1 **Do welfare regimes matter for oral health? A multilevel analysis of European countries**
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3
4 **Abstract**

5 While the role of political factors on population health has recently received increasing
6 attention, relatively little is known in that respect for oral health. We aimed to assess the
7 influence of welfare state regimes on the variation in adult oral health between European
8 countries, building on the existing literature by using a multilevel approach. Our analysis also
9 explored how the oral health of people with different socioeconomic position was influenced
10 by living in five different welfare state regimes. We analysed data from the Eurobarometer
11 survey 2009. The main outcome was no functional dentition, defined as having fewer than 20
12 natural teeth. Age, gender, marital status, education and occupational social class were the
13 individual-level explanatory variables, while welfare regimes, GDP per capita and GDP annual
14 growth were the country-level variables. Multilevel logistic regression models were fitted
15 with individuals nested within countries. Results revealed that country-level characteristics
16 accounted for 8.1% of the variation in oral health. Adults in all welfare regimes were more
17 likely to have poorer oral health than their counterparts in the Scandinavian regime, with
18 those in Eastern countries being 6.94 (95% CI: 3.62-12.67) times as likely to lack a functional
19 dentition as adults in Scandinavian countries. The variation at country-level reduced
20 significantly when welfare regimes were introduced into the model (from 0.57 to 0.16; 72%
21 reduction), indicating that welfare regime explained much of the variation in the outcome
22 among European countries. Finally, adults with less education and lower occupational level
23 were more likely to have no functional dentition, especially in the Eastern and Bismarckian
24 welfare regimes.
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26 Key words: Welfare state regime; oral health; Europe; multilevel
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28 **Introduction**
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30 Oral health plays a key role in people's general health and quality of life. It affects other
31 chronic diseases and is independently related to various physical, psychological and social
32 functions such as eating, speaking, smiling, and socializing comfortably (Sheiham, 2005).
33 While there is a large body of research about the influence of social determinants on oral
34 health, the role of political factors has gained importance only recently (Guarnizo-Herreno et
35 al., 2013a; Guarnizo-Herreno et al., 2013b, 2014; Sanders et al., 2009). As social policy can
36 potentially influence the allocation and distribution of resources that are relevant for oral
37 health, the study of the political context (referring to the structure or affairs of government,
38 the state, public policies, power and authority (Bambra et al., 2007; Solar and Irwin, 2010)) is
39 central to the understanding of oral health and patterns of inequalities. Furthermore, the

socioeconomic and political context affects psychosocial factors (Dahl et al., 2006) which in turn influence the distribution of oral health outcomes (Boyapati and Wang, 2007; Locker, 2009; Sabbah et al., 2009; Sanders and Spencer, 2005; Sheiham and Nicolau, 2005). Political systems that prioritize the concentrated accumulation of private wealth over redistribution of power and privilege contribute to larger socioeconomic inequalities with poorer health for those experiencing adverse living and working conditions (Birn, 2009; Krieger et al., 2010). The theoretical perspective of this study postulates that the underlying distal determinants are in the socio-political structure and the more immediate proximal determinants are socially and politically patterned (Borrell et al., 2009; Navarro et al., 2006; Solar and Irwin, 2010).

Comparative research on welfare states has been used to analyse the potential impact of social policy on population health and health inequalities (Alvarez-Galvez et al., 2014; Bambra, 2007a; Bambra and Eikemo, 2009; Bambra et al., 2010; Bambra et al., 2009; Eikemo et al., 2008a; Eikemo et al., 2008b; Eikemo et al., 2008c; Richter et al., 2012). For that purpose, countries have been grouped in types or regimes according to the principles of their welfare structure and institutions (Bergqvist et al., 2013; Dahl and van der Wel, 2013). A welfare state regime framework is used in that respect to assess the potential role of a general approach of a combination of social policies. Characteristics of the welfare states could influence oral health through different pathways. First, the distribution of resources that are important to oral health, such as education, income support and access to healthy foods, strongly depends on political decisions, particularly in relation to the social policies of the welfare state (Borrell et al., 2007; Eikemo et al., 2008b; Espelt et al., 2008; Zambon et al., 2006). In turn, those social policies have the potential to influence population oral health and the relationship between socioeconomic position and oral health (Eikemo et al., 2008b; Olafsdottir, 2007). Second, health care systems, including oral health services, are organized and reformed according to the social policies and political institutions in different countries (Kunitz and Pesis-Katz, 2005). Characteristics of the oral health services, such as funding, coverage, and characteristics of provision are expected to be related to population oral health and patterns of inequalities (Palencia et al., 2014). Third, the social organization of welfare states is related to interpersonal trust, social cohesion and sense of belonging (Martikainen et al., 2004). These are aspects of social capital at the collective level with the potential to benefit oral health.

