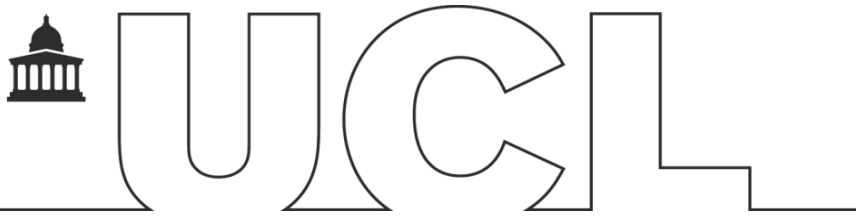

# Political factors and oral health inequalities: a cross-national analysis

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Thesis submitted for the degree of Doctor of Philosophy

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2014

I, Carol C. Guarnizo-Herreño confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

## Abstract

**Background:** Macro-level factors (related to the economic and political context) have been considered as determinants of health inequalities. In particular, the role of political factors (such as welfare state regimes) has recently received increasing attention. However, very little is known in that respect for oral health inequalities.

**Aim:** To examine the relationship between oral health inequalities and political factors (welfare state regimes) in Europe and the US.

**Methods:** The project involved three stages. First, oral health inequalities were compared across 21 European countries grouped into different welfare state regimes (Scandinavian, Anglo-Saxon, Bismarckian, Southern, and Eastern). Second, a multilevel approach was employed to assess the influence of welfare regimes on the variation in oral health between European countries. Third, inequalities were compared between two countries classified in the same welfare regime, but with different health care systems: England and the US. In stages one and three, relative and absolute socioeconomic inequalities were examined using the relative and slope indices of inequality (RII and SII, respectively).

**Results:** The Scandinavian welfare regime showed consistently lower prevalence rates of edentulousness, no functional dentition and oral impacts than the other regimes. Significant educational and occupational inequalities on edentulousness and no functional dentition were observed in all welfare regimes. The comparison on the magnitude of inequalities across regimes showed a complex picture with different findings according to the outcome, socioeconomic indicator and nature of the inequalities (absolute and relative). Overall, results of this comparison did not support the hypothesis of lower inequalities in the Scandinavian regime. When using a multilevel approach, results revealed that grouping countries into welfare regimes contributed to explaining the variation in oral health among European countries. In the England-US comparison, significant relative (RII) and absolute (SII) inequalities were found in the two countries in all oral health measures. These inequalities were consistently higher in the US compared to England.

**Conclusions:** Oral health inequalities exist in all European welfare state regimes. The Scandinavian regime exhibited better oral health, but not lower inequalities compared to the other regimes. The US showed consistently larger inequalities than England. Overall, results suggest that political factors influence socioeconomic inequalities in oral health.

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## Acronyms

**ADHS** Adult Dental Health Survey

**CAPI** Computer Assisted Personal Interview

**CSDH** Commission of Social Determinants of Health

**DIC** Deviance Information Criterion

**ESS** European Social Survey

**GDP** gross domestic product

**HBSC** Health Behaviour in School-aged Children survey

**IRR** incidence rate ratio

**MCMC** Markov chain Monte Carlo

**MOR** median odds ratio

**NHANES** National Health and Nutrition Examination Survey

**NHS** National Health Service

**NS-SEC** National Statistics Socio-Economic Classification

**NUTS** Nomenclature of Territorial Units for Statistics

**OECD** Organization for Economic Cooperation and Development

**OHIP** Oral Health Impact Profile

**OHRQoL** Oral Health Related Quality of Life

**OR** Odds ratio

**PR** prevalence ratio

**PSU** primary sampling unit

**RII** Relative Index of Inequality

**SHA** Strategic Health Authority

**SHARE** Survey of Health, Ageing and Retirement in Europe

**SEP** socioeconomic position

**SII** Slope Index of Inequality

**SSS** subjective social status

## Acknowledgements

I am enormously grateful to my supervisors Prof Richard Watt and Dr Georgios Tsakos. They have been excellent mentors throughout my PhD studies providing invaluable support and constant guidance with my research work and student life. Their kindness and generosity combined with admirable academic qualities and enthusiasm for research are really inspiring. Thank you for making my PhD such a wonderful experience.

I would also like to especially thank Prof Aubrey Sheiham, my joint supervisor, who not only has shared with me his knowledge and experience on difference aspects of dental public health, but also has given me wise advice and the most generous support on different aspects of life. I truly appreciate all he has done for me as a mentor. I also feel very privileged to have been sharing an office with him and enjoyed many enriching conversations.

It has been a great honour to share time with different people at the Department of Epidemiology and Public Health at UCL who at different stages helped me with academic support. I would particularly like to thank Dr Hynek Pikhart and Dr Mai Stafford for their statistical advice.

I also gratefully acknowledge my friends of the Dental Public Health group who have made my time at UCL a very enjoyable experience. Thanks for showing me how a good cup of tea, cake and biscuits can make life easier. A big thank you must also go to my friends in London and Bogotá who have been an indispensable source of emotional support through these years.

I would finally like to thank my amazing family. All my gratitude goes to my parents and brother who have given me immense love and motivation throughout my PhD studies, and life in general. I am privileged for being part of the great Guarnizo-Herreño clan. I am also enormously grateful with my husband Francisco, my companion and strength during these years. This thesis was possible thanks to the warmth and shelter of his unlimited love.

# Chapter 1 - Background

Health inequalities are one of the most important problems of social injustice worldwide and are increasingly recognized as a serious, public health concern. There are differences in health status between population groups defined by socioeconomic position (SEP), gender, ethnicity and geographical location (1-3). These differences are considered inequalities when they are systematic, unfair, avoidable, and are observed across population groups with different levels of wealth, prestige or power (4, 5). Inequalities exist not only between the higher and lower social groups but extend throughout the social hierarchy, a phenomenon known as the social gradient in health (6, 7). The underlying causes of these inequalities are related to systematic social disadvantage and lower access to resources (4, 5, 8, 9). During the last decades, while there have been improvements in various measures of population health, inequalities in health have not reduced consistently (3, 10-12). Disadvantaged groups in contemporary societies still endure a higher burden of mortality and morbidity, and there is a growing body of evidence showing the persistence of social gradients in many health outcomes (3, 13-19). It is highly likely that health inequalities will increase as social inequalities have risen following recent processes of reforms in social policies, changes in labour markets and the global economic crisis (20-24). Therefore, assessing and understanding health inequalities remains a policy and research priority.

In analyses of health inequalities, various studies and conceptual models have highlighted macro-level factors, related to the economic and political context, as crucial determinants (25-27). The analysis of the mechanisms underlying the unequal distribution of health indicates that the social conditions in which people live and work are the main drivers. In turn, the political context shapes how those social conditions are distributed within a society (28-30). The political context here refers to the structure or affairs of government, the state, public policies, power and authority (25, 31). To illustrate this point, the Commission on Social Determinants of Health stated that “health inequalities result from unfair

opportunities in daily living conditions which originate in the inequitable distribution of power, money, and resources" (8, 32).

There is a sound theoretical basis for the impact of political factors on health inequalities. First, the distribution of resources that are important to health, such as housing and education, strongly depends on political decisions, more specifically on the social policies of the welfare state (33-36). Then, those social policies have the potential to influence the relationship between SEP and health (29, 33). For example, the negative psychosocial effects of events such as unemployment and disability, would be counterbalanced if the society provided generous and universal benefits as protection (37). It is expected that such protection increases the sense of security and control (particularly among those in lower SEP) which in turn would have a positive impact on mental and physical health (37). Second, health care systems are organized and reformed according to the social policies and political institutions in different countries (38). Characteristics of the health care systems, such as funding, coverage, and characteristics of provision, have been related to population health and health inequalities (38-43). Third, the social organization of welfare states is related to interpersonal trust, social cohesion and sense of belonging (44). These are considered public resources with the potential to benefit population health (45-47) and might affect how a society approaches health inequalities.

Even though the role of political factors on health inequalities has recently received increasing attention, very little is known in that respect for oral health inequalities. Moreover, although there is a growing body of research about the influence of social determinants on the distribution of oral health, there is very little information about the role of political factors. To date, research on oral health has shown a consistent relationship between SEP and different clinical and subjective measures (48-53). Evidence from different settings worldwide suggests that subjects in lower socioeconomic levels are more likely to have poorer oral health than their counterparts in higher positions (14, 48-59). Furthermore, these inequalities often form a gradient with worse oral health at consecutively lower socioeconomic levels

(57-63). The extensive evidence base on social determinants, contrasts with the dearth of research on the political determinants of oral health. As a more detailed understanding of the root causes of socioeconomic inequalities in oral health is needed, the aim of this thesis is to examine the relationship between oral health inequalities and certain political factors in Europe and the US. To do that, countries with different welfare state arrangements and health care systems are compared.

This thesis is organized as follows. It begins by presenting some concepts and a review of the literature on three topics: socioeconomic position and how it affects health, the relationship between welfare state regimes and health inequalities, and socioeconomic inequalities in oral health (Chapter 2). The literature review assesses the evidence and identifies a gap in knowledge which this project aims to address. In Chapter 3, the study aim, hypotheses and objectives are presented. That is followed by a Chapter 4 on Methods in which the main characteristics of the data sources, variables and statistical analyses carried out are described.

Chapters 5 to 8 present the results of the analyses. Chapter 5 is focused on socioeconomic inequalities in oral health across different European welfare regimes with no functional dentition and edentulousness (no natural teeth) as the outcomes. In this analysis, absolute and relative socioeconomic inequalities are investigated along three dimensions of SEP: education, occupational social class and subjective social status. In Chapter 6 a similar analysis is presented, this time using oral impacts on daily life as the outcome of interest. Chapter 7 describes the results of analyses performed using a multilevel approach aimed to assess the influence of welfare state regimes on the variation in oral health between European countries. In turn, results of a comparison on educational inequalities in oral health between England and the United States are presented in Chapter 8. Finally, results of the project are discussed and compared with other studies in Chapter 9.

# Chapter 2 - Literature review

This chapter provides a context for this project by giving an overview of relevant concepts and existing literature concerning three main topics: socioeconomic position and how it affects health, the relationship between welfare state regimes and health inequalities, and finally socioeconomic inequalities in oral health. These topics are discussed in separate sections below.

## 2.1 Socioeconomic position and how it affects health

### 2.1.1 Socioeconomic position (SEP)

Socioeconomic position is a concept frequently used in public health research and particularly relevant in analyses of health inequalities. Socioeconomic position (SEP) has been defined as 'the social and economic factors that influence what positions individuals or groups hold within the structure of a society' (64). It has been argued that structural inequalities operate through SEP which defines differential access to key resources for health (65). A number of authors have agreed that two main sociological approaches are particularly relevant for the understanding and use of SEP in epidemiological research (64, 66). These approaches, which elaborate on the issue of social position in industrialised capitalist societies, are based on the work of Karl Marx and Max Weber.

In the Marxist approach, the society is stratified in 'social classes' which are defined by the relationship that individuals establish with productive resources or 'means of production' (factories, financial institutions, land). The main division, with an inherent class conflict, is then generated between those who sell their labour (exploited) and those who own the means of production and control the workers (exploiters) (67, 68). The idea of a 'middle class' which both exploits and is exploited was later introduced by the Marxist sociologist Erik Olin Wright (69). In his theory of 'contradictory class location', Wright argues that those in the middle class are

involved in activities to manage other workers, while having little influence over organizational policies and not ownership control (70). Therefore, they simultaneously belong to capitalist and working classes (64, 71). Further development of his ideas led Wright to suggest a social class scheme with 12 classes divided according to the interplay of four dimensions: ownership of means of production, relationship with authority (management), possession of skills or credential assets and, among owners, the number of employees (69). Wright's classification has been used to examine the association between social class and health outcomes in certain epidemiological studies (71-74).

In the Weberian approach, the class structure is defined by access to and exclusion from certain economic opportunities (68). Although Weber also recognizes the importance of individuals' relation to the means of production, for him that relationship matters because it generates different sets of goods, assets, knowledge, and skills (64). These resources held by individuals can be interchanged by income and therefore, they generate different chances in the marketplace, what Weber called 'life chances'. Groups of people who share similar life chances also share values, beliefs, circumstances and life styles (dress codes, marriage patterns, eating habits, etc.) then becoming status groups (75, 76). In commonality with the Marxian approach, Weber also placed property ownership at the core of class division in capitalist societies (76). However, he focused more on the unequal distribution of opportunities generated by this basic division. For that reason, indicators of 'life chances' at the individual's level, such as education, are said to be more grounded in the Weberian theory (64).

In this thesis, socioeconomic position is used as a term to refer to material and non-material resources of individuals that influence their position in society. The choice of SEP indicators used in the project was somehow limited by the availability of information in the datasets. However, different measures were used whenever possible in order to capture different dimensions of people's socioeconomic circumstances. In the context of the two above-mentioned sociological approaches, one could say that the indicators employed are closer to the Weberian school of

thought as they are mainly concerned with skills, knowledge and resources held by individuals. The following subsection discuss some measures of SEP, mainly those used in this project.

**Selected measures of socioeconomic position**

In public health research, different measures of SEP have been used, including education, occupational social class, income, wealth, subjective social status, housing conditions, and SEP indicators at area level (77-79). Among these, three measures have been largely used in analyses of health inequalities: education, occupational social class and income. These three factors are inter-related and have been accepted as good indicators of relative position in a society. Furthermore, numerous cross-national analyses of health inequalities have considered them as SEP indicators (11, 29, 33, 34, 80-82), and there is strong evidence of their association with oral health (14, 50, 51, 53, 56, 57, 59, 83-86). These three measures are discussed below along with subjective social status, which was used in some analyses of this project as SEP indicator.

*Education*

Education attempts to capture the knowledge related resources of a person and is a good proxy of life time SEP since it is usually achieved relatively early in life (79). As such, education can capture both SEP circumstances of family origin and own SEP as it has a significant effect on occupation and income (66, 79). Education is relatively easy to interpret and also allows classifying the whole population and not only those who are active in the labour market (18, 87). Besides, education is frequently used in cross-national comparisons given its good level of comparability (18). Nevertheless, education has also some drawbacks as SEP indicator. As it remains stable during adult life, it could reflect less accurately the current living circumstances of the person (19). Also, its meaning can vary among birth cohorts since under different historical contexts education might have led to different potential occupational opportunities and income levels. Since education has improved over the years for many populations, older cohorts could be over represented among those in lower educational levels (66). In terms of

measurement, education has been assessed in various ways including literacy, enrolment, the highest level of formal education achieved, age when finished education and number of years of completed education.

Education has been related to health in different ways. First, level of education is strongly associated to work opportunities, characteristics of jobs and economic conditions. People with higher educational level are more likely to receive higher income from employment, work in full time jobs, and feel more secure and satisfied with their job, compared to their less educated counterparts (88). These aspects, in turn, have a significant relationship with health (88-90). Second, education can influence the acquisition of social and psychological resources. In particular, more educated subjects have a better sense of control over their lives and more social support, both of which potentially protect health (88). Third, it has been argued that education influences the way in which people receive health education messages, interact with health services and make decisions about risk behaviours (79, 91). These relationships have been explained by the effect that education could have on both cognitive functioning and time preferences or 'time-horizon'. Regarding the later, cognitive resources may increase the importance that individuals give to long-term goals over short-term rewards, affecting their decisions on certain behaviours, e.g., smoking (79, 92).

*Occupational social class*

Occupational social class is considered as indicator of SEP in adulthood and parental occupation has been used as indicator of SEP in early stages of life (66). Occupational social class is used to reflect: 1) economic and political relationships between owners and workers, and level of subordination (from the Marxist tradition), or 2) as proxy of a person's place in society associated to social status, income and education (from the Weberian tradition) (66, 79, 93). The first aspect refers to 'social classes' which are based on relations created in the labour market according to the control over certain resources: ownership of means of production, control of organizational assets (management), and possession of skills or credentials (34, 69, 94, 95). Thus, social classes convey how groups exist in

relationship to each other, e.g. employer-employee and manager-subordinate worker (96). The aforementioned Wright's classification operationalizes this conceptual approach. Most occupation-based classifications are, however, less focused on the relational aspect and tend to categorize occupations according to skills, job title, employment status, and levels of independence or job control. The National Statistics Socioeconomic Classification (NS-SEC), used in this thesis, is an occupational measure based on both employment conditions and relations (97). Aspects considered by the NS-SEC to form occupational groups include distinction between wages and salaries, the level of job security and autonomy that workers have, and the existence of a career structure and prospects for promotion (1, 87).

Occupation also has strengths and limitations as a SEP indicator. According to Galobardes et al. (66), one important advantage is its availability. Measures of the current, longest held or most recent occupation are frequently included in large population surveys and other data sources, particularly in high income countries (66, 90). However, an important disadvantage is that it cannot be assigned to those who are not active in the labour market, and therefore, an important group of people may be excluded from analyses (1, 66). In addition, occupation has limitations as a SEP indicator in studies of older populations where the longest held or most recent occupation may not accurately reflect current socioeconomic circumstances.

Different mechanisms of how occupation affects health have been suggested. The first is through the influence of occupation on income and the resulting access to material resources which defines standard of living (90). Another mechanism is that people in more prestigious occupations may gain access to certain privileges for them and their families such as better health care and education (66). Occupation may also act through psychosocial mechanisms given its relationship with meaningful social networks, stress at work, autonomy and control (98-100). Finally, certain jobs are more related to specific health risks such as accidents or toxic environments (66).

*Income*

Income is considered the major determinant of people's living standards as it captures the material-related resources of a person or household (1, 66). Compared to individual income, household income is thought to be a more appropriate indicator to assess SEP especially for those who are not the main earners in the household (79). To make this measurement comparable across households, income is usually transformed or 'equivalized' to adjust for household size and composition (1). It has been argued that what matters for health is not the money itself, but how it enables access to health-related goods and services (79). In that sense, consumption might be considered a better measure of material circumstances for studies on health inequalities. However, it can be more difficult to capture, is prone to recall bias and is not frequently included in population surveys (101). Income is considered the SEP indicator that fluctuates the most in time, but also one that has a cumulative effect over the life course (90). Compared to education and occupation, income is more prone to certain measurement bias, as people are less willing to give accurate information on their income (102).

The links between income and health operate through diverse pathways. Income allows the acquisition of health enhancing goods and services like food, shelter and health care (66). Income can also affect health through psychosocial factors. More specifically, income provides material conditions to participate in society which has the potential to enhance self-esteem and social standing. Finally, income may also affect certain health related behaviours such as smoking and alcohol consumption (79).

*Subjective Social Status*

This SEP measure is concerned with the individual's perception of his/her position in the social structure (103). Although this perception is strongly linked to objective socioeconomic circumstances, it has been said that subjective social status (SSS) could capture other dimensions that are not directly measured by objective SEP indicators (104, 105). Some have further suggested that SSS is a comprehensive measure that can capture not only current but also past socioeconomic situation

and even future social prospects (103). In fact, among older adults SSS is considered a proxy of life-time socioeconomic status (104, 106). The most common way to assess SSS is by asking people to place themselves in one of the steps of a visual ladder according to their perceived social status, what is known as the MacArthur scale of subjective social status (107, 108). The version of the scale most frequently used asks persons for their perceived social status in relation to the national population or the society as a whole. Other reference groups have also been used. That involves asking people to compare themselves with other members of their community, schools or working places (107, 108).

SSS has shown a significant association with health, particularly self-rated health, even after taking into account objective SEP measures such as education, income and occupation (104, 107, 109, 110). It has been argued that SSS might affect health through pathways linking the perceived relative deprivation with stress, anxiety and other negative emotions. These psychological effects of lower social position have physiological effects on cardiovascular and mental health, and also can make people more likely to adopt behaviours such as smoking and drug use (105, 109, 111).

Subjective social status and other SEP indicators, including the aforementioned, have been used in studies on health inequalities showing that socio-economically disadvantaged groups tend to exhibit poorer health outcomes. This relationship between health and SEP has been explained by different mechanisms (or mediating pathways). Scholars have suggested these mechanisms in an effort to elucidate how the systematic differences in health according to SEP are produced. A number of these mechanisms were briefly outlined above in relation to specific measures of SEP. The following section presents them separately in a short overview.

### 2.1.2 Brief overview of mechanisms explaining health inequalities

A brief review of the mechanisms suggested in the literature to explain the socially patterned distribution of health is useful in the context of this thesis for two reasons. First, many of those pathways have also been applied to socioeconomic

inequalities in oral health and, second, it contributes to give a conceptual background to better understand findings of studies on health inequalities under different political contexts.

**Materialist and neo-materialist**

The materialist mechanism highlights the direct effect on health of material living/working conditions and access to material resources (food, shelter, services and amenities). The evidence supporting a direct link between material conditions and health comes primarily from studies on income-related health inequalities. Many of these studies have shown not only that mortality and diseases are more likely to occur among the 'poor', but that there is a graded relationship with worse health outcomes at successively lower income levels (112). The materialist approach states that income influences health through the difference that it can make in accessing health-related material resources. These resources include better food, quality of housing, safer living and working environments and access to local amenities and health care (113). A number of studies support the materialist approach as they have found that housing conditions, homeownership, overcrowding, pollution, lack of heating, level of material sufficiency and other material conditions make an independent contribution to health (114-117).

Neo-materialist explanations consider health inequalities in connection with the public provision of social services, living environment and basic infrastructure (112). This approach, originated in the debate about the relationship between income inequality and health, states that income inequality is a result of historical and political-economic processes which also affect the economic resources available to individuals and the distribution of other social resources (112, 118). Therefore, health is related to income inequality because the latter is a manifestation of the social distribution of conditions that have the potential to affect health: availability of food, quality of housing, transportation, environmental control, education, health services and occupational health regulations (118).

**Psychosocial**

This mechanism focuses the attention on differences in psychological factors, including the experience of stress, among socioeconomic groups. Higher levels of stress have been related to having low control at work, unemployment, not being at the top of the social hierarchy (relative position) and living in communities with lower levels of trust and higher levels of crime (119). In addition to being more exposed to stress, individuals in disadvantaged positions are less likely to have resources to buffer its impact (e.g., self-esteem, social support and sense of control over life) (120).

Higher levels of acute and chronic stress influence health through direct and indirect pathways. Probably one of the most studied processes involves a direct effect in which stress triggers different responses of the autonomic and neuroendocrine systems, which culminate in higher risk of cardiovascular diseases (121, 122). In addition, psychosocial stress can affect health through indirect pathways given its influence on behaviours like smoking and comfort eating (123, 124).

An extensive body of literature supports the psychosocial mechanism. For example, the significant associations between psychosocial work stressors and different health outcomes have been demonstrated in studies using the job strain and effort-reward imbalance models. Subjects who experience job strain (high demands combined with little control over the tasks, the skills used or the pace of work) have significantly higher risk of coronary heart disease and emotional exhaustion (125, 126). Also, evidence has revealed that workers under conditions of high effort combined with low rewards (payment, approval of superiors, security and opportunities of promotion) are more likely to have high blood pressure, cardiovascular diseases, stroke and other physical and mental health problems (112, 127, 128). Studies have also shown that social support, self-esteem, sense of coherence and other psychosocial factors are significantly related to various health measures and can play a role in explaining health inequalities (99, 129-132).

**Behavioural**

The behavioural mechanism points out the fact that health-related behaviours like diet, smoking, physical activity and alcohol consumption differ according to SEP. Two main perspectives have been put forward regarding the behavioural mechanism. The first view considers behaviours as result of individual choices linked to cognitive processes. An alternative perspective is that behaviours are mainly socially patterned through cultural norms of behaviour (133-135). Linked to the latter perspective is the idea that social groups express and preserve their 'distinction' from other groups through shared lifestyles (112). Then, processes of social distinction could strongly influence the adoption of health related behaviours including eating habits and forms of leisure activity (112, 136).

Evidence has shown that behaviours differ by SEP with unhealthier behaviours clustered among members of less advantaged social groups (136-138). Smoking, diet, physical activity, alcohol consumption and personal care practices have all been related to socioeconomic circumstances (136-138). This distribution of behaviours has been interpreted as a result of social interactions and shared lifestyles in specific social groups and contexts (139). Also, behaviours could be influenced by stressful living or working conditions and differential access to material resources. Smoking, drug use and comfort eating might be ways of coping with the psychosocial stress and pressures of certain socioeconomic circumstances (137). In turn, eating habits are related to economic resources required to purchase, for example, fruits and vegetables, which in many countries are more expensive than less nutritious food (138). These relationships between behaviours, psychosocial factors and material resources suggest that in many cases the mechanisms of health inequalities do not act separately but are most likely to interact in different ways.

**Life course perspective**

In addition to the three aforementioned mechanisms, the life course perspective proposes that current health at any stage of life is influenced not only by

contemporary SEP but also by exposures related to socioeconomic circumstances over time, i.e., across the life course (112, 140, 141). Among the issues frequently analysed from this perspective are how socioeconomic circumstances in early life set people on trajectories over the life course and how disadvantage accumulates over time affecting health in later life (142). This perspective can also be applied to study how the behavioural, psychosocial and material mechanisms act and interact at different stages across the life course.

Within the life course perspective, there are different theoretical models: critical period, accumulation model and pathways or social trajectory model. First, the critical period model highlights the fact that certain exposures have stronger effects on later health if they occur at specific periods in life. The term critical period is frequently used when talking about a period of inalterable biological development and therefore, permanent effects (143, 144). Similarly, a sensitive period is a time when the effect of an exposure is greater compared to other times, but in this case, there are more chances to modify the effects outside the time period (144). In the health inequalities literature this conceptual model has also been called the 'latent effects' model which proposes that early life circumstances have effects on adult health independent of intervening experiences (135, 145). Second, the accumulation model focuses on how exposures add gradually over time to produce effects on health. This model has been used to study the relationship between cumulative disadvantage across different stages of life and adult health (143). The first version of the accumulation model proposes that exposures accumulate over time but they do not interact, while alternative versions suggest interaction between experiences (145). Finally, the pathway or social trajectory models suggest that socioeconomic circumstances in early life impact adult health outcomes through later life SEP (142, 146). In this model, early life circumstances set individuals on trajectories over the life course where harmful exposures increase the likelihood of subsequent negative exposures in what has been called 'chains of risk' (145).

The above-discussed complex interactions between SEP and health occur under different socio-political contexts. These contexts would have the potential to influence the pathways linking SEP and health. In particular, political processes and distribution of power could impact the social position of individuals (for example, through the education system) and how much being at a certain SEP level affects the access to resources relevant for health. Therefore, the effect on health of being in a low SEP may be different across societies or in different historical periods within the same society (147). The next section explores these issues focusing on the relationship between health inequalities and welfare state regimes.

## 2.2 Selected Political Factors and Health Inequalities

There is an increasing interest in the role played by political factors in population health and socioeconomic inequalities in health (26, 93, 148-150). Specifically, it has been acknowledged that welfare state policies and institutions can influence the distribution of important determinants of health, such as education, housing, nutrition, health and child care (151). Therefore, social policies of the welfare state would have the potential to influence the relationship between SEP and health (29, 152). In the analysis of some of these matters, the welfare state framework has been influential as a theoretical perspective. Some general concepts on this perspective and studies that have used it for analysis of health inequalities are discussed in the following sub-sections.

### 2.2.1 Welfare state regimes and health inequalities

Given the focus of this thesis, the aim of this section is to present a summary of certain studies on the relationship between health inequalities and welfare state regimes. In order to present a broader conceptual framework to the studies being reviewed, the concept of welfare state and the main welfare state typologies are discussed first.

#### 2.2.1.1 Concept of welfare state

In the context of modern competitive economies, social policies of the welfare state contribute to organise labour markets and protect citizens from the negative impacts of social risks such as unemployment, lone parenthood, disability and illness (28). In their glossary about politics and health, Bambra and colleagues (31) affirm that welfare state usually refers to the role played by the state in the provision of social benefits and services including housing, education, health, and poverty relief, among others. These authors also highlight that from a broader perspective, welfare state refers to 'a particular form of state or specific type of society'. While the role of the state is the central aspect considered when talking about welfare state, other definitions have also included the family and the market. Welfare state is then described as the combination of state, market, and family in providing benefits and services within a country (149).

According to Dahl and van der Wel (153), there are three main approaches to typify welfare states: social expenditure, welfare institutions and welfare regimes. The first one refers to countries' level of expenditure on social benefits, that is, public resources transferred as cash, goods and services. The second is focused on features of specific social policies such as pensions, unemployment, housing and family. The third approach is based on the idea that countries can be grouped in types or regimes according to the principles of their welfare structure and institutions (153, 154). This project first uses welfare regimes because they allow assessing the role of a general approach of the combination of social policies. Since very little is known about the political determinants of oral health inequalities, it was considered that initial steps in this research area should benefit if general political factors are explored first, before considering more specific aspects of the welfare state.

#### 2.2.1.2 Welfare state typologies

In the welfare state theory, differences in principles, coverage and generosity of the social policies, and different mechanisms to assign resources have been taken into

account to group countries in distinctive regimes (93). Perhaps the most influential work in this field is *The Three Worlds of Welfare State Capitalism* by Gøsta Esping-Andersen (155) who suggested that countries could be grouped in welfare state regimes according to three principles: decommodification, social stratification and the private-public mix. First, decommodification is the extent to which families and individuals can maintain a socially acceptable living standard irrespective of how good they do in selling their labour in the market. Second, social stratification refers to the role of the state and more specifically social policies, in the reduction of existing social differences. And third, the private-public mix is concerned with the interplay of private and public sectors and the institutional dispositions that allocate welfare functions to the market, state, and family (29, 36, 150, 152, 155-157).

Based on those principles, Esping-Andersen defines three welfare state regimes. The liberal, where the state benefits are modest, with very strict entitlement rules focused only on low-income people. Additionally, in the liberal regime, the state encourages the participation of the market in the provision of welfare goods and services (155). The conservative welfare regime is characterized by a state that provides certain earnings-related benefits, but it is not committed to reducing social differences. The key role played by the family in the welfare provision also characterizes this regime. Finally, in the social-democratic regime the state provides comprehensive and universal benefits, and it is highly committed with achieving high levels of decommodification.

Although this typology has been broadly used and has remarkable insights, various authors have also identified weaknesses including some misclassification problems (158-160), the methodology used (159, 161), and the omission of gender (162, 163). Alternative typologies have been proposed to account for those drawbacks. Among those alternative typologies, the ones more frequently mentioned in the public health literature or used in analyses of health inequalities, are described below. In addition, the main welfare state regime typologies, including Esping-Andersen's, are presented in Table 2.1.

*Ferrera*

Ferrera addresses certain problems of the Esping-Andersen's typology in terms of country range and variation. By focusing on how social benefits are organised and delivered, this typology identifies four welfare state regimes: Scandinavian, Bismarckian, Anglo-Saxon and Southern (158, 164). Whereas the first three regimes resemble the Esping-Andersen's social-democratic, conservative and liberal types respectively, the additional Southern regime clusters countries with a fragmented welfare provision. This is, the combination of income maintenance systems with high generosity in certain provisions (e.g., pensions) and weak in others (protection to those in non-institutional labour market), the establishment of National Health Services based on universalistic principles but at the same time extended opportunity for private provision, a marked public-private mix in welfare benefits and services, and certain corruption in the distribution of cash subsidies (158, 165).

*Navarro and Shi*

Navarro and Shi grouped countries based on their political traditions, namely, political orientation of parties in government during the greatest proportion of the period 1950-2000. Four categories are identified: Social Democratic (countries where social democratic parties governed during the majority of the period), Christian Democratic (countries mostly governed by conservative parties), Liberal (countries governed by liberal parties or conservative parties of a liberal persuasion), and Ex-fascist or Late democrats (countries with conservative dictatorships during many years of the reference period) (166). Navarro and colleagues (26) also argue that these groups exhibit distinctive redistributive policies with social democratic countries having higher public health expenditure, generous universal social transfers and services, and lower income inequality.

*Castles and Mitchell*

Addressing some problems of misclassification of the Esping-Andersen's typology, Francis Castles and Deborah Mitchell considered two main dimensions of the welfare state to offer a new typology: welfare expenditure (household transfers as a percentage of GDP) and benefit equality (use of equalizing instruments such as

contributory insurance and means tested assistance). By using those criteria, one more type of welfare state emerges called 'Radical' which corresponds to a subgroup of the liberal type. Radical countries have low social expenditure but high average benefit equality. In this group, redistributive goals would be achieved through instruments instead of high social expenditure. The other three types are: liberal (low welfare expenditure, low benefit equality), conservative (high welfare expenditure, low benefit equality), and non-right hegemony (high welfare expenditure, high benefit equality) (160, 167, 168).

*Bambra*

Bambra's classification is based on two indices, an updated version of the decommodification index used by Esping-Andersen and a health care decommodification index (159, 161, 169). The first one considers generosity and coverage of three welfare provisions: pensions, unemployment, and sickness. The second index includes measures of private health expenditure as a percentage of GDP, private hospital beds as a percentage of total bed stock, and the percentage of the population covered by the public health care system (169). By comparing the scores obtained on these indices, countries are clustered as follows: social democratic (high scores in both cash benefit and health care decommodification), liberal (low scores in both decommodification indexes), liberal subgroup (higher than the average in health care decommodification but lower in cash benefits), conservative (close to average scores in both indexes), conservative subgroup (higher than the average in health care decommodification but lower in cash benefits).

Table 2.1 - Main Welfare State Typologies

| Author | Welfare State Regimes | | | | |
|---|---|---|---|---|---|
| Esping-Andersen (1990) | **Liberal** | **Conservative** | **Social Democratic** | | |
| | Australia | Finland | Austria | | |
| | Canada | France | Belgium | | |
| | Ireland | Germany | Netherlands | | |
| | New Zealand | Japan | Denmark | | |
| | UK | Italy | Norway | | |
| | US | Switzerland | Sweden | | |
| Leibfreid (1992) | **Anglo-Saxon** | **Bismarck** | **Scandinavian** | **Latin Rim** | |
| | Australia | Austria | Denmark | France | |
| | New Zealand | Germany | Finland | Greece | |
| | UK | | Norway | Italy | |
| | US | | Sweden | Portugal | |
| | | | | Spain | |
| Castles and Mitchell (1993) | **Liberal** | **Conservative** | **Non-right hegemony** | | **Radical** |
| | Ireland | Germany | Belgium | | Australia |
| | Japan | Italy | Denmark | | New Zealand |
| | Switzerland | Netherlands | Norway | | UK |
| | US | | Sweden | | |
| Ferrera (1996) | **Anglo-Saxon** | **Bismarck** | **Scandinavian** | **Southern** | |
| | Ireland | Austria | Denmark | Greece | |
| | UK | Belgium | Finland | Italy | |
| | | France | Norway | Portugal | |
| | | Germany | Sweden | Spain | |
| | | Luxemburg | | | |
| | | Netherlands | | | |
| | | Switzerland | | | |
| Bonoli (1997) | **British** | **Continental** | **Nordic** | **Southern** | |
| | Ireland | Belgium | Denmark | Greece | |
| | UK | France | Finland | Italy | |
| | | Germany | Norway | Portugal | |
| | | Luxemburg | Sweden | Spain | |
| | | Netherlands | | Switzerland | |
| Korpi and Palme (1998) | **Basic security** | **Corporatist** | **Encompassing** | | **Targeted** |
| | Canada | Austria | Finland | | Australia |
| | Denmark | Belgium | Norway | | |
| | Ireland | France | Sweden | | |
| | Netherlands | Germany | | | |
| | New Zealand | Italy | | | |
| | Switzerland | Japan | | | |
| | UK | | | | |
| | US | | | | |
| Navarro and Shi (2001) | **Liberal-Anglo-Saxon** | **Christian Democrat** | **Social Democratic** | **Ex-Fascist** (late democracies) | |
| | Canada | Belgium | Sweden | Spain | |
| | Ireland | Netherlands | Norway | Greece | |
| | UK | Germany | Denmark | Portugal | |
| | US | France | Finland | | |
| | | Italy | Austria | | |
| | | Switzerland | | | |
| Bambra (2005) | **Liberal** | **Conservative** | **Social Democratic** | **Conservative subgroup** | **Liberal subgroup** |
| | Australia | Austria | Finland | Germany | Ireland |
| | Japan | Belgium | Norway | Switzerland | UK |
| | US | Canada | Sweden | Netherlands | New Zealand |
| | | Denmark | | | |
| | | France | | | |
| | | Italy | | | |

Sources: Bambra, 2007 (18) and Bambra, 2011 (93)

In addition to the abovementioned proposed typologies, complementary welfare state types have been identified to account for specific features of non-Western and former communist countries. The Confucian or East Asian type clusters non-Western countries (Japan, South Korea, Taiwan, Hong Kong and Singapore) where the family and voluntary sector are the most relevant in providing welfare services (152, 159, 168, 170). The Eastern European welfare type 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 (152, 165, 171, 172).

In this thesis, the typology by Ferrera along with the complementary Eastern European type were used to cluster European countries in five welfare state regimes: Scandinavian, Bismarckian, Anglo-Saxon, Southern, and Eastern (details about countries included in each regime are presented in the Methods chapter, section 4.2.1.3). Ferrera's typology was selected for this thesis because it has been acknowledged as one of the most accurate classifications -as it examines both the quantity of welfare provided and the way in which benefits are delivered- (164, 165, 173), it has shown high within-regime homogeneity and between-regime heterogeneity (93), and it has been used in earlier studies on cross-national comparisons of health inequalities (33, 164, 171, 172). In fact, this clustering of European welfare regimes was confirmed by a recent analysis that compared 15 European countries based on their redistributive economic outcomes (174). It is also worth mentioning that the five welfare regimes used in this project have been increasingly used in analyses of health inequalities and population health (33, 159, 164, 171, 172, 175-178). That was taken into account since it was considered very useful to compare results of this thesis with the existing literature in the field using a valid and well-established typology.

#### 2.2.1.3 Studies on welfare state regimes and health inequalities

This section presents a summary of the existing literature on the relationship between welfare state regimes and socioeconomic inequalities in health. For this

review, cross-national analyses which examined welfare regimes in high income countries were considered as that is the focus of this project. Studies were found using three strategies: search on PubMed and Web of Science, identification of eligible studies from literature reviews related to the subject, and tracking down studies using references in published papers. Further, title and abstract were reviewed to retain studies focusing on comparisons of socioeconomic inequalities in health across different welfare state regimes. In this section, literature reviews on the subject are presented first, followed by specific studies according to the SEP measure used to assess health inequalities.

The relationship between welfare state regimes and health inequalities has been examined in recent literature reviews (28, 37, 150, 154, 179). Arguably the main hypothesis tested in these reviews was that of smaller health inequalities in Social democratic or Scandinavian welfare regimes. This hypothesis is based on the idea that welfare states with a more generous and universal welfare provision have a more equal distribution of well-known determinants of health and therefore, are expected to exhibit lower health inequalities. However, all literature reviews have concluded that there is little support for this hypothesis. Dahl et al., 2006 (37) used the Esping-Andersen's typology to compare results from cross-national studies on health inequalities and did not find a consistent pattern across welfare regimes. Dahl's overview assessed studies which compared countries but did not test for significant differences among welfare regimes. However, later reviews confirmed that evidence on the relationship between welfare regimes and health inequalities was inconclusive. Beckfield and Krieger, 2009 (150) found that among 3 studies, one showed larger inequalities by family affluence in the liberal welfare regime compared with the social democratic and conservative, another found higher educational inequalities in the Southern and Scandinavian regimes, and a third revealed a similar pattern of inequalities across regimes, particularly for men. In another review, Muntaner et al., 2011 (179) identified 8 studies and established that relative health inequalities did not systematically differ among welfare regimes and were not consistently smaller in social democratic countries. In turn, Brennenstuhl et al., 2012 (28) identified 10 studies which explicitly tested between-

regime differences in the magnitude of health inequalities. Although 9 of these studies showed significant differences, no consistent pattern across welfare regimes was found. Finally, the most recent review, by Bergqvist et al., 2013 (154), encompassed 15 analyses that used welfare state typologies to compare health inequalities across countries. The authors found a large variation in results and concluded that the evidence showed a mixed picture with contradictory findings.

Although additional eligible studies were identified at the time of writing of this chapter (September 2014), their results did not change the general picture of inconclusive evidence on the subject. The most recent studies are discussed below along with other analyses included in this review. Studies were grouped by the SEP measure used to assess inequalities in order to examine if the potential influence of welfare regimes might vary according to different dimensions of people's socioeconomic circumstances.

*Education*

Education has been associated with health in different welfare regimes but the pattern of this relationship across regimes is not constant. While some studies observed significantly smaller educational inequalities in welfare states with more generous and universal benefits, others showed differences unexpected from theory. Among the former, a study of 13 European countries grouped according to their political tradition (Navarro and Shi typology) showed smaller relative inequalities in the Scandinavian/Social democratic regime for men's self-rated health (95). Furthermore, Avendano et al. (180) used data from the Survey of Health, Ageing and Retirement in Europe (SHARE) and found that the association between education and health among Europeans aged over 50 was significant for Southern and Bismarckian countries while it was non-significant for the Scandinavian. Another study using SHARE data revealed that educational inequalities in quality of life were lowest in the Scandinavian regime followed by the Bismarckian, and largest in the Southern and Eastern regimes (181). Likewise, a study of educational inequalities in 'sickness' (defined as non-employment in people with long standing illness) showed that among working age women,

absolute and relative inequalities were lowest in the Scandinavian regime compared to the Bismarckian, Anglo-Saxon, Eastern and Southern regimes (182).

In contrast to these findings, other analyses reported either intermediate or large relative educational inequalities in Scandinavian countries. Two comparisons of 11 Western European countries found higher inequalities in perceived morbidity and general health by levels of educational attainment in Sweden and Norway (80, 81). A third study registered higher levels of relative educational inequalities in self-assessed health in the Scandinavian welfare type compared to the Anglo-Saxon and Eastern (164). A fourth analysis examined premature mortality in 13 European countries and found smaller inequalities in Southern countries, larger in the Eastern with Scandinavian countries lying in between (183).

Besides findings about Scandinavian/Social democratic countries, some studies have observed smaller educational inequalities in the Bismarckian welfare regime. Three of these studies, by Bambra et al. (172), Eikemo et al. (164) and Alvarez-Galvez et al. (178), analysed data from different waves of the European Social Survey (ESS), used years of full-time education as SEP measure, and clustered countries according to the Ferrera's typology (with the additional Eastern regime in two of the studies). In the three analyses Bismarckian countries showed smaller inequalities in self-perceived general health and long standing illness, among both men and women. Two additional analyses of European countries aimed to compare inequalities in self-assessed health by educational attainment and also reported lower inequalities in Bismarckian countries (39, 184).

*Occupational social class and employment status*

Similar to the previously mentioned results for education, a mixed picture is apparent from studies analysing health inequalities by social class and employment status in different welfare regimes. Four studies compared social class inequalities among two or three countries with different welfare states and showed mixed results. A similar magnitude of inequalities in self-rated health was found in Britain compared to Sweden although in Britain a larger part of these inequalities was

explained by the distribution of income across occupational social classes (185). Similar magnitude of relative inequalities by occupational social class was also found in Britain and Finland among male employees (44). Moreover, a complementary study reported that differences in poor physical functioning among non-manual workers were slightly smaller in Finland than in Britain and Japan (186). Contrary to this finding, and against expectations from theory, Lahelma et al., (187) showed larger relative inequalities by social class in Finland compared to Britain.

Another group of analyses reported lower occupational-related inequalities in Bismarckian countries and either intermediate or large inequalities in Scandinavian countries. For example, larger inequalities in Sweden and lower in Germany were identified in one study comparing relative inequalities in perceived general health, long-term disabilities and chronic conditions among 7 European countries (188). Bismarckian countries also exhibited smaller inequalities in the study by Espelt et al., (34) who used political tradition (Navarro and Shi typology) to cluster 9 European countries and analysed inequalities by Wright's dimensions of social class. In that analysis, in addition to the lower inequalities in Bismarckian countries, Scandinavian countries held an intermediate position, and significantly larger inequalities were identified in Spain and Greece, particularly among women. Southern countries also exhibited greater occupational inequalities in a study on quality of life among adults aged 50-75 years (181).

Two studies examined health outcomes by employment/working status in different welfare regimes, and their results did not show a consistent pattern. In the first study, authors compared employed and unemployed adults and found that in all five welfare regimes analysed (Scandinavian, Bismarckian, Anglo-Saxon, Southern and Eastern), those unemployed were more likely to report poor health than their counterparts in employment (176). In addition, larger inequalities were identified in the Bismarckian, Anglo-Saxon and Scandinavian regimes, particularly among women. The second study examined all-cause mortality by working status (working vs. not-working) among adults around the retirement age (189). Mortality was consistently higher among those not-working in the three welfare regimes

considered: social-democratic, liberal and conservative. The relative and absolute differences in mortality by working status were larger in the social-democratic regime and lower in the conservative.

Finally, the association between health and working conditions was compared across welfare regimes in two studies which showed conflicting results. One study investigated the relationship between self-rated health and working conditions among adults aged 16-60 years using data from the European working conditions survey (190). Authors observed that, among various physical and psychological conditions considered, reporting painful and tiring working conditions was the only one significantly associated with poorer health in all welfare regimes. This association was strongest in the Bismarckian and Scandinavian regimes and weakest in the Southern. In general, the study revealed weaker associations between working conditions and health in the Anglo-Saxon regime. Contrasting findings were observed in a study that assessed the association between depressive symptoms and psychosocial working conditions (effort-reward imbalance and low control at work) among 50-64 year-olds. Associations were strongest in the Anglo-Saxon regime and weakest in the Scandinavian (191).

*Income*

A more consistent pattern, than that observed for education and occupational measures, seems to emerge from findings on health inequalities by income level. Smallest inequalities in Bismarckian/Conservative countries, largest in Liberal/Anglo-Saxon and intermediate positions for Scandinavian/Social democratic countries, are common results in studies which compared income related health inequalities. Most of these studies looked at self-assessed health as the outcome, analysed European countries, and used data either from national health surveys or from internationally harmonised surveys such as the ESS or the European Community Household Panel (39, 171, 192, 193). Furthermore, one of the studies showed that, even after controlling for educational attainment, Anglo-Saxon countries exhibited the largest income-related inequalities and Bismarckian countries the lowest (171). Greater income inequalities in Anglo-Saxon countries

were also observed in a comparison of 29 European countries based on ESS data (194).

The only previous study on oral health inequalities across welfare regimes showed the same pattern of lowest income inequalities in Bismarckian/Conservative countries, intermediate in Scandinavian/Social democratic and largest in Liberal/Anglo-Saxon (195). The comparison was performed by Sanders and colleagues who used the welfare typology from Korpi and Palme to assess the relationship between welfare regimes and oral health related quality of life. Korpi and Palme's classification of welfare states is based on the generosity and coverage of two social programmes: pensions and sickness cash benefits. The study compared four countries representing different welfare regimes, Finland, UK, Germany, and Australia. There were significantly lower income inequalities in Germany, where the two social programmes have earnings-related benefits, but eligibility for these benefits is based on membership in specified occupational groups. Larger inequalities in oral health were identified in Australia, where benefits are means-tested and the coverage is limited to the low-income part of the population. In Finland, where the benefits are universal, generous and earnings-related (as opposed to flat-rate), inequalities exhibited an intermediate level.

Four other studies also found larger inequalities in health in liberal countries compared to Bismarckian or Scandinavian. Although the first of these analyses presented Ireland (a liberal country) in an intermediate position, smaller income-related inequalities in Bismarckian countries and larger in the UK were also found (193). The second study identified a significant association between income and health in liberal welfare states whereas the association was insignificant for the Social-democratic (29). The third analysis showed that among families with children, income inequalities in self-rated health were larger in the United Kingdom compared to Sweden and Slovenia (196). In the fourth study, using the five welfare regimes derived from the Ferrera typology and the additional Eastern European, there were larger inequalities in depression in the Anglo-Saxon regime compared to the other 4 regimes (197). The common result of large income-related inequalities

in Anglo-Saxon/Liberal countries is in agreement with expectations from theory as they exhibit also large income inequalities and less generous welfare benefits.

*Wealth*

Wealth was included as socioeconomic indicator in one analysis to assess inequalities in quality of life among older European adults (181). There were significant inequalities in all four regimes examined: Southern, Scandinavian, Eastern and Bismarckian. Although the magnitude of inequalities was not very different across regimes, results suggested larger inequalities in the Southern and Eastern regimes and lower in the Scandinavian.

*Family affluence (as a measure of adolescents' SEP)*

Although the majority of studies on health inequalities and welfare regimes were concerned with adult populations, there are at least two analyses on adolescents which showed mixed results (36, 177). Both studies employed data from the Health Behaviour in School-aged Children (HBSC) survey and measured SEP using a family affluence scale which assesses consumption in the family. The earliest study used 2001-02 data to examine inequalities in self-perceived health; quality of life; and frequency of certain health symptoms including headache, backache, stomach-ache, irritability and difficulties in getting to sleep (36). Findings of that analysis showed a pattern of smaller inequalities in social democratic and conservative regimes compared to liberal, post-communist and Southern regimes. The most recent analysis, based on 2006 data, also assessed self-perceived health and health symptoms, and did not find a clear specific pattern of inequalities across welfare regimes (177).

*Other studies*

Among studies concerned with socioeconomic inequalities in health across welfare regimes, at least three used a life course perspective and examined changes by age in the magnitude of inequalities. Bambra et al. (172) used data from three waves of the ESS and compared 4 welfare regimes according to Ferrera's typology. Results showed larger differences in the magnitude of health inequalities by age group in

the Southern regime and a pattern of increase in relative educational inequalities with age in all welfare regimes. Similarly, a second study also found a rise in health inequalities with age in all welfare states studied (US, Britain, Denmark, Germany) (198). The third of these studies examined inequalities in depression and found different patterns of inequalities by welfare regime (197). In the Bismarckian and Scandinavian regimes there were no significant differences in the magnitude of inequalities across the life course, in the Southern and Eastern inequalities increased with age, and in the Anglo-Saxon inequalities decreased as people get older.

Using a different approach to measure inequalities, Popham et al., (199) estimated the total level of inequality in mortality across welfare state regimes. For that estimation, instead of comparing mortality levels across groups defined by SEP, the authors calculated the overall distribution of the outcome to get an estimate similar to the Gini coefficient. Results of that analysis revealed lowest inequalities in the Social democratic regime among men, and in the Sothern regime among women.

Other studies have considered not the magnitude of health inequalities, but the potential buffering effect of welfare states against widening inequalities in periods of adverse structural changes (82, 200). From that perspective, some analyses have demonstrated that generous and universal social policies were able to protect disadvantaged groups in times of economic crisis and health inequalities did not increase during or following the economic recession in the 1990's in Finland and Sweden (11, 82, 201, 202). One of these studies showed that education- and income-based inequalities in self-assessed health increased comparatively less in Scandinavian countries than in other European countries after an economic crisis (11). In addition, a study carried out among former communist countries showed that educational inequalities in mortality increased less during the period of transition to capitalism in those countries with more protective labour market policies and spending higher proportion of their GDP on social transfers (203).

Summary - Studies on welfare state regimes and health inequalities

As research on health inequalities has incorporated the analysis of broad upstream determinants, the welfare state theory has been increasingly used. Overall, evidence of the relationship between welfare state regimes and socioeconomic inequalities in health showed that: 1) socioeconomic inequalities in health exist in all welfare regimes, 2) there is variation in findings according to the socio-economic indicator used, 3) the evidence is inconclusive when testing the hypothesis of consistent lower socioeconomic health inequalities in welfare regimes with more generous, universal and redistributive policies, and 4) Conservative/Bismarckian countries appear to show smaller health inequalities, particularly by income level.

Based on the reviewed studies it is possible to note that most of the evidence on welfare regimes is based on European countries which is somehow expected given the development of the welfare state, its theory and typologies (204). In addition, self-perceived health and long-standing illness were the health outcomes most frequently used, and oral health was considered only in one study. Regarding methods to assess inequalities, most studies included relative measures and only few explored absolute estimates. A more comprehensive approach to compare welfare state regimes should include both, absolute and relative measures of inequalities (a further discussion about this topic is presented in the Methods chapter). Some authors faced problems of precision and comparability of data, particularly when using national health surveys or health components of multipurpose surveys. To deal with this issue, researchers have increasingly used internationally harmonised surveys or standardized health questionnaires.

Overall, the evidence is inconclusive for the hypothesis that stronger welfare states have lower socioeconomic health inequalities. Reasons explaining that Scandinavian countries do not show consistently lower level of inequalities include relative deprivation, class-related health behaviours, and social exclusion (37, 80, 164). The first argument is that Scandinavian states generate high expectations of prosperity and upward social mobility among more disadvantaged people and these expectations are often unmet. Then, poor self-assessed health reflects the stressful

situation of being in a relatively deprived position in comparison to a reference group (205). Second, it has been suggested that health inequalities in Scandinavian countries can, to some extent, be explained by the considerable socioeconomic differences in health related behaviours, particularly smoking (39, 206). Third, Eikemo and colleagues (164) argue that the increasing immigration to Scandinavian countries could play a role since immigrants are frequently excluded from the complete benefits of social policies, are more likely to experience social exclusion, unemployment, discrimination, poor acculturation, and have higher levels of poor self-perceived health.

**Welfare state regimes and population health**

Some of the above mentioned studies compared population health across welfare regimes as the first step in their analyses. Moreover, certain additional studies specifically aimed to evaluate the association between welfare regimes and population health measures. Since this project compared oral health outcomes across welfare state regimes as the first step in analyses, it is worth briefly discussing the evidence on that subject.

Findings of comparative studies of population health across welfare regimes vary according to the health outcome analysed. When infant mortality is used as health indicator, there is strong evidence of the positive impact of more generous, universal and redistributive policies, as lowest infant mortality rates have been consistently found in Scandinavian countries (21, 26, 35, 168, 170, 207-211). These analyses have also revealed that infant mortality rates were highest in the Liberal/Anglo-Saxon and Southern welfare regimes. A similar pattern of better health in the Scandinavian regime has been observed for low birth weight, another child health outcome (168).

However, for other health measures, results of analyses on welfare regimes and population health have been less consistent. For instance, comparisons on self-rated health have shown mixed results and a less clear positive effect of the Scandinavian welfare regime. Some studies have shown similar levels of poor self-

rated health across the Scandinavian, Bismarckian and Anglo-Saxon welfare regimes and higher prevalence of poor health in the Eastern (176, 212-215). The Eastern regime also displayed the poorest level of health in other studies where the best self-rated health was found in the Anglo-Saxon regime while the Scandinavian, Bismarckian and Southern held average positions (164, 171). There were studies that found worse health in the Eastern and Southern regimes and better health in the Scandinavian (33, 178, 216). In those studies, better health was also reported in the Anglo-Saxon regime (33, 178) or in the Bismarckian (216). Showing a slightly different picture, one study revealed that adolescents were more likely to rate their health as fair or poor in the Anglo-Saxon and Eastern regimes and less likely in the Southern (177).

Although infant mortality and self-rated health have been the outcomes more frequently analysed, certain studies have considered other health measures including life expectancy and long standing illness. Comparisons of life expectancy have indicated either no significant differences across welfare regimes (207, 211) or, lowest life expectancy in the Eastern regime compared to other regimes (170, 199, 209). Two of these analyses suggested a higher life expectancy in the Scandinavian regime, particularly for men (199, 209). Likewise, studies on limiting long standing illness have detected either similar levels between the welfare regimes (34) or, highest levels in the Eastern and lowest in the Southern regimes (164, 171). Finally, from three studies on very specific outcomes, two showed better health in the Scandinavian regime (lower levels of depression and better oral health related quality of life) (195, 197), and a third suggested higher levels of depression in the Southern regime compared to other welfare regimes (217).

Some of the studies on welfare regimes and health have used a multilevel analytical approach with at least two levels (individuals nested within countries). These analyses have revealed that individual characteristics account for most of the variation in health, while country-level characteristics account for around 10% of that variation (33, 177, 215, 217, 218). Furthermore, these studies provided evidence that grouping countries into welfare regimes plays an important role in

explaining some variation in health across countries (33, 168, 177, 215, 217, 218). For example, using 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 (168).

### 2.2.2 Health inequalities and a specific welfare state policy

The potential impact of more specific features of the welfare provision on health inequalities has been the focus of certain studies. Given its expected effect, the health policy (or health care system) is the welfare policy more frequently studied in these analyses. Certain features of the health care system have been associated with lower health inequalities. These include a health care system with universal coverage (38-40), higher public health expenditure (219, 220), lower participation of the private sector (41), less co-payments for health services (minimum out-of-pocket spending) (41-43), equal access to good-quality services when needed (42, 54), development of intersectoral policies or strategies (42, 43), and a primary care approach instead of emphasis on specialist care (221, 222). On the other hand, total spending on health care alone does not seem to have an effect on health inequalities (223).

To study the potential role of the health system on health inequalities, it seems plausible to compare countries with a similar approach to their general welfare provision, but with different features in their health system. In that sense, a comparison between England and the United States provides a unique opportunity. The two countries are usually classified in the same welfare state regime, the Liberal/Anglo-Saxon, and are characterized as having relatively high levels of income inequality and less labour market regulation (224). Despite their significant similarities, the two countries differ in some social policies, with the health care system being arguably the most notable of them. In general terms, while England has a universal and publicly funded health care system with a clear focus on primary care, that is not the case for the US and in 2012, 45.5 million Americans were uninsured (225).

Within these different health care systems, the provision of oral health services in the two countries is also distinctively featured. In the US, access to dental services is mainly through a private insurance plan which usually requires a separate contribution as few medical insurance plans cover those services (226). There are some federal and state public programmes which include dental services, but they are mostly focused on children. Public programmes for adults are limited. Medicare -the health plan for adults aged 65 and over- does not cover oral health services (227) and in Medicaid -the program for certain low-income persons- it is optional for states to include adult dental services as part of their benefits (228). While in the US the provision of services is largely private, in England most dental services are provided under the National Health Service (NHS) with a mixed-funded scheme. Public resources are allocated on a capitation basis and patients pay fees per item up to specific thresholds for different levels of treatment. For people under public benefits (unemployment, income support, disability, among others), persons aged less than 18 years and expectant mothers, dental services are fully state-funded (229). To assess if these and other differences between the two countries have a potential relationship with the magnitude of oral health inequalities, a comparison of England and the US was conducted as part of this research.

Previous studies have compared health inequalities between England and the US and their findings are mixed. Analyses have showed some steeper gradients (larger inequalities) in the US (230, 231), mixed results (13, 231), or non-significant differences between the two countries (13, 232). Among the former, a study of adults aged 40-70 years analysed diverse health measures including self-reported conditions such as diabetes, hypertension, heart disease and stroke; and biological measures of glycosylated haemoglobin, C-reactive protein and HDL-cholesterol. For this broad spectrum of outcomes, authors examined inequalities by educational level and income. They found socioeconomic gradients in all outcomes except cancer in the two countries. In addition, health gradients were generally steeper in the US compared to England for both self-reported and biological measures (230). Another study using a life-course approach and data on 25-51 year-olds, examined socioeconomic gradients in health trajectories in the US compared to Britain. In this

analysis, the outcome measure was self-rated health and the SEP indicators were educational level, income, employment status and occupation. Results indicated that gradients in health trajectories by education and income were significantly steeper in the US compared to Britain, while the occupational gradient was slightly more steep in Britain (231).

In contrast with these findings, other analyses did not find significant differences in health inequalities between the two countries. For example, similar wealth-based inequalities in chronic diseases and disability were found in the US and England in a study of adults aged 50-74 years (232). Differences between bottom and top wealth tertiles were assessed for disability and various chronic diseases: diabetes, hypertension, stroke, heart disease, cancer (excluding skin cancer) and lung disease. Similar income gradients in England and the US were also found in a comparison that considered different health outcomes in people at all ages (from 0 to 80 years) (13).

These previous comparisons of health inequalities between England and the US have focused on general health measures and there is a lack of studies on oral health outcomes. Assessing the extent to which oral health inequalities differ between these two countries could contribute to understand the role of macro-level determinants, including the health care system, in the relationship between SEP and oral health.

## 2.3 Socioeconomic inequalities in oral health

Given the topic of this PhD, it is also important to highlight in this chapter what is known about socioeconomic inequalities in oral health. This section presents a review of some studies on that area. First, evidence on the relationship between socioeconomic position and oral health is discussed and then, some studies on political factors and oral health inequalities are presented.

### 2.3.1 The relationship between socioeconomic position (SEP) and oral health

The association between oral health and socioeconomic position has been well established and there is strong evidence of a socially patterned distribution of oral health. Inequalities exist with worse oral health for those in lower socioeconomic position and living in more deprived areas (14, 48-56). The role of different mechanisms related to these inequalities is a matter of increasing interest. The literature suggests that material living conditions have a direct effect on oral health (233, 234) and also effects through psychosocial mechanisms (233-237). In addition, although future research is needed to clarify the role of behaviours, studies support the idea of oral health related behaviours being a consequence of material and social conditions rather than individual choices linked to cognitive processes (134, 136).

**Socioeconomic position at individual-household level and oral health**

Various dimensions of people's socioeconomic circumstances including income, education and occupational social class have been significantly associated with oral health. For example, a recent meta-analysis of 92 studies found evidence of significant relationships between current or previous dental caries and SEP indicators of own or parental education, income and occupation (238). In addition, studies have shown that inequalities in oral health exist not only when comparing two groups but also in gradients along the social hierarchy. A review of some studies on the relationship between oral health and SEP measured at individual or household level is presented below.

The association between income and oral health has been reported in studies carried out in different countries. In the US, studies have shown that adults in lower income levels are significantly more likely to rate their oral health as fair/poor, lose a larger number of teeth, and have periodontitis (51, 56, 239, 240). In Norway, low personal and family incomes were associated with increased odds of having less than 20 natural teeth (241). Similarly, in a study based on a representative sample

of Australian adults, Sanders and Spencer (50) found significant associations between low family income and different oral health outcomes including social impact from oral conditions, tooth loss, and poor self-rated oral health. The study showed not only the influence of being in the lowest income level but also a social gradient with better oral health outcomes at each higher income level. An income gradient was also observed for edentulousness (no natural teeth) and untreated decayed teeth in a study of nationally representative samples of adults in Canada and the US (58). Using also nationally representative data from Canada, income-related inequalities were identified in number of missing teeth, decayed teeth and oral pain (242, 243). Likewise, a multilevel analysis found that Australian adults with lower income level were more likely to report their oral health as fair or poor even after adjusting for age, gender, education and neighbourhood socioeconomic disadvantage (53). As with literature on general health, some studies on oral health have shown an income gradient (50, 58, 86, 234) while others support the idea of an income threshold below which the relationship between income and oral health was stronger (51, 244).

The above mentioned studies provide extensive evidence on the relation between income and oral health. This link can operate through diverse pathways. Under the materialist approach, this could be explained by the difference that income can make in accessing material resources such as oral health care and healthier food products (134). Moreover, income could affect oral health through psychosocial factors including self-esteem, sense of coherence and social standing (66).

Similarly, as observed for income, there is evidence of the relation of oral health with education and occupational-social class. For example, Australian adults with vocational education level were twice as likely as those with tertiary education to report poor oral health (50). Also, an analysis in Finland showed that educational attainment of both, parents and the individual were significantly associated with differential oral health outcomes (self-rated oral health, edentulousness, caries and periodontal disease) (83). Furthermore, adults in New York with less than 12 years of education were significantly more likely to rate their oral health as fair/poor (51),

and Brazilian adults without a degree were more likely to have less than 20 teeth (245). Oral health inequalities by occupational social class have also been acknowledged by different studies (50, 57, 84, 246). For example, Australian adults in blue-collar occupation had higher oral impacts on quality of life and higher tooth loss compared with those in the upper white collar occupation group (50). Moreover, a meta-analysis of case-control studies revealed that low occupational social class was significantly associated with a higher risk of oral cancer in different global regions (246). In this study, consistent evidence of inequalities was also found for the other SEP measures included, education and household income.

In addition to the aforementioned studies, further evidence highlights the importance of relative SEP and the effects of social hierarchy on oral health as social gradients have been found in different countries. There was consistent poorer oral health outcomes at each lower level of education and income among adults in the US (14, 247, 248), even among low-income mothers (249). Social gradients in oral health have also been identified in the UK (48, 250), Japan (57, 84, 251), Germany (62, 252, 253), Sweden (54, 60), Norway (254), Canada (58), Australia (244, 255), Brazil (63) and Chile (61). In the UK, Watt and Sheiham (48) evaluated evidence from oral health surveys and found significant social class gradients in edentulousness, caries, periodontal disease and trauma. In Japan, Morita et al. analysed data from employed males and identified clear social gradients by occupational social class in periodontal disease and caries experience (57, 84).

Social gradients in oral health have also been observed among children and adolescents in studies using family or parental indicators of SEP. For example, studies have shown that the likelihood of having carious lesions or poor rated oral health gradually increased at lower maternal educational levels among Italian (256) and American (249) children, and Brazilian adolescents (257). Moreover, clear and significant gradients in children's caries status and levels of periodontal disease were found in a study from Spain that employed a composite indicator of family social class based on both mother's and father's occupation (258). Differences in oral health by family social class were also found among Irish and German children

(259). Inequalities in children and adolescents have been also apparent when employing other measures of SEP. Analyses have revealed worse oral health outcomes in children and adolescents living in families with lower income, more crowded houses, less paternal education, higher household poverty level, and lower level of assets ownership (61, 260-267). In addition, adolescents' perception of their own socioeconomic position has been significantly associated with oral health measures of self-rated oral health and oral symptoms including dental pain (268, 269).

While most studies about socioeconomic inequalities in oral health are based on cross-sectional designs, some longitudinal analyses have tested the prospective association between socioeconomic position and oral health. Tsakos et al. (59) evaluated data from the English Longitudinal Survey of Ageing (ELSA) which includes English adults aged 50 years and above. Authors found significant social gradients in edentulousness for all SEP measures including childhood SEP, education, income, occupational class, wealth and subjective social status. Among dentate subjects, gradients were also significant in self-perceived oral health and oral impacts on daily life. Another analysis conducted in New Zealand (85) used data on oral health and SEP measured at ages 5 and 26 years. Oral health outcomes were dental caries experience, tooth loss, and periodontal disease. SEP measures were parental occupation (SEP at age 5) and own occupation (SEP at age 26). Results showed that being in lower socioeconomic position at age 5 was significantly associated with higher levels of decay and tooth loss in adulthood, even after accounting for SEP at age 26. Moreover, those who were consistently at low SEP over time had the poorest oral health outcomes. Other studies have also observed an association between childhood SEP and adult oral health (270, 271). This longitudinal evidence is particularly important to rule out arguments of health selection as an explanation for the association between oral health and SEP. Although less likely to occur in the case of oral health, the health selection approach states that people who have worse health can become poorer (or less educated), as a result, in these cases, health is thought to be the determinant of low SEP and not vice versa (272, 273).

The way in which oral health inequalities have evolved over time has also been the focus of certain analyses. For example, Holst (86) used repeated cross-sectional data from 1975 to 2002 in Norway to assess the association between income level and two oral health measures, edentulousness (no natural teeth) and having functional dentition (more than 20 natural teeth). There were income gradients for the two outcomes throughout the period, with a decrease in absolute inequalities, while relative inequalities increased, particularly among older adults. Another study by the same author, found that educational inequalities in number of teeth and caries experience decreased between 1983 and 2006 in a Norwegian region (254). In addition, a study undertaken by Celeste et al. (274), explored changes in the magnitude of income-related inequalities in edentulousness in Brazil (from 1986 to 2002) and Sweden (from 1968 to 2000). The authors found that absolute inequalities decreased over time in the two countries, while relative inequalities remained unchanged. The same pattern of decline in absolute inequalities and unchanged relative inequalities was observed for deprivation-related inequalities in caries experience among Scottish children during the period 1993/4 to 2007/8 (275). Also using data from Scotland, a study of the period 1995-2008/9 found that absolute inequalities in edentulousness by education, occupation and area-based SEP narrowed for adults aged 45-64 years, remained stable for those aged 65-74 years and widened in those aged 75 and over. In this analysis, relative inequalities showed an increasing trend in all age groups (276). Data from the other three countries of the UK (England, Wales and Northern Ireland) suggests that between 1988 and 2009, social class inequalities in tooth loss narrowed in absolute terms while increased in relative terms among adults aged 16 years and over (277). The same study found that inequalities remained relatively unchanged over time when analyses were performed among dentate adults only. Finally, at least three studies from North America have explored trends in oral health inequalities. Cunha-Cruz found that absolute income inequalities in edentulousness remained stable among American adults between 1972 and 2001 (278). Dye and Thornton-Evans also identified a steady trend for absolute income inequalities in tooth loss among American adults aged 35-44 years, but an increase among those aged 65-74 years (279). In a study using national data from Canada and the US, Elani et al., concluded

that absolute educational and income-related inequalities in decay and edentulousness declined in the two countries between 1970-74 and 2007-09 (58).

Different findings for trends in inequalities when using absolute and relative measures have been previously observed. In situations of improving health status for all SEP groups, an increase in relative inequalities with a decrease in absolute inequalities will occur if the rate of improvement is faster in the group with the best initial health, usually the highest SEP group (280). In the same situations of general improvement, both relative and absolute inequalities would diminish if the rate of improvement is faster in the most disadvantaged groups. Since reductions in relative inequalities alone need to be viewed with caution as they do not capture information about prevalence rates in each group or changes in health status in the whole population, it is strongly recommended to use both absolute and relative measures in studies of trends in health inequalities (280, 281).

Although the vast majority of research on oral health inequalities shows that poorer oral health outcomes are more common among those in lower SEP, some evidence reveals non-significant associations or worse oral health among those in better socioeconomic circumstances. For example, certain studies carried out in different Scandinavian countries did not find significant associations between educational level and oral health measures such as number of teeth and caries incidence (241, 282, 283). Even though the more equal distribution of oral health across SEP groups cannot be ruled out, these null findings could also be partly explained by some methodological aspects. Some of those studies adjusted for mediating factors like behaviours in the regression models to assess the relationship between SEP and oral health. As a result, the mediating role of these factors was not taken into account and they were considered as potential confounders. Then, their inclusion in the models could have attenuated potential inequalities. In addition, some of the results refer to specific groups which are not representative of general population. It is also worth mentioning that some studies which did not find association between a SEP indicator and oral health, found a relationship for another SEP measure. This is in line with the idea of using more than one SEP measure in health

inequalities research as different dimensions of people's socioeconomic circumstances could affect specific health outcomes in different ways (66).

Regarding evidence of worse oral health among those in better SEP, some studies from low-middle income countries have reported higher caries levels among individuals in socially and economically advantaged positions (255, 284, 285). These findings could be mainly explained by changes in food consumption, the so-called 'nutrition transition'. This transition is a shift from the traditional high fibre, low fat, and high starch diet to a high saturated fat, refined carbohydrates and low fibre diet (286). In certain contexts, mostly low-income countries, the change first occurs among those with better socioeconomic circumstances and therefore, belonging to the lower SEP groups confers certain protection against health outcomes like caries and obesity (287).

**Socioeconomic position at area level and oral health**

The importance of considering measures of socioeconomic position at area level in health inequalities research has been highlighted (77, 288). These SEP indicators use aggregate data from small areas on unemployment, education, social class or property ownership. Then, a score is usually calculated which allows the characterisation of areas on a scale between deprivation and affluence (288, 289). For oral health, multilevel and individual level studies have found associations between area SEP and oral health outcomes such as self-perceived oral health, caries severity, and oro-facial pain (49, 53, 56, 290-294). Different pathways have been suggested to explain these associations including social capital and availability of and access to healthy foods, health-related information, and oral healthcare providers. Evidence on oral health inequalities by area SEP includes a review of the literature by Locker (49) which indicated that a significant association exists between deprivation and oral health with poorer outcomes for those living in more deprived areas. While most studies showing this association (including those reviewed by Locker) have been in children and adolescents, evidence about oral health inequalities by area SEP in adult population is mixed. As examples, the above-mentioned studies by Borrell and Baquero (51), Sanders and Spencer (50),

and the multilevel analysis of data from Scotland performed by Bower et al. (295) did not find associations between neighbourhood SEP and oral health once individual SEP was accounted for. Additionally, Tassinari and colleagues in Brazil considered different geographic structures to test socioeconomic contextual effects on self-perceived oral health (296), and found that the smallest geographic area was the best option to explain contextual effects on oral health. Results from other studies also suggest that oral health is less likely to be significantly associated to area level SEP if the deprivation measure is derived for large geographic areas (297).

### 2.3.2 Political factors and oral health inequalities

In the literature on socioeconomic inequalities in oral health, there are some studies that have explored the potential role of political determinants. The political factors considered in these analyses have been: impact of political changes, specific public policies and welfare state regimes. A summary of these studies is presented below.

**Political changes**

Some studies have examined the impact of political changes on oral health inequalities. For example, Ståhlnacke et al. (298) hypothesized that oral health inequalities would persist or even increase in Sweden between 1992 and 1997 due to political changes implemented in the early 1990s including reductions in the oral care system, cuts in other public benefits and increase in the unemployment rate. However, social gradients were identified in a cohort of Swedish adults both in 1992 and 1997 but no big changes were found. In an effort to explain these results, the authors highlighted that either the impact of the contextual changes was not significant, or the duration of the study was not long enough to detect it. A similar study gauged socioeconomic and ethnic inequalities in dental caries in New Zealand after the reduction of welfare benefits implemented in the early 1990s (299). By analysing data obtained from 1995 to 2000, inequalities were observed over the whole period. Ethnic inequalities increased with poorer outcomes for those of Maori and Pacific ethnic origin.

**Public policies**

In Brazil, a multilevel analysis tested the influence of public policies on oral health outcomes in subjects aged 15-17 years (300). The authors employed a scale of Municipal Public Policies which combined indicators of education, child's welfare, sanitation and infra-structure, and public dental services. The study showed that the effects of policies were different by SEP with higher positive impacts (e.g., fewer decayed teeth) among those with higher income and education level. Also in Brazil, there is a group of studies focused on the impact of certain oral health policies on oral health inequalities. A review of this evidence showed that implementation of the water fluoridation policy did not have the expected impact on inequalities due to regional and socioeconomic differences in access to fluoridated water within the country. The oral health care public policy was associated with reductions in oral health inequalities, even though it was still in expansion to get the universal and comprehensive coverage (301).

**Welfare state regimes**

The only previous study on oral health inequalities and welfare state regimes (already described in more detail in section 2.2.1.3) compared four countries representing different regimes according to the welfare typology from Korpi and Palme: Corporatist (Germany), Targeted (Australia), Encompassing (Finland) and Basic Security (UK) (195). The study found the lowest income-related inequalities in Germany, largest in Australia and intermediate positions for Finland and the UK.

Although not intended to assess the role of welfare state regimes, a recent study compared oral health inequalities across 14 European countries using SHARE data (302). This analysis examined income-related inequalities in chewing ability and showed that individuals from the higher income levels had better outcomes than their counterparts with lower income. There were significant absolute inequalities in all countries with the exception of Switzerland, Italy, Poland, Czech Republic and Ireland. Relative inequalities were significant in all countries except Ireland.

Summary – Socioeconomic inequalities in oral health

Significant associations between SEP and oral health as well as gradients across the social hierarchy are supported by relevant evidence from different countries, using various measures of SEP and oral health outcomes. Better oral health has been consistently found among those in higher levels of education, income, occupation, and living in less deprived areas. Moreover, evidence on socioeconomic inequalities in oral health has been found in adult populations and also among children and adolescents, when using family or parental measures of SEP. On the other hand, few studies have found non-significant associations or even associations in the opposite direction. Some methodological aspects and the nutritional transition could help to explain those results.

In addition, area-based SEP has been frequently associated with oral health measures, but evidence of this association is stronger in children and adolescents than in adult populations. Some studies have suggested that contextual SEP effects on oral health are more likely to appear when smallest geographic areas are used.

The effect of childhood SEP on oral health was the focus of some studies which showed a significant association in the expected direction, regardless of the type of SEP measure used. These findings suggest that effect of people's socioeconomic circumstances on oral health is likely to begin early in life. With respect to trends over time in oral health inequalities, absolute and relative measures of inequalities have been used, and there is not a clear trend. Therefore, it is difficult to conclude if socioeconomic inequalities in oral health are decreasing or increasing over time. Finally, some analyses have explored oral health inequalities in relation to some political factors. Among them, only one study compared the magnitude of oral health inequalities across welfare state regimes.

## 2.4 Gaps in the literature

It is apparent from the above literature review that there is little evidence on the relationship between oral health inequalities and macro-level determinants, particularly those related to the political context. To date, very few studies have analysed the effect of political factors and only one study has compared the magnitude of oral health inequalities across welfare state regimes. That study used the welfare state typology by Korpi and Palme which limits its comparability with other studies in the field, as that classification is seldom used in analyses of health inequalities (154). Additionally, previous international studies have been limited to one socioeconomic measure, or one oral health outcome, and have not considered the same data source for all countries, which is important in terms of comparability. Furthermore, no analysis has performed a comparison of oral health inequalities across welfare regimes considering more than one country per regime, and involving both absolute and relative measures of inequality. Given that different conclusions can be drawn from measures of inequalities in absolute or relative terms, the use of the two kinds of measures in analyses of health inequalities is highly recommended (93, 281, 303). Finally, there is a lack of research comparing oral health inequalities among countries within the same welfare regime to assess the potential role of a specific welfare state policy. This project aims to address these gaps in the literature by exploring the relationship between welfare state regimes and oral health inequalities.

# Chapter 3 - Conceptual model, aim, objectives and hypotheses

In this chapter, the aim, objectives and hypotheses are stated to address the gaps in literature identified in the previous chapter. In addition, the conceptual model of this project is presented in the first section. This conceptual model is relevant because, although it was not within the scope of this thesis to assess the mechanisms of oral health inequalities, it explains why political factors are postulated to play a role in health inequalities.

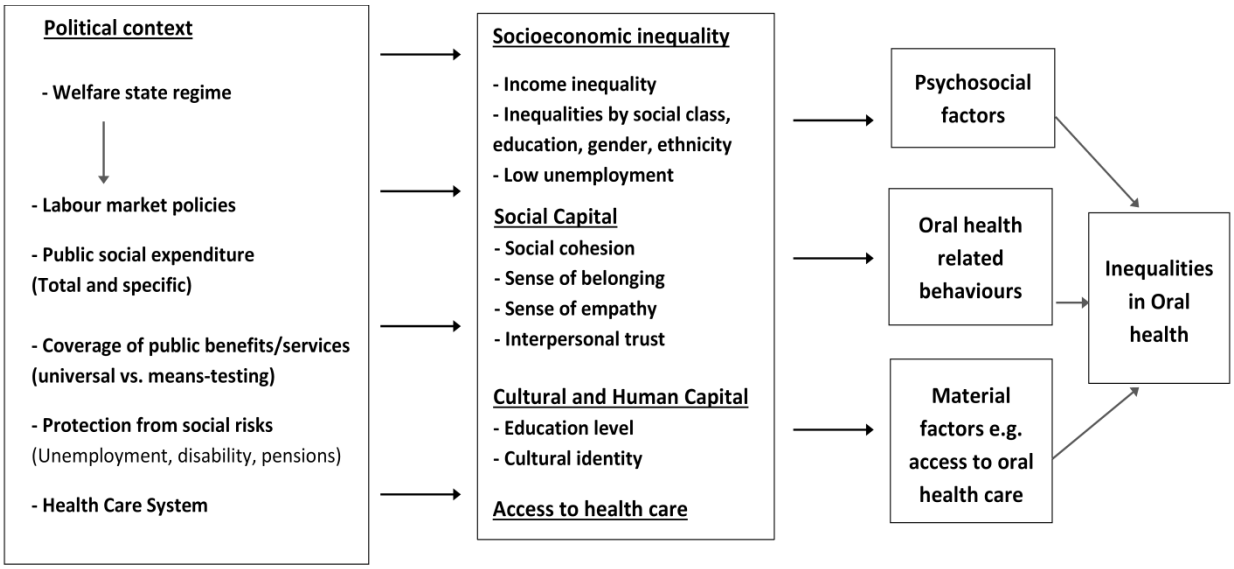
## 3.1 Conceptual model

The approach to this analysis (Figure 3.1) draws on the Social Determinants of Health model from the Commission of Social Determinants of Health (CSDH) (25, 32) and the model by Navarro and colleagues about the relationship between politics and health (26, 95). These models are presented in Appendix 1.

In the context of political determinants of oral health inequalities, there are reasons to believe that socioeconomic-related inequalities in oral health would vary according to contextual characteristics which influence the distribution of resources that are relevant for oral health. The perspective of this study is that the root causes of oral health inequalities are in the socio-political structure and more immediate determinants are socially and politically patterned. For example, evidence shows that different socioeconomic contexts generate different practices of personal oral hygiene, diet, and use of services related to oral health (136, 293, 304-307). In that way, oral health related behaviours reflect the living conditions in which behavioural choices are made. In turn, inequalities in living conditions are strongly related to public policies in each society. Evidence also supports the pathway from the socioeconomic and political context, to psychosocial factors and distribution of oral health outcomes. Political systems that prioritize the concentrated accumulation of private wealth over redistribution of power and privilege

contribute to larger socioeconomic inequalities with worse health for those experiencing adverse living and working conditions (308, 309). Along the whole social hierarchy, especially in the context of broad social inequalities, those in lower positions experienced higher levels of chronic stress, lower sense of coherence and more effort-reward imbalance at work. These factors play a significant role in explaining the distribution of oral health outcomes (233, 234, 310).

Figure 3.1 - Conceptual model for the impact of political factors on oral health inequalities




It is important to clarify that this thesis was not aimed to test the conceptual model nor the pathways and relationships presented on it. Instead, the model provides theoretical support for the analysis of differences in the magnitude of oral health inequalities across welfare state regimes, the focus of this study.

## 3.2 Study aim, objectives and hypotheses

### 3.2.1 Aim

To examine the relationship between socioeconomic inequalities in oral health and certain political factors (welfare state regimes) in Europe and the US.

### 3.2.2 Hypotheses

The overall working hypothesis is that different types of welfare state have the potential to affect both oral health and oral health inequalities. Social policies affect social inequality, cultural and social capital, and characteristics of the health care system. Those factors, in turn, have a significant influence on material, psychosocial and behavioural factors related to oral health (33, 35, 36, 134, 136, 304, 310). Taking the abovementioned concepts into account, the following hypotheses are generated:

**Hypothesis 1**

It is hypothesized that population oral health varies according to characteristics of the welfare provision. Therefore, the first hypothesis of this study is: There are differences in adults' oral health across different welfare state regimes. According to theory, better oral health outcomes are expected in the Scandinavian regime.

**Hypothesis 2**

In line with the theoretical basis of hypothesis 1, it is also hypothesised that by using a multilevel analytical approach, welfare state regime (a country-level characteristic) will contribute to explain some of the variation in oral health among European countries.

**Hypothesis 3**

In addition, it is expected that lower levels of SEP will be associated with poorer oral health outcomes, and that the magnitude of these inequalities will differ across

welfare regimes. Regarding the direction of these differences, based on the theory of welfare state regimes, one would expect lower inequalities in the Scandinavian regime. However, based on previous empirical work on inequalities in general health, lower inequalities in Bismarckian countries or no clear pattern across regimes could be expected.

In addition to comparing welfare state regimes, this thesis aimed to assess oral health and inequalities in two countries within the same regime but with differences in certain social policies, most notably the health care system. The health care system is a social institution reflecting political decisions and power resources of both private and public sectors (311). The health care system is one of the largest areas of welfare services and could influence to some extent the process of disadvantaged groups having worse health (43, 169, 222, 312-314). Moreover, publicly financed, universal health systems offer a safety net and financial protection from economic consequences of diseases (315-317). Based on these arguments regarding the health care system and considering that England has a more comprehensive range of 'social safety net' policies, the following final hypothesis was generated:

**Hypothesis 4**

It is hypothesized that oral health inequalities will be lower in England compared to the US.

### 3.2.3 Objectives

To address each of the above-described hypotheses, the overall aim of this thesis is broken down in to four objectives:

1. To evaluate population oral health in adults from a wide range of European countries grouped by welfare state regime, using measures of no functional dentition, edentulousness (no natural teeth) and oral impacts, as outcomes.

2. To assess the influence of welfare state regime (a country-level characteristic) on the variation in oral health between European countries.

3. To compare the magnitude of relative and absolute oral health inequalities among different European welfare state regimes.

4. To compare the magnitude of relative and absolute oral health inequalities among two countries classified in the same welfare state regime: England and the US.

# Chapter 4 - Methodology

This thesis used a macro comparative study design to analyse political determinants which are usually homogeneous within countries and therefore only revealed with cross-national comparisons (179). The research process involved three main stages. The first stage corresponded to the comparison of socioeconomic inequalities in oral health between different European welfare regimes (based on the Ferrera's typology and the additional Eastern regime). The second stage was focused on a multilevel analysis to assess the degree to which welfare regime explained the proportional variation in oral health between European countries. Finally, the third stage explored oral health inequalities in two countries classified in the same state welfare regime, but with different health care systems: England and the US.

This chapter describes the methods used to address the objectives of this study. The datasets, variables, statistical analyses and sample sizes are presented in the four sections of the chapter. First, the description of the datasets includes the study population, sampling procedure and a brief mention of the oral health and SEP measures available in each survey. Then, the variables used in the analyses are described, including how they were chosen and coded. Next, the statistical analyses used in this project are presented and discussed. Finally, characteristics of the analytical samples and missing data are summarized.

## 4.1 The datasets

Data from the Eurobarometer 72.3 2009 survey were used for the first two stages of the project, while the Adult Dental Health Survey (ADHS) 2009 and the National Health and Nutrition Examination Survey (NHANES) 2005-2008 were employed for the third stage. Details of these datasets are given below.

### 4.1.1 Eurobarometer wave 72.3 (2009)

The Eurobarometer surveys have been carried out regularly since 1973 at the request of the European Commission to provide data for the adult population in the European Union members and applicant countries. In each wave, personal interviews are conducted based on a core questionnaire plus an additional questionnaire with particular topics. The surveys use multi-stage national probability sampling methods, and traditionally the samples are of about 1000 participants from most countries.

The Eurobarometer wave 72.3 is a cross-sectional survey conducted in 2009 by TNS Opinion and Social (318). It contains a module aimed to assess some aspects of oral health in 31 European countries: the 27 European Union Member States; the three candidate countries -Croatia, Turkey, the former Yugoslav Republic of Macedonia (FYROM)-; and the Turkish Cypriot Community (TCC). The 31 countries included in the survey are: Austria, Belgium, Bulgaria, Croatia, Cyprus (Republic and TCC), Czech Republic, Denmark, Estonia, Finland, France, Germany (East and West), Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Macedonia (FYROM), Malta, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, The Netherlands, Turkey, and the UK.

**Study population and sampling procedure**

The survey used a multi-stage, random sampling design to produce representative samples of persons aged 15 years and over in the surveyed countries. In every country, all the administrative regional units were pondered. These units represented the whole national territory according to the EUROSTAT NUTS 2 (Nomenclature of Territorial Units for Statistics) (319) and reflect the distribution of the population in terms of metropolitan, urban and rural areas. From each administrative regional 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. The fieldwork was conducted under detailed

and uniform instructions with questionnaires that were translated into the relevant languages. The master questionnaire was translated by local institutes (including proof reading and back-translation-after interim adaptation). The interviews were conducted face-to-face in respondents' homes using the Computer Assisted Personal Interview (CAPI) method. The total sample of the survey was 30,292 with sample sizes in individual countries ranging from 500 in Malta and the Turkish Cypriot Community, to 1550 in Germany. Unfortunately, the European Commission does not make publicly available the information on response rates for the Eurobarometer surveys. Attempts were made to contact the Eurobarometer team to obtain this information but no response was forthcoming. Although this could be a drawback of the survey, the data contain integrated post-stratification and population size weights which were derived to adjust the samples to the EUROSTAT population data. The post-stratification weighting (also called non-response weighting) was derived using data from national statistics in each country about gender, age, region NUTS 2, settlement size, household size, and education level. In turn, the population size weight corrects for the fact that countries with different populations have similar sample sizes so each country is represented in proportion to its population size (320). These weights were employed in the first stage of analysis of this project, but not in the multilevel strategy as the selected programs used to fit multilevel models did not allow for the use of weights.

Since the focus of the first two stages in this research was on welfare state regimes, only countries previously classified in one of the five welfare state regimes derived from the Ferrera's typology or the additional Eastern type were included in the analyses. For the 21 countries categorized in these welfare regimes, data on 21,731 people were available. Table 4.1 shows the sample size in each country.

The Eurobarometer wave 72.3 was chosen for the analysis of oral health inequalities in different European welfare state regimes for various reasons. First, it was the only available European survey measuring oral health and different SEP indicators. The survey included oral health data on number of natural teeth and oral impacts on daily life, and SEP indicators of education, occupation-based social class,

and subjective social status (SSS). Second, the survey has strengths in terms of precision and comparability for cross-national analyses since it used the same methodology and time lag for all countries. Third, the wide range of countries included in the survey allows for analyses of the five European welfare regimes derived from the Ferrera's classification and the complementary Eastern regime. Finally, it is worth mentioning that attempts were made to get national oral health surveys with information about adults' oral health in different countries. However, few were available and among those that were, some did not include SEP measures, or their oral health or SEP indicators were not comparable.

Table 4.1 - Survey sample sizes in countries grouped by welfare regime, Eurobarometer 2009

| **Welfare regime** | **Country** | **Sample size** |
|---|---|---|
| Scandinavian | Sweden | 1012 |
| | Finland | 1017 |
| | Denmark | 1040 |
| Bismarckian | Austria | 1005 |
| | Belgium | 1001 |
| | France | 1000 |
| | Germany | 1550 |
| | Luxemburg | 513 |
| | Netherlands | 1007 |
| Anglo-Saxon | UK | 1354 |
| | Ireland | 1008 |
| Southern | Greece | 1000 |
| | Italy | 1032 |
| | Portugal | 1031 |
| | Spain | 1003 |
| Eastern | Czech Republic | 1066 |
| | Estonia | 1011 |
| | Hungary | 1044 |
| | Poland | 1000 |
| | Slovakia | 1006 |
| | Slovenia | 1031 |

### 4.1.2 Adult Dental Health Survey (ADHS) 2009 in England, Wales and Northern Ireland

In the UK, a series of national dental surveys have been conducted since 1968 with a 10 year interval to provide information on adults' oral health and assess changes over time (321). The Adult Dental Health Survey (ADHS) 2009 is the fifth and most recent of these surveys and was carried-out in England, Wales and Northern Ireland. Similar to the previous national dental surveys, the ADHS 2009 collected data from a questionnaire-based interview and a clinical examination. The survey was commissioned by the NHS Information Centre for Health and Social Care and was conducted by the Office for National Statistics (ONS) in consortium with the National Centre for Social Research (NatCen), the Northern Ireland Statistics Research Agency (NISRA), and experts from various universities in the UK.

**Study population and sampling procedure**

The ADHS 2009 has a two-stage cluster and probabilistic sample design which provides representative data at national level (England, Wales and Northern Ireland) and at the level of each Strategic Health Authority (SHA) in England. The SHAs used to be part of the National Health Service (NHS) structure in England, and were responsible for developing health services, implementing health policies and managing other NHS organizations at a regional level (322). Between 2006 and 2013, England was divided up into ten SHAs (323). In each of those SHAs, 23 primary sampling units (PSU) were selected for the ADHS 2009. Also, 23 PSUs were selected in Wales, while 15 PSUs were sampled in Northern Ireland. Each PSU comprised two postcode sectors which were combined together to increase the diversity of the population within each PSU and to help reduce the effects of clustering. From each postcode sector, 25 addresses were sampled for a total sample of 13,400 addresses of which 12,054 were eligible for inclusion. At an eligible sampled household, all adults aged 16 years and over were invited to participate in the interview and those with at least one natural tooth were also invited to a dental examination. The interviews were carried out by trained interviewers and the clinical examinations by trained and calibrated dentists. Both interviews and examinations were completed

in participants' homes. Data were collected in two fieldwork periods from October to December 2009 and from January to April 2010. During these periods, the survey collected interview data from a sample of 11,380 adults, of which 6,469 completed the clinical dental examination. Among the participants who did not complete the examination, 813 were not eligible because they were edentate and 1,504 gave their consent to take part in the examination but the dental examiners could not arrange to examine them within the fieldwork period. The overall household response rate for the ADHS 2009 was 60%, and the individual response rate within households was 84%. The survey made available weights to account for the complex sampling design and to lessen the potential bias caused by non-response at the interview and examination stages. These weights were employed in all reported analyses.

The ADHS 2009 was chosen as the source of information for England in the third stage of this project, which is focused on a comparison of oral health inequalities between England and the US. In addition to being the most recent nationally representative survey on adults' oral health in England, the ADHS 2009 provides a unique opportunity to study inequalities since it includes various SEP indicators and a wide range of measures of oral health and quality of life. Among the former, educational attainment, household income and occupational social class were incorporated in the survey. Subjective measures of oral health include self-rated oral health and different aspects on how oral health affects people physically, psychologically and socially (what is known as oral health related quality of life - OHRQoL). In turn, clinical data provided a comprehensive assessment on number of natural teeth; condition of the teeth, roots and supporting tissues; state and use of dentures; functional tooth contacts and spaces.

### 4.1.3 US - National Health and Nutrition Examination Survey (NHANES) 2005-2008

In order to use a national survey that was fairly comparable with the ADHS 2009, the oral health component of the National Health and Nutrition Examination Survey

(NHANES) 2005-08 was selected as the data source for the US. The two surveys provide nationally representative samples, have a similar structure including interview and clinical examination, contain certain comparable oral health and SEP measures, and were conducted during relatively similar time periods.

The NHANES is a series of studies conducted by the US National Center for Health Statistics at the Centers for Disease Control and Prevention to assess different aspects of health and nutritional status of adults and children in the United States. The survey provides a nationally representative sample of the resident civilian non-institutionalized population. People in institutional settings, such as prisons and hospitals, are not included in the sample. The survey collects data by interviews and clinical examinations, including laboratory tests.

The NHANES program began in the 1960s and from 1999 is a continuous annual survey with data released on two-year cycles. While each two-year cycle provides a nationally representative sample, the combination of multiple 2-year periods is possible and often recommended to increase the sample size and statistical power (324). The periods 2005-06 and 2007-08 were combined for this study because, for the oral health component, they included the same information and used identical data collection methodology. Previous analyses of oral health measures in NHANES adopted the same approach of combining these two-year periods (248, 325, 326).

**Study population and sampling procedure**

The NHANES 2005-08 has a fourth-stage, cluster sampling design with oversampling of certain subgroups of the population to increase statistical reliability of estimates for these groups (see details in Table 4.2). The survey considered all counties in the US, and the primary sampling units (PSU) were generally single counties or, in few cases, a combination of small counties. The selection of these PSUs used probabilities proportional to size and comprised the first stage of sampling. The other three stages were the selection of area segments within the PSUs, then households within segments, and finally, individuals within households. One or

more individuals per household were selected based on screening of demographic characteristics.

The survey consisted of two components, a face-to-face interview conducted in respondents' homes, and an examination performed in Mobile Examination Centers (MEC). The examination involved physical measurements such as blood pressure, audiometry, visual and dental examination; and the collection of blood and urine samples for laboratory testing. The combined surveys NHANES 2005-08 collected interview data from a sample of 20,497 individuals of all ages of which 19,712 completed the examination. The response rates were 80% for interview and 77% for examination in the period 2005-06 and 78% and 75% respectively for the period 2007-08. Although the survey includes data for different age groups, only adults were considered in the analyses as that is the population of interest in this project. For the combined period 2005-08, oral health data from the interview were completed for 11,791 persons aged 18 years and over, of which 10,276 also participated in the clinical examination. A summary of certain characteristics of the NHANES periods 2005-06 and 2007-08 are presented in Table 4.2.

Table 4.2 - Selected characteristics for the NHANES survey, periods 2005-06 and 2007-08

| Characteristic | NHANES 2005-06 | NHANES 2007-08 |
|---|---|---|
| Oversampled groups | Persons 12-19 years and 60 years +; Mexican-Americans; non-Hispanic Blacks | Persons 60 years and older; all Hispanics; non-Hispanic Blacks |
| Sample sizes | | |
| Interview (all ages) | 10,348 | 10, 149 |
| Examination (all ages) | 9,950 | 9,762 |
| Oral health data (among persons 18 years and older) | | |
| Interview | 5,563 | 6,228 |
| Examination | 5,334 | 5,995 |

Sources: Dye et al, 2011 (327) and own estimates from the NHANES datasets.

The oral health component of the NHANES 2005-08 consisted of a clinical examination and questions about self-rated oral health and OHRQoL as part of the interview. The examination was a basic oral health screening carried out by trained health technologists. This screening was aimed to measure number of teeth and presence of untreated dental caries, restorations, and sealants. Data quality analyses performed for the examination showed very good reliability statistics of the health technologists when compared to the survey reference examiner (a dentist). For the combined NHANES period 2005-08, the kappa scores for tooth count ranged from 0.89 to 1.00, for untreated caries from 0.82 to 0.83, for dental restorations from 0.88 to 0.90, and for dental sealants from 0.83 to 0.87 (327).

The NHANES datasets contain interview and examination sample weights that can be used to produce nationally representative estimates. These weights take into account the differential probabilities of selection given that some groups were oversampled, the non-response, and differences between the final sample and the total population (324). All reported analyses in this study were weighted. The combination of the two periods and use of sample weights were done following the analytic guidelines from the NHANES surveys (324).

## 4.2 Variables

This section presents the variables used in this PhD project. Each subsequent chapter includes a clarification regarding the variables used at each stage of analysis. In this section, the characteristics of variables are presented according to their data source. First, variables from the Eurobarometer 72.3 2009 survey and then, variables from the ADHS 2009 and NHANES 2005-08 are described.

### 4.2.1 Variables - Eurobarometer 72.3 (2009) survey

Data from the Eurobarometer survey were employed to compare oral health inequalities among different European welfare state regimes, and to assess the

degree to which welfare regime explains the proportional variation in oral health between European countries.

#### 4.2.1.1 Oral Health indicators

The survey collected data on two self-reported oral health measures: 1) number of natural teeth and 2) frequency of impacts of oral conditions on daily life.

*Measures based on number of teeth*

Number of natural teeth is considered a measure of life-time oral health since captures the cumulative effect of different determinants of health (52, 328, 329). Moreover, the number and distribution of teeth have been linked to important functions such as eating without difficulties and socializing comfortably (330, 331). Specifically, inadequate dental functioning and impaired masticatory ability have been associated with having fewer than 20 natural teeth (330, 332, 333). By contrast, having a "functional dentition" of more than 20 natural teeth is significantly associated with better chewing ability (334), higher consumption of fruits and vegetables (335), and is considered a quality of life measure in older adults (328). Number of natural teeth was even found to be a predictor of mortality among adults aged 70 years independent of general health status, socio-economic factors and health-related behaviours (336). Studies have also shown an association between tooth loss and oral health related quality of life in the adult population, both in general and in older adults (328, 337).

The measure of number of natural teeth in the Eurobarometer survey was self-reported based on a question with five response options: all; 20 or more, but not all; 10-19; 1-9; no natural teeth. From this information, two binary indicators were created: 1) no functional dentition (fewer than 20 natural teeth), and 2) edentulousness (no natural teeth). Although these two indicators capture the cumulative effect of oral disease and experience of dental treatment, edentulousness is a robust measure of 'total tooth mortality' while functional dentition is relevant to assessing oral health status in populations where

edentulousness is not prevalent. In addition, while edentulousness has been a key broad oral health indicator, its importance is diminishing because of its lower prevalence in current cohorts of young and middle-aged adults. As a result, while both outcomes are reflections of the number of natural teeth, the use of drastically different cut-off points changes the emphasis considerably and makes their complimentary use an asset. Based on this rationale, these two outcomes were considered in the analyses.

*Oral impacts on daily life*

In general, measures of oral impacts on daily life aim to assess the functional, psychological and social effects of oral health (338, 339). In addition to their association with general wellbeing, clinical outcomes and unmet treatment needs, these measures are highly relevant because they affect decisions related to oral health and use of dental care services (340-344). By capturing the perceived impacts of oral health on people's lives, these indicators can complement the clinical assessment of oral health which is usually focused on diseases (345). This combination of clinical and self-perceived measures of oral health has been increasingly used for assessing oral health needs and for planning and evaluating health services and health promotion interventions (346). Oral impacts on daily life are usually gauged through measures of oral health-related quality of life (OHRQoL), being the two most commonly used the Oral Health Impact Profile (OHIP-14) and the Oral Impacts on Daily Performances (OIDP).

The Eurobarometer survey contained questions of how regularly people had experienced disruptive impacts because of oral health problems. The questions referred to the frequency of the following 7 impacts during the last 12 months:

1. Difficulties eating food
2. Difficulties in chewing/biting foods
3. Experiencing pain
4. Feeling tense
5. Feeling embarrassed

6. Avoiding conversation
7. Reducing participation in social activities

The frequency of these impacts was assessed on a scale with four response categories: 'often', 'from time to time', 'rarely', and 'never'. Because this analysis intended to identify adults reporting recurrent impacts, the first two categories ('from time to time' and 'often') and the last two ('rarely' and 'never') were combined to create a dichotomous indicator. This indicator was derived so it shows the prevalence of having experienced any of the oral impacts either 'from time to time' or 'often'.

While this questionnaire of oral impacts was not a previously validated measure, its reliability was calculated and found to be very good with a Cronbach's alpha of 0.893. Cronbach's alpha coefficients were also calculated by welfare regime, and the estimates obtained were: 0.824 (Scandinavian), 0.845 (Anglo-Saxon), 0.840 (Bismarckian), 0.919 (Southern) and 0.889 (Eastern). These estimates indicate very good reliability of the scale in all regimes considered in this study. In addition, the scale was employed consistently in all countries.

#### 4.2.1.2 Socioeconomic position measures

Three socioeconomic position measures assessed in the Eurobarometer survey were used in the analyses: education, occupational social class, and subjective social status (SSS). These indicators helped to give a more comprehensive picture of oral health inequalities as they represent different dimensions of people's socioeconomic circumstances (see Chapter 2, section 2.1.1).

*Education*

As discussed in Chapter 2, education captures the knowledge-related resources of a person and is a measure of life time SEP since it is generally achieved earlier in life (79). Education was measured in the survey as age at which the participant completed full-time education. This way of measuring education is considered a

marker for years of schooling and has been used in previous analyses of oral health inequalities (347). Measures reflecting number of years of schooling have advantages for cross-national comparisons as they assess education as a continuous scale and therefore, are less influenced by international variations in the distribution of educational levels (180). It is important to mention however, that number of years of schooling and age when completed full-time education are related to educational attainment as more years indicate that the person is more likely to have reached higher milestones in the educational process.

In the Eurobarometer survey, age when completed full-time education was assessed by a single question with nine response categories: 'up to 14 years', then individual years, and '22 years and older'. From this measure, a categorical variable was derived with three education-level groups: before 16 years, 16-19 years, and 20 years and older. This categorization took into account the distribution of the response options in the sample. In addition, individuals older than 20 years who reported being still studying were categorized in the highest educational level.

*Occupational social class*

Occupational social class refers to people's relationship to work and to others through the economic structure of a society (96). The survey included a question about the current or most recent occupation with 18 possible responses. Due to requirements of the inequality indices used in the analysis (Relative Index of Inequality and Slope Index of Inequality), a minimum of three categories and a hierarchical social group classification had to be established. The UK three-category National Statistics Socio-Economic Classification scheme (NS-SEC) has been recognized as an occupational classification where some hierarchy can be assumed (79). For this thesis, occupations were fitted into this NS-SEC (3-categories): 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 because conceptually these categories do not follow a hierarchical relationship with the other categories of

occupational social class. Despite the drawback of excluding participants from the analyses, the advantages of applying the Relative Index of Inequality and Slope Index of Inequality balance out the potential limitation (see section on statistical analyses in this chapter).

*Subjective social status*

This measure of SEP corresponds to the individual's perception of his/her position in the social hierarchy. It has shown to be a good predictor of health and in older adults is considered a proxy of life-time socioeconomic status (104). In the Eurobarometer survey, the question about subjective social status (SSS) was based on a scale with 10 levels representing the social hierarchy. Participants were then asked to specify which level of the scale they would situate themselves on. Considering previous analyses (59, 348) and based on the distribution of the SSS variable in the sample, in this analysis, SSS was categorized into lowest social rank (steps 1-3), second lowest social rank (steps 4-5), second highest social rank (steps 6-7), and highest social rank (steps 8-10). It is worth mentioning that previous studies using SSS as a categorical variable agreed that standard cut-off points have not been established (106, 110, 111, 349). Additionally, although the use of quartiles was considered as alternative option of grouping, quartiles from this specific dataset led to the following four categories: 1-4, 5, 6, and 7-10, with a distribution of 17%, 28%, 23% and 32% respectively. Therefore, the former categorization was preferred to identify groups with different perceived social status.

#### 4.2.1.3 Welfare state regimes

At the first and second stages of analysis in this project, countries were grouped in five welfare state regimes based upon Ferrera's typology and the additional Eastern regime. As previously discussed (see Chapter 2, section 2.2.1.2), the typology by Ferrera accounts for methodological and theoretical weaknesses identified in alternative typologies and has high within-regime homogeneity and between-regime heterogeneity (93). Moreover, it has been used in earlier studies on cross-

national comparisons of inequalities in health (33, 164, 171, 172). In this typology, countries are clustered according to their eligibility criteria for welfare benefits, coverage, funding regulations, and administrative processes of the social security systems (164, 350). Based on how welfare goods and services are granted and delivered, Ferrera identified four welfare regimes: Scandinavian, Bismarckian, Anglo-Saxon, and Southern.

The Scandinavian welfare regime has universal, generous welfare benefits provided by the state with social security programs designed to have a redistributive impact. In the Bismarckian regime, the state provides some earnings-related welfare benefits, the family plays an important role in welfare provision and the market participation in social services and benefits is minimal. Unlike the Scandinavian regime, the Bismarckian does not have a welfare provision with significant redistributive effects. The Anglo-Saxon regime is distinguished by minimal state-provided benefits and services and a significant role of the market in the provision of goods and services. The Southern regime exhibits a fragmented welfare system with a combination of generous and weak provisions, a clear public-private mix, and a scheme of cash subsidies prone to corruption (158).

In addition to the Ferrera's four welfare state regimes, this thesis included the Eastern European welfare regime grouping former Communist countries which have experienced severe changes in their social policies from the 1990s. These countries have moved from a communist welfare state to welfare schemes distinguished by marketization and decentralization (165, 171, 172). The more recent inclusion of the Eastern regime in the social policy literature has led to the increasing use of five European welfare regimes in public health research: Scandinavian, Bismarckian, Anglo-Saxon, Southern, and Eastern (164, 171, 176, 177). These five regimes were used in this project. Countries were then grouped by welfare regime as follows:

Table 4.3 - Countries grouped by five welfare 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 |

#### 4.2.1.4 Other variables

*Age*

Age was self-reported in years, and was used as a categorical variable divided into ten-year age groups. Age was considered in all analyses because different age distributions between the countries and also differences in the mean ages across the SEP categories could influence findings. Age standardisation was used to estimate prevalence rates, so that they were comparable across countries (and welfare regimes) with different age structures. Furthermore, all regression models (including those used to estimate RII and SII) included a measure of individual age as a covariate.

*Gender*

Gender was taken into account in the analyses given its relationship with oral health and socioeconomic position. Additionally, the gender composition of countries could potentially affect results. Gender was included in all analyses as a binary variable: female or male.

*Marital status*

Marital status has been significantly associated to general health outcomes and to oral health measures (351-354). Similarly, marital status has been previously related to socioeconomic position (355, 356). Considering these relationships, analyses in this thesis were adjusted for marital status. Participants were categorised into one

of three levels based on self-reported marital status: single, married/cohabitee, and divorced/widowed.

Although it might had been conceptually relevant, data on ethnicity were not considered in the analyses since it was not available in the Eurobarometer survey.

### 4.2.2 Variables - ADHS 2009 and NHANES 2005-08 surveys

Data from the ADHS 2009 and NHANES 2005-08 surveys were used in the third stage of analysis which was focused on a comparison of oral health inequalities between England and the US. Since the variables were selected and coded to achieve comparability across the two surveys, they are presented together in this section.

#### 4.2.2.1 Oral Health indicators

The surveys collected data on certain clinical and self-reported oral health measures. After examining the available measures and technical information from the two surveys regarding data collection criteria and procedures, three indicators with acceptable comparability were chosen: number of missing teeth, self-rated oral health and oral impacts on daily life.

*Number of missing teeth*

As discussed above, number of teeth is a cumulative oral health measure that reflects a life-time experience of disease and use of dental care services (see section 4.2.1.1, measures based on number of teeth). In the ADHS 2009 and NHANES 2005-08, number of missing teeth was derived from the clinical examination data. To achieve comparability across the two surveys, only data on dentate participants was considered in the NHANES 2005-08 as only dentate individuals were included in the ADHS 2009 clinical examination. It is worth mentioning that although the clinical assessment of number of teeth was performed by health technologists in the NHANES 2005-08, data quality analyses showed very good reliability statistics for the technologists when compared to the dentist reference examiner (kappa scores

from 0.89 to 1.00) (327). Number of missing teeth was treated as a count variable in the analyses for this project.

*Self-rated oral health*

This summary measure reflects people's perception of their own oral health. It captures various dimensions related to this perception and is significantly associated with clinical measures and unmet treatment needs (340-343). Self-rated oral health expresses a general perception which is informative itself and is considered a valid indicator of oral health (51, 56, 59, 234). It reflects the current rather than historic oral health status and has importance for health services and health promotion planning as it influences decisions on behaviours and use of oral health services (340-344, 346).

It has been argued that cultural differences in the perception of health could undermine the validity of cross-national comparisons based on self-perceived measures (357, 358). However, these indicators have been widely used in analyses of health inequalities since there is evidence of a positive association between self-reported health and morbidity, healthcare needs and later mortality (359). Moreover, as discussed in Chapter 2, self-rated health is one of the outcomes most frequently used in international comparisons of health inequalities (see Chapter 2, section 2.2.1.3).

Self-rated oral health was assessed in the ADHS 2009 via the question 'would you say your dental health (mouth, teeth and/or dentures) is...' with five response categories: very good, good, fair, bad, and very bad. In the NHANES 2005-08 the question was 'how would you describe the condition of your teeth and gums? Would you say…' and the answer options were: excellent, very good, good, fair, and poor. For the purposes of these analyses a binary variable was derived to differentiate persons who perceived their oral health as good or better (a clear positive perception about their oral health) from those who did not. In the ADHS 2009, this was done by combining the answers of very good and good versus the options fair, bad, and very bad. In the NHANES 2005-08, the response categories of

excellent, very good and good were pooled versus fair and poor. Therefore, for this study, 'less than good oral health' was set as the outcome of interest.

*Oral impacts on daily life*

As noted earlier, indicators of oral impacts on daily life capture how people's lives are disrupted functionally, socially and psychologically due to oral health problems. Both the ADHS 2009 and NHANES 2005-08 surveys contained six comparable questions on oral impacts based on certain items from the Oral Health Impact Profile-14 scale (OHIP-14). The OHIP is a very frequently used measure of oral health-related quality of life and aims to assess how frequently oral conditions impact on people's daily life and wellbeing. The original OHIP questionnaire contains 49 items assessing seven conceptual dimensions that were derived from a theoretical framework of oral health developed by Locker (360). The seven conceptual dimensions are: functional limitation, psychological discomfort, psychological disability, physical pain, physical disability, handicap and social disability. From the original scale with 49 questions (OHIP-49), a shorter version with 14 items was later derived and validated: the OHIP-14. This short version includes two questions from each conceptual dimension of the OHIP-49. In the validation process, the OHIP-14 showed very good reliability, accounted for more than 90% of the variance in OHIP-49, and had very similar associations with socio-demographic and clinical measures compared with the original scale (361).

For the six questions based on OHIP-14 which were included in ADHS 2009 and NHANES 2005-08, data were collected in an identical fashion in the two surveys. Every participant was asked about how often he/she had experienced each impact during the last 12 months. Responses to these questions were given on a scale with five categories: never, hardly ever, occasionally, fairly often, and very often. In this analysis, a binary measure was derived for having any response of 'very often' or 'fairly often' to any of the questions. This summary variable is commonly used to identify prevalence of oral impacts based on OHIP-14 (362-364). The impacts assessed in the six questions included in ADHS 2009 and NHANES 2005-08 with their corresponding conceptual dimensions are presented in Table 4.4.

Table 4.4 - Oral impacts similarly assessed in ADHS 2009 and NHANES 2005-08

| **Oral impact assessed** | **Conceptual dimension** (From OHIP-49) |
|---|---|
| Feeling painful aching | Physical pain |
| Feeling life less satisfying | Handicap |
| Difficulty doing usual jobs | Social disability |
| Affected sense of taste | Functional limitation |
| Feeling uncomfortable eating any food | Physical pain |
| Being self-conscious or embarrassed | Psychological discomfort/disability |

In this study, only the six questions on oral impacts that were comparable in the two surveys were considered in analyses. The NHANES 2005-08 included one additional question on oral impacts while the ADHS 2009 included the additional eight questions from the OHIP-14. The question from the NHANES 2005-08 excluded from analyses was not an OHIP-14 question and therefore, it was not comparable with any ADHS 2009 item.

#### 4.2.2.2 Socioeconomic position measure

From the SEP measures available in ADHS 2009 and NHANES 2005-08, education was selected for analyses as it showed good comparability across the two surveys. For this reason, educational inequalities in oral health were compared between England and the US in the third stage of analysis of this PhD.

*Education*

As previously noted, education is considered a very inclusive measure of SEP, particularly in high-income countries where the majority of people attend school. Furthermore, education has important advantages for analysis of health inequalities. For example, given that it is usually achieved in early life, education is less likely to be influenced by later health status and, compared to income and occupation, it remains relatively stable during adult life (87).

Data on education were collected in the ADHS 2009 and NHANES 2005-08 as educational attainment, which denotes the highest level of education achieved. In

the ADHS 2009, only three categories of educational attainment were available: no qualifications, qualifications lower than degree and degree level. To match this categorization, the NHANES educational data were grouped into three levels: low, medium, and high. Participants with less than high school were allocated in the low level, those with a high school diploma but not college degree were in the medium, and persons with a college degree or above, in the high level. This categorization was chosen because it was considered conceptually valid and yielded to similar educational distributions in the two countries.

#### 4.2.2.3 Other variables

Taking into account the previously discussed relationships of age, gender and marital status with both oral health and SEP (see section 4.2.1.4), these variables were considered in all analyses. Additionally, as data on ethnicity was available in the ADHS 2009 and NHANES 2005-08 datasets, it was also included in all analyses for the England-US comparison.

*Age*

Ten-year age groups were used for standardisation of prevalence rates. Age was also included as a covariate in the regression models throughout the analyses.

*Gender*

Gender was considered in all analyses as binary variable: female or male.

*Marital status*

Marital status was also included as a covariate in all regression models of this stage of analysis. Based on self-reported marital status, adults were classified into the following categories: single, married/living with partner, separated/divorced, and widowed.

*Ethnicity*

Although the ADHS 2009 and NHANES 2005-08 surveys included a variable for ethnicity, the answer categories in each survey were different. Therefore, to achieve comparability in the ethnicity measure between the two countries, a binary indicator of White versus non-White was created and included in analyses. Further, a sensitivity analysis was conducted restricting the analytical sample to White population in the two countries to test if the results were sensitive to this specification given the differences in the ethnic composition between England and the US.

## 4.3 Statistical analyses

The statistical methods used in this thesis are presented in this section. The section is divided into five sub-sections which describe the methodological approaches used for the analyses presented in the results chapters 5 to 8.

The analytical strategy for examining oral health inequalities in European welfare regimes and in the England-US comparison was similar and included three main steps: 1) estimation of age-standardized prevalence rates, 2) fitting multivariable regression models to assess the association between the oral health and SEP, and 3) estimation of the Relative Index of Inequality (RII) and the Slope Index of Inequality (SII). These methods are presented in distinct sub-sections below. In addition, the multilevel modelling carried out for the second stage of analysis of this project is explained in a separate sub-section. Finally, the description of sensitivity analyses is included at the end of this section.

### 4.3.1 Age-standardization

In order to account for differences in age structures across countries and welfare regimes, age standardisation was used to estimate prevalence rates of oral health measures. For the count variable of number of teeth used in the England-US comparison, means were also age-standardized. The direct method of

standardization was employed using ten-year age groups with the following standard populations:

- The pooled sample from European countries for analyses of the Eurobarometer survey.

- The OECD 2009 standard population for analyses of the ADHS and NHANES surveys. The OECD standard population was chosen for the England-US comparison as it reflects the age structure of high income countries. The OECD 2009 age structure was obtained from OECD statistics website http://stats.oecd.org/ (Accessed 24 November 2013).

It is also important to mention that in the results chapters, all reported prevalence rates and means were also weighted using the sampling design variables and weights of each survey.

### 4.3.2 Regression models to assess the association between oral health and socioeconomic position

In the second step of analysis of oral health inequalities, the strength and direction of associations between oral health measures and SEP indicators were examined by fitting multivariable regression models. In these models, the oral health measure was introduced as the outcome variable, the SEP indicator as the categorical explanatory variable, and age, gender, marital status and ethnicity (when available) as covariates. For binary measures of oral health, prevalence ratios (PRs) were obtained using robust Poisson regression models. Prevalence ratios were estimated instead of odds ratios because the oral health outcomes used in this project had relatively high prevalence. Previous analyses have found that ORs can overestimate associations in analyses of outcomes with high prevalence (>10%) and have, therefore, suggested that PRs should be preferred in those cases (365, 366). Some authors have also compared different methods to directly estimate PRs and have recommended the use of Poisson regression with robust variance, or log-binomial

regression models (365, 367, 368). In this study, robust Poisson regression models were used as they are considered appropriate to obtain PRs, and the log-binomial regression showed some convergence issues. These problems of convergence with log-binomial models have been previously reported and are likely to occur in models where the outcome has high prevalence, there is a continuous covariate in the model, or analyses are conducted in surveys with complex sampling design (survey data) (367, 369).

For the count variable of number of missing teeth, used in the England-US comparison, incidence rate ratios (IRRs) were estimated using Poisson regression models. This regression model was selected for analyses of number of missing teeth since the variable did not include zero values (only analysed among dentate participants), and tests ran to compare different models for count data (370) showed that the Poisson model should be preferred over other options (e.g. negative binomial). In these Poisson models, the number of missing teeth was the outcome variable, SEP was the explanatory variable, and age, gender, marital status and ethnicity were covariates. The IRRs in this study can be interpreted as the ratio of the mean number of missing teeth in a certain SEP level compared with that in the reference level adjusted for other covariates in the model.

Assessment of significance for trend in PRs or IRRs was performed in all models.

### 4.3.3 Relative Index of Inequality (RII) and Slope Index of Inequality (SII)

In international comparisons, the use of absolute or relative measures of health inequalities lead to different conclusions, and this has been the subject of an intense academic debate (156, 371). Relative inequalities tend to be larger when the prevalence rate of the outcome is low, while absolute inequalities can be small at both low and high levels of overall rates (372). In the context of analyses by welfare regimes, it has been argued that the inclusion of absolute measures would provide a more comprehensive picture of the potential effects of different welfare states on health inequalities (28, 156). This is because relative inequalities strongly

depend on the situation of those with better socioeconomic position. Therefore, in welfare states with universal social policies that benefit all social groups (including those in higher SEP), the good health of those in more privileged positions would contribute to increase the magnitude of relative inequalities (28, 156). As a result, it has been strongly recommended to report both kinds of measures in cross-national analyses of health inequalities (93). In addition, Mackenbach and Kunst (373) state that there is an important limitation in measures of absolute and relative health inequality which only compare two socioeconomic groups. Since they do not take into account other groups or differences within groups, important information regarding the nature of the relationship between SEP and the selected health outcome is missed. As improved alternatives, regression-based measures of health inequalities, such as RII and SII, consider all socioeconomic groups and gauge how the health measure varies according to the socioeconomic position of these groups.

The RII and SII summarise the association between the SEP measure and the outcome of interest with one single value that consider all socioeconomic groups at once. Thereby, these indices use all available data and differences in the sample sizes of socioeconomic groups are removed as potential causes of variation in the magnitude of health inequalities (39, 80, 373). This property of the indices is especially useful for comparisons of inequalities across time or places, when sizes of socioeconomic groups change over time or vary between geographic locations (366, 374).

These indices are regression-based indicators with a fairly straightforward interpretation. The RII is obtained from regression models where the regression coefficients are converted to relative risks or odds ratios. Estimates of the RII are interpreted as the prevalence ratio of the health outcome among persons at the lowest and highest levels of the socioeconomic hierarchy (39, 93). Values of RII larger than 1 indicate inequality with higher prevalence of the outcome among those in lower socