and absolute inequalities varies

Table 4. Pairwise t-tests for differences in Concentration Indices (CI) and Slope Indices of Inequality (SII) according to denture wearing

Country	*Concentration Index*	*Slope Index of Inequality*
Sweden	0.85	**2.62**
Switzerland	0.53	0.50
Netherlands	-1.22	**-3.22**
Germany	1.36	**2.12**
Denmark	0.37	0.25
Ireland	0.52	0.84
Austria	0.90	**2.15**
Greece	1.41	0.64
Spain	-0.70	-1.62
France	-1.07	**-2.20**
Italy	0.50	1.41
Belgium	0.04	-0.03
Czechia	1.43	**3.63**
Poland	-0.08	0.06

Notes: Positive (negative) values indicate that inequality is higher (lower) amongst denture wearers in comparison with individuals not wearing a denture; Values in bold indicate statistical significance at the 5% level.

across countries, there seems to be no clear association (neither uniform nor diametrical) between the ranking of countries according to absolute and relative indices. Nevertheless, the present study provides evidence for income-related inequalities in chewing ability for several European elderly populations.

There are many potential pathways through which such patterns of income-related inequality could materialise. In particular, the level of oral impairment may *per se* vary from country to country and this may mediate the influence of economic cirumstances. In this regard, the present study gives some evidence albeit mixed. For most countries, neither the extent of absolute inequalities nor the extent of relative inequalities was attributable to denture wearing. A significant influence of denture status became apparent for absolute (but not relative) inequalities in only some countries but without uniform direction: in Austria, Germany, Sweden and Czechia higher absolute inequalities prevail amongst denture wearers whereas in the Netherlands and France higher absolute inequalities exist amongst persons without denture. Even if denture wearing may be considered only a proxy for oral health status, the results of this study nevertheless suggest that pro-rich inequalities persist despite absolute inequalities being partly attributable to denture wearing.

Another explanation for the observed inequalities may be differences by country in the degree to which patients share the costs of dental treatment. Higher costs to the patient could restrict access to care and result in worse oral health for lower income individuals (Kington *et al.*, 1995). According to the OECD (2008), the fraction of dental expenditures which is borne by patients' out-of-pocket payments (OOP), amounts to 97% in Spain, 91,% in Switzerland, 69% in Denmark and Poland, 63% in Sweden, 34% in Belgium, 30% in Czechia, as well as 28% in France. The lowest OOP payment fraction is reported for Germany though no such data are available for the Netherlands, Greece, Italy, Ireland and Austria (OECD, 2008). No obvious association, however, is detectable between these different extents of OOP payment and the inequalities found in our study.

Some further limitations surrounding the present study should be mentioned. First, some may argue it an oversimplification to just ask if people can bite and chew on hard foods without difficulty (with a yes/no answer) to measure chewing ability. But the strength of our data base is its external validity (i.e. reliability and representativeness for many European countries) rather than its internal validity (i.e. accuracy of measuring chewing ability). A trade-off between both types of validity is frequently the case (Campbell and Stanley, 1966). Second, the analysis relies on cross-sectional data and does not facilitate causal inferences (Flanders *et al.*, 1992). As additional waves of SHARE become available further insights into the associations of the observed inequalities may be available. Another concern may be that the data are survey based and may not be fully clear of reporting bias. Yet as there are no comparable epidemiological data bases, SHARE does provide a unique opportunity for cross-country comparisons of oral health.

Conclusions

This study is the first to investigate income-related inequalities in chewing ability of elderly populations across many European countries. The findings suggest considerable income-related inequality in chewing ability in most of the countries included in SHARE Wave 2. Future research is needed to detect the causal pathways through which such disparities evolve.

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Appendix

Formula F.1: Equivalence income according to the OECD-modified equivalence scale

$$Equivalence\ income = \frac{net\ monthly\ household\ income}{\mu + \phi * \left[\left(\sum_{i=1}^{n} \mathrm{I}\{\mathrm{age}_i > 14\}\right) - 1\right] + \kappa * \left[\sum_{i=1}^{n} \mathrm{I}\{\mathrm{age}_i \leq 14\}\right]}$$

where

$\mu = 1$: weighting for the household head
$\varphi = 0.5$: weighting for other household members aged older 14 years
$\kappa = 0.3$: weighting for other household members aged 14 years or younger

$$\mathrm{I}\{\ \} = \begin{cases} 1 & \textit{if condition in brackets is met} \\ 0 & \textit{otherwise} \end{cases}$$

Formula F.2: Regression model for obtaining the Slope Index of Inequality (SII)

$$h_i = \alpha + \beta * X_i + \varepsilon_i$$

where

h_i: chewing ability of individual i
α : the constant of the regression model
β : the SII
X_i: fractional rank of individual i according to income deciles
ε_i : the error term

Formula F.3: Concentration Index (CI)

$$CI = \frac{2}{\bar{h}} * \mathrm{cov}(h_i, r_i)$$

where

$\bar{h}$: the mean of chewing ability
h_i : chewing ability of individual i
r_i : the fractional income rank of individual i