In our previous work, we compared population oral health and patterns of socioeconomic inequalities across five European welfare regimes: Scandinavian, Anglo-Saxon, Bismarckian, Southern, and Eastern. We found consistently lower prevalence rates of edentulousness (no natural teeth), no functional dentition and oral impacts in the Scandinavian regime (Guarnizo-Herreno et al., 2013a), while significant educational and occupational inequalities in oral health were identified in all welfare regimes (Guarnizo-Herreno et al., 2013b). Comparing the magnitude of inequalities in oral health across regimes showed a complex picture with different findings according to the outcome, socioeconomic indicator and nature of the inequalities (absolute and relative) (Guarnizo-Herreno et al., 2013b, 2014). However, such analyses did not consider the role of economic growth and development and did not formally quantify the between country variation in oral health or modification of the social gradient by welfare regime since they were based on stratified analysis.

Consequently, in this analysis, we aimed at quantifying the influence of welfare state regime on the variation in oral health, in particular functional dentition, between European countries by using a multilevel analytical approach. In addition, we account for country differences in economic growth and development –by introducing variables on GDP per capita (at purchasing power parity) and GDP annual growth rate (%), since they were considered to potentially confound the primary association of interest between welfare regimes and no functional dentition. We also examined cross-level interactions between welfare regime and individual socioeconomic position. Such information would be relevant to discuss the role of the welfare state not only in terms of reducing overall inequalities, but also for improving the situation of those at the bottom of the socioeconomic hierarchy (Bambra, 2013). We are not aware of previous studies using multilevel modelling to examine the role of welfare regimes on oral health.

Methods

Data source and study sample

We employed data from the Eurobarometer 72.3, a survey carried out in 2009 in 31 European countries. The survey used a multi-stage, random sampling design to produce nationally representative samples. In every country, all administrative regional units (EUROSTAT -

statistical office of the European Union, 2012) were assessed and from each unit, sampling points were selected with probability proportional to population size and density. Then, households were randomly selected from each sampling point, and in each household, one person was randomly selected for the interview. Since the focus of the analysis was on welfare regimes, we considered the 21 countries classified in one of the five European regimes frequently used in analyses of health inequalities and population health: Scandinavian, Bismarckian, Anglo-Saxon, Southern and Eastern (Alvarez-Galvez et al., 2014; Bambra, 2007a; Bambra and Eikemo, 2009; Bambra et al., 2010; Bambra et al., 2009; Eikemo et al., 2008a; Eikemo et al., 2008b; Eikemo et al., 2008c; Richter et al., 2012). In addition, our sample was limited to 16,314 individuals aged 20 years and older with complete data on the study variables. Participants aged less than 20 were excluded because a large proportion of them were still studying and therefore, including them in analyses based on contemporary educational attainment and occupation could have introduced some bias in the SEP measurement. The proportion of respondents with missing data was less than 3% and therefore, no imputation of missing data was carried out.

Variables

Oral health outcome

The main outcome was no functional dentition, defined as having fewer than 20 natural teeth (Moynihan and Bradbury, 2001; Sarita et al., 2003; Sheiham et al., 1999). This captures the cumulative effect of oral disease and experience of dental treatment. A binary variable was derived from the question on number of natural teeth (five response options: all; 20 or more, but not all; 10-19; 1-9; no natural teeth), with respondents answering '10-19', '1-9' or 'no natural teeth' classified as not having a functional dentition.

Individual-level explanatory variables

These included demographic and socioeconomic characteristics. The demographic variables were: 1) Age in years, treated as continuous and centred at the sample mean of 51 years; 2) Gender; and 3) Marital status, categorized as married/cohabiting, single, and divorced/separated/widowed. The socioeconomic variables were: 1) Education, measured as age when completed full-time education and categorized into: 20 years and older, 16-19 years, and up to 15 years; and 2) Occupational social class: managerial and professional,

intermediate, and routine-manual. For retired participants, allocation to an occupational class was based on their last job. Students, unemployed, homemakers, and subjects who never did any paid job were not included in the occupational classification.

Country-level explanatory variables

We considered five welfare state regimes according to Ferrera's classification (Ferrera, 1996) and the additional Eastern European regime. Ferrera's typology examines both the quantity of welfare provided and the way in which benefits are delivered (Bambra, 2007b; Eikemo et al., 2008c; Kim et al., 2012). It has shown high within-regime homogeneity and between-regime heterogeneity (Bambra, 2011), and has been used in population health and health inequalities studies (Bambra et al., 2010; Eikemo et al., 2008a; Eikemo et al., 2008b; Eikemo et al., 2008c). Ferrera identified four welfare regimes: Scandinavian, Bismarckian, Anglo-Saxon and Southern. The Scandinavian regime is characterised by generous and universal welfare provisions with a state committed with socioeconomic equality. In the Bismarckian regime, the state provides certain earnings-related benefits with little impact on the socioeconomic redistribution. In this regime, the market does not have a key role in the provision of welfare benefits and services. In the Anglo-Saxon, the market has a dominant role in the welfare provision while the role of the state is minimal. Finally, the Southern regime clusters countries with a fragmented welfare provision, clear public-private mix in services and benefits, and a system of distribution of cash subsidies more liable to corruption (Ferrera, 1996; Kim et al., 2012). In addition, the Eastern European welfare regime clusters countries which have experienced severe changes in their social policies in the last two decades going from a communist welfare state to welfare systems characterized by marketization and decentralisation (Bambra et al., 2010; Eikemo and Bambra, 2008; Eikemo et al., 2008a; Kim et al., 2012). Countries included in each regime are presented in Table 2. Welfare state regime was introduced in analyses as a categorical variable with the Scandinavian regime as the reference category, in order to be able to compare each regime with the Scandinavian, the most generous and universal welfare state among those examined.

In addition, derived from the EU statistics and measured as five-year averages (2005-2009) (EUROSTAT - statistical office of the European Union; EUROSTAT - statistical office of the European Union), GDP per capita (at purchasing power parity) and GDP annual growth rate

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1 (%) were included in analyses to account for country differences in economic growth and

2 development.

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4 *Statistical analysis*

5 In our analyses, data followed a two-level hierarchy with individuals (level-1) nested within

6 countries (level-2). Multilevel regression analyses were used to model the study outcome as

7 a function of explanatory variables at both the individual and country levels. By using this

8 approach, we were able to examine the extent to which no functional dentition differed

9 across countries and simultaneously identified factors that may explain this country-level

10 variation. As the outcome was binary, we used multilevel logistic regression models with a

11 logit function included to 'link' the probability of the outcome happening or not (π_{ij}) with the

12 parameters. After this transformation in the multilevel model, it is no longer possible to

13 estimate the variance of the individual residuals from the data. To deal with this issue, the

14 latent variable approach (Eikemo et al., 2008b; Richter et al., 2012; Steele, 2009) specifies a

15 distribution of the individual residuals with the value of the variance at individual level fixed

16 at $\pi^2/3$ = 3.29 (because $\pi^2/3$ is the variance of the logistic distribution). In turn, the country-

17 level residuals are assumed to be normally distributed and the value of the variance at country

18 level is obtained by fitting the model. Therefore, with σ^2_u the variance at country level, the

19 following formulas were used to estimate the proportion of variance attributable to each

20 level:

21   % of total variance attributed to individual level= [3.29/ (3.29+σ^2_u)] ×100

22   % of total variance attributed to country level= [σ^2_u / (3.29+σ^2_u)] ×100

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24 Two-level random intercept models were fitted. First, a null or empty model (Model 1)

25 provided a baseline estimation of the country-level variance in no functional dentition

26 (variance attributed to country differences). In Model 2, only individual-level variables were

27 included to provide information on how much of the country-level variance was explained by

28 individual-level variables, and how the outcome varied by means of individual demographic

29 and socioeconomic characteristics. In Model 3, welfare regime was entered to analyse

30 whether it contributes to explaining the variation in oral health across countries when

31 individual characteristics are accounted for. In Model 4, the country-level variables of

economic development (GDP per capita and GDP growth rate) were added to determine whether any association between welfare regime and oral health was robust to adjusting for these variables. Finally, two additional models were fitted including cross-level interaction terms between individual SEP and welfare regimes while adjusting for all individual- and country-level variables. The interaction terms indicate whether the socioeconomic gradient is modified by welfare regime and were introduced with the highest SEP group in the Scandinavian welfare regime as the reference category. Model 5a included interactions between welfare regime and education while Model 5b between welfare regime and occupational social class.

Analyses were conducted using the Markov Chain Monte Carlo estimation procedure with a chain of length of 50,000 burn-in 5,000 (Aida et al., 2011; Tabuchi et al., 2014). Odds ratios with 95% confidence intervals were calculated to assess associations between the outcome and the individual and country-level variables. We also derived median odds ratio (MOR) to quantify the country-level variance with an odds ratio approach (Larsen and Merlo, 2005; Merlo et al., 2006). If the MOR is one, there is no variation between countries in the probability of the outcome. If there are strong country-level differences, the MOR is large and greater than one (Merlo et al., 2006). The Deviance Information Criterion (DIC) diagnostic was used to compare the goodness-of-fit of each model, with lower DIC values suggesting a better model (Browne, 2012). Models were fitted in MLwiN 2.27 from within Stata (Leckie and Charlton, 2013).

Results

Table 1 shows the descriptive statistics by welfare regime. Over a quarter of adults had no functional dentition in the Anglo-Saxon, Bismarckian and Southern regimes, while this prevalence was 16% and 45% in the Scandinavian and Eastern regimes respectively.

Table 1 - Descriptive statistics by welfare regime (16,314 adults aged ≥20 years)

Variables	Weighted percentage or mean (SD)				
	Scandinavian (n= 2,572)	Anglo-Saxon (n= 1,619)	Bismarckian (n= 4,606)	Southern (n= 2,724)	Eastern (n= 4,793)
Age	52.03 (30.12)	50.24 (15.10)	51.30 (14.76)	47.85 (13.08)	49.16 (23.53)
Gender					
Male	50.22	53.88	51.93	58.92	49.88
Female	49.78	46.12	48.07	41.08	50.12
Marital status					
Married/cohabiting	66.55	58.96	70.26	68.10	66.71
Divorced/widowed	17.30	18.17	15.36	11.52	19.47
Single	16.15	22.87	14.39	20.38	13.82
Education (Age when completed full-time education)					
20 years and older	65.27	25.81	32.04	23.52	26.13
16 - 19 years	24.11	49.88	46.17	42.75	59.64
Up to 15 years	10.61	24.31	21.79	33.73	14.23
Occupational class					
Managers/professionals	33.25	29.24	28.59	15.52	17.83
Intermediate	25.51	26.16	24.42	33.74	29.02
Manual workers	41.24	44.59	46.99	50.74	53.15
No functional dentition[a]	16.25	25.87	27.53	27.31	45.52

[a] Age-standardized prevalence (%)

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Table 2 - Countries grouped by five welfare state regimes

Scandinavian	Bismarckian	Anglo-Saxon	Southern	Eastern
Sweden	Austria	UK	Greece	Czech Republic
Finland	Belgium	Ireland	Italy	Estonia
Denmark	France		Portugal	Hungary
	Germany		Spain	Poland
	Luxemburg			Slovakia
	Netherlands			Slovenia

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Variation between countries

There was significant variation in no functional dentition across countries (0.29, SE=0.11), with 8.07% of the variation in the outcome attributed to differences between countries. The MOR estimate between adults with higher versus lower risk of no functional dentition is 1.67 (1.44, 2.04) and confirms these significant country-level differences in the outcome (Table 3, Model 1).

Individual-level characteristics

After adjusting for individual-level characteristics (Table 3, Model 2), the country-level variance was 0.57, with 15% of the total remaining unexplained variation in no functional dentition being attributed to differences between countries. Considering that multilevel logistic regression models have the level 1 variance fixed, the addition of a level 1 explanatory variable can only change the level 2 variance, and in fact, it could increase the proportion of total level 2 variance - an example of a suppression effect (Steele, 2009). Therefore, the increase in country-level variance (from 0.29 in Model 1 to 0.57 in Model 2) indicates that adjustment for demographic and socioeconomic characteristics at individual level did not explain differences between countries. Model 2 showed that having no functional dentition was significantly associated with being male, older, divorced, widowed or single (compared to being married), having lower education and belonging to lower social classes. The associations of the outcome with education and occupational social class revealed social gradients with higher odds of having no functional dentition at each lower SEP level. Including individual-level variables substantially improved the fit of the model, as shown by a reduction of the DIC score.

Welfare state regimes

When welfare regime variables were included in the model (Table 3, Model 3), results showed that adults in all other regimes were more likely to lack a functional dentition than those in the Scandinavian regime, with adults in Eastern countries being 6.94 (95%CI: 3.62-12.67) times as likely to lack a functional dentition as adults in Scandinavian countries. There was, however, no significant difference between the Scandinavian and the Anglo-Saxon regimes. The country-level variance was reduced from 0.57 in Model 2 to 0.16 in Model 3, indicating

1 that welfare regimes explained a considerable proportion (around 72%) of the variation

2 between countries observed in Model 2. As a consequence, the proportional variance at

3 country level decreased from 15% to 5%, and the MOR was reduced from 2.05 to 1.46,

4 confirming that variations in no functional dentition between countries were substantially

5 explained by welfare regime typology.

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7 The economic development variables were not significantly related to functional dentition.

8 After adjusting for these variables (Model 4, results not presented), there were just some

9 modest changes in the ORs. Additionally, adding the two economic variables did not explain

10 the country-level variance observed in Model 3, and actually caused the fit of the model to

11 decline slightly (according to the DIC score).

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Table 3 - Multilevel analyses of no functional dentition (16,314 individuals nested within 21 countries)

	Model 1	Model 2	Model 3
		OR (95% CI)	
Individual-level variables			
Sex			
Men		1.00	1.00
Women		0.91* (0.83-0.99)	0.91* (0.83-0.99)
Age per year (centred on 51)		1.11** (1.10-1.11)	1.11** (1.10-1.11)
Marital status			
Married/cohabiting		1.00	1.00
Divorced/separated/widowed		1.32** (1.18-1.47)	1.31** (1.18-1.46)
Single		1.25* (1.08-1.44)	1.25* (1.08-1.45)
Education (Age when stop full-time education)			
20 years and older		1.00	1.00
16 - 19 years		1.38** (1.23-1.54)	1.37** (1.21-1.53)
Up to 15 years		2.26** (1.96-2.58)	2.25** (1.96-2.59)
Occupational social class			
Managerial and professional		1.00	1.00
Intermediate		1.47** (1.29-1.67)	1.47** (1.29-1.68)
Routine and manual		2.10** (1.86-2.37)	2.11** (1.87-2.38)
Country-level variables			
Welfare state regime			
Scandinavian			1.00
Bismarckian			2.76** (1.49-4.83)
Anglo-Saxon			2.28 (0.99-4.80)
Southern			2.03* (1.01-4.10)
Eastern			6.94** (3.62-12.67)
Country-level variance (SE)	0.289 (0.107)	0.566 (0.203)	0.156 (0.067)
% of total variance (partition)			
Individual level (%)	91.93	85.33	95.47
Country level (%)	8.07	14.67	4.53
% change in country-level variance	-	95.85	-72.44
MOR (95% CrI)	1.67 (1.44-2.04)	2.05 (1.68-2.68)	1.46 (1.29-1.73)
DIC	19889.21	13089.87	13089.51

Asterisks indicate level of significance (* $p<0.05$, **$p<0.001$)
MOR: Median Odds Ratio
DIC: Deviance Information Criterion

Interaction effects between SEP and welfare state regimes

Tables 4 and 5 present the results of models with cross-level interactions between SEP measures and welfare regimes while adjusting for all individual- and country-level variables (including the economic development variables). Compared to those in the highest educational level in the Scandinavian regime, participants in any educational level from the Bismarckian, Anglo-Saxon, Southern and Eastern regimes had significantly higher odds of not having a functional dentition. Clear educational gradients, with higher likelihood of no functional dentition at each lower educational level, were found in all welfare regimes with the exception of the Southern, where the associations were significant but less clearly linear (Table 4). These findings also show that in terms of functional dentition adults in the lowest educational level are better off in the Scandinavian regime and worse in the Eastern followed by the Bismarckian regime.

A general pattern of social gradients was also found for occupational social class (Table 5). Again, compared to those in the managerial or professional group in the Scandinavian regime, adults belonging to any occupational social class in all other regimes had higher odds of no functional dentition, with the exception of the marginally non-significant odds for the managerial/professional category in the Anglo-Saxon regime. Similar to the results for education, findings suggest that among those in routine/manual occupations it was most detrimental (in terms of no functional dentition) to live in the Eastern regime followed by the Bismarckian, and much less detrimental to live in the Scandinavian regime.

Results of these models with interaction terms suggest that inequalities in oral health by education level and social class exist in all welfare regimes. Moreover, we found higher odds ratios for adults belonging to low, medium and even the highest SEP groups in the Eastern and Bismarckian regimes compared to the equivalent socioeconomic groups in the Scandinavian regime.

1 Table 4 - Multilevel analyses of no functional dentition with interaction effects between
2 education and welfare state regime

	Model 5a		
	Education (Age when stop full-time education)		
	20 years and older	16 - 19 years	Up to 15 years
	OR (95% CI)		
Welfare state regime			
Scandinavian	1.00	1.57* (1.18-2.07)	3.28** (2.37-4.42)
Bismarckian	3.46* (1.68-6.40)	4.82** (2.37-8.91)	6.79** (3.29-12.63)
Anglo-Saxon	2.82* (1.08-6.06)	4.01* (1.60-8.21)	5.02** (1.99-10.49)
Southern	2.85* (1.28-5.54)	2.66* (1.26-5.00)	5.02** (2.45-9.30)
Eastern	8.14** (3.67-15.94)	10.61** (4.76-20.71)	21.51** (9.43-42.66)
Country level variance (SE)	0.175 (0.078)		
% of total variance (partition)			
Individual level (%)	94.96		
Country level (%)	5.04		

3 Asterisks indicate level of significance (* p<0.05, **p<0.001)
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7 Table 5 - Multilevel analyses of no functional dentition with interaction effects between
8 occupation and welfare state regime

	Model 5b		
	Occupational social class		
	Managerial and professional	Intermediate	Routine and manual
	OR (95% CI)		
Welfare state regime			
Scandinavian	1.00	1.55* (1.08-2.15)	2.90** (2.19-3.80)
Bismarckian	3.51* (1.82-6.42)	5.69** (2.92-10.32)	6.42** (3.31-11.66)
Anglo-Saxon	2.25 (0.94-4.76)	3.68* (1.52-7.74)	5.91** (2.52-12.16)
Southern	2.42* (1.11-4.81)	3.42** (1.65-6.61)	4.33** (2.14-8.14)
Eastern	8.19** (3.41-17.42)	10.13** (4.26-21.71)	16.24** (6.94-34.25)
Country level variance (SE)	0.174 (0.085)		
% of total variance (partition)			
Individual level (%)	94.97		
Country level (%)	5.03		

9 Asterisks indicate level of significance (* p<0.05, **p<0.001)
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Discussion

We assessed the influence of welfare state regimes on the variation in oral health between European countries using a multilevel approach. We found large differences in not having a functional dentition between welfare regimes, with all regimes showing larger odds ratios compared to the Scandinavian, and being particularly large for the Eastern regime. Results also revealed that 92% of the variation in no functional dentition was related to individual-level factors, while the remaining 8% was attributable to differences between countries. We also found that welfare state regimes contributed to explaining a significant proportion (72%) of the variation attributable to differences between countries. It also seems that the Scandinavian regime has arrangements, irrespective of its economic development, which gave it an oral health advantage compared to the other welfare systems, particularly compared to the Eastern European regime. Moreover, results of the cross-level interactions between SEP and welfare regimes showed that at any educational and occupational level, participants in the Scandinavian regime had lower odds of no functional dentition compared to all other welfare regimes. And importantly, adults in the lowest SEP levels are worse in terms of functional dentition in the Eastern regime followed by the Bismarckian.

Previous analyses on general health outcomes using a multilevel approach with individuals nested in countries have also shown that the country-level variance explains small proportions of the overall variations, ranging between 4% and 15% depending on the population and health outcome chosen (Chung et al., 2013; Eikemo et al., 2008b; Foubert et al., 2014; Levecque et al., 2011; Richter et al., 2012; Witvliet et al., 2012). Consistent with other studies on general health, our results provide support for the hypothesis that welfare state regimes contribute to explaining the variation in health across countries (Chung and Muntaner, 2007; Chung et al., 2013; Eikemo et al., 2008b; Foubert et al., 2014; Richter et al., 2012; Witvliet et al., 2012). Such evidence on general health includes two studies using the five welfare regimes according to the Ferrara typology and the additional Easter regime, which showed that 48% of the country-level variation in self-rated health (Eikemo et al., 2008b) and 73% in depressive symptoms (Levecque et al., 2011) were explained by welfare state regimes. In addition, Foubert et al. (Foubert et al., 2014) used a nine-fold welfare regime typology to study 57 countries from different regions of the world, and revealed that 36% of the national variation in self-rated health was explained by welfare regimes. In a study of

adolescents from 32 high-income countries, Richter et al. (Richter et al., 2012) found that 20% of the national variation in self-rated health and 11% in health complaints was explained by welfare regimes. Also, analysing data from 19 high-income countries, Chung and Muntaner showed that about 20% of the country-level variation in infant mortality and 10% in low birth weight was explained by the type of welfare state (Chung and Muntaner, 2007).

Our findings provide further evidence of the good population oral health in the Scandinavian welfare regime. This is so, even in times of regressive policy reforms or the era of 'welfare state retrenchment' across all Europe (Chung and Muntaner, 2007; Huber and Stephens, 2001). In Scandinavian countries, the increasing socioeconomic inequalities and recent changes in their social policies have brought into question the extent to which they still represent the ideal social democratic welfare state (Bambra, 2013; Fritzell et al., 2012). However, it is important to keep in mind that the presence of a functional dentition is a cumulative measure of lifetime oral health (Aida et al., 2011; Bernabe and Marcenes, 2011; Celeste et al., 2009). Therefore, the observed effects of the Scandinavian welfare regime may operate through diverse pathways over the life course and could still reflect some potential benefits of the 'golden age' of the Scandinavian states (1950s to early 1970s) (Bambra et al., 2010). This potential lag effect is particularly important in this study since the outcome of no functional dentition is more prevalent among older adults who have had diverse welfare state experiences, but lived in societies with the most generous welfare benefits during their youth.

We suggest that there are elements of the political context of a country, besides its economic development, which are key factors in shaping the association between SEP and oral health. In particular, it seems that characteristics of the Scandinavian welfare states - the universal and generous welfare policies, a strong redistributive social security system, health policies explicitly aimed to address the social determinants of health, more gender equality and stronger social cohesion and social trust - seem to help in buffering the association between SEP and oral health as adults in the lowest educational and occupational levels were better off in terms of no functional dentition in the Scandinavian regime than in other welfare regimes. This finding would be in line with the view that the role of the welfare state is not only to reduce overall inequality, but also, improve the situation of those at the bottom of the socioeconomic hierarchy (Bambra, 2013). In agreement with a previous multilevel

analysis on self-perceived general health (Eikemo et al., 2008b), our findings showed a non-significant difference in the odds of having no functional dentition between the Scandinavian and Anglo-Saxon regimes. However, analyses by SEP revealed that the Anglo-Saxon regime was 'protective' of good oral health for the more affluent (highest occupational class) but did fall well short of the Scandinavian regime in the more deprived groups. Research in this area will benefit from future studies assessing the specific mechanisms leading to oral health inequalities in different welfare regimes.

The study findings should be interpreted considering certain caveats. The outcome was self-reported and such measures may reflect differences in health perceptions and cultural backgrounds (Mitchell, 2005; Zimmer et al., 2000). However, self-reported indicators are valid measures of oral health and significantly associated with diverse clinical conditions (Borrell and Baquero, 2011; Kojima et al., 2013; Locker, 2009; Silva et al., 2014; Tsakos et al., 2011). In addition, the number of natural teeth is less sensitive to cultural variations than other self-reported measures. Future work should also include clinical measures of oral health. Regarding the SEP indicators, while age when completing full time education is considered as a proxy for years of schooling, international comparisons based on this measure could be slightly inaccurate as countries differ in their policies regarding age when starting and leaving compulsory full time education. There are also limitations in the use of occupation for cross-national comparisons, as the same occupational level could lead to dissimilar access to oral health related resources (material and immaterial) in different countries. Nevertheless, the three occupational categories used in the analyses came from the UK NS-SEC, a classification designed to capture well-differentiated conditions of occupations and employment relations in modern societies (Chandola, 2000; Chandola and Jenkinson, 2000). In addition, the analysis was limited by data availability and at the country level we adjusted only for GDP per capita and GDP growth rate but not for other attributes. Although analyses were not intended to establish causal relationships, but rather to identify associations, the cross-sectional nature of this study implies that results on inequalities may be prone to questions about health selection.

Potential limitations of the welfare regime approach are also worth discussing. This approach fails to take into account cross-national variations in different social policy areas (Bambra,

2005; Kasza, 2002) then limiting to a certain extent the possibility to assess more specific pathways and mechanisms linking welfare state characteristics and health (Chung et al., 2013). To account for some of the within-regime variation, some researchers have included in their analyses of welfare regimes, measures of welfare state generosity (i.e., indicators of social spending), such as total public expenditure as percentage of GDP or public health spending as percentage of total health spending (Levecque et al., 2011). Others have argued, however, that including social spending information would not change substantially results of analyses, as the welfare regime and welfare generosity approaches are strongly related (e.g., the Scandinavian states are also the most generous) (Chung et al., 2013). A second limitation has to do with the change over time in social policies of the welfare states. Pressures for managing public budgets, changes in labour markets and the economic crisis have led to different reforms in the social welfare policies of European countries (Dahlgren, 2014; Kangas, 2010; Naumann, 2014), making the welfare state types less differentiated now than they were in the past. Despite these disadvantages, the welfare regimes are considered a valid and relevant approach in the study of political determinants of health and health inequalities. Cross-national comparisons of specific welfare provision areas (e.g., health care, labour market and family) have identified clusters of countries that tend to mirror the existing welfare regimes (Bambra, 2004, 2005). Moreover, despite the principles and institutional design of different social policies, the clusters of welfare regimes are also evident when assessing social 'outcomes' such as income inequality and poverty (Fritzell et al., 2012; Kammer et al., 2012). Despite existent variations, countries seem to follow certain patterns and tend to cluster along different dimensions of the welfare state (Bambra, 2004). All these highlight the usefulness of the welfare state regimes approach in analysing the potential influence of the general principles behind welfare policies and studying the political determinants of health.

Future research on political determinants of population oral health and patterns of inequalities should focus on more specific features of the welfare provision and particular policy areas. Features of the welfare provision that theoretically could affect oral health and inequalities, and have support from certain evidence on general health include: public spending on social programs (Leinsalu et al., 2009; Lundberg et al., 2008; Navarro et al., 2003), universalism in social protection systems (Brennenstuhl et al., 2012; Lundberg et al., 2008;

Sanders et al., 2009), efforts directed to minimize the effects of negative life events (e.g. loss of job, disability) (Eikemo et al., 2008b; Leon et al., 1992; Olafsdottir, 2007), and supportive family policies (Lahelma et al., 2002; Lundberg et al., 2008). Likewise, further comparative research should examine characteristics of the dental health systems, alone and in combination with different features of health and social policies. Such information would guide public health strategies towards effectively reducing oral health inequalities.

In conclusion, using multilevel modelling on a large dataset with standardized data collection across a range of European countries, we showed that welfare state regimes contributed to explain a considerable proportion of the variation in oral health among European countries. Bismarckian, Anglo-Saxon and Eastern regimes were observed to have higher odds of not having a functional dentition compared to the Scandinavian regime. Moreover, there was evidence that the Scandinavian welfare regime protected against the adverse oral health effects of lower socioeconomic conditions. Results of this analysis may imply that despite the limitations of the welfare regime approach, clustering countries according to features of their welfare provision has a relevant role in explaining differences in oral health and patterns of inequalities. This should be considered in the design of public health strategies aimed to improve population health and reduce oral health inequalities.

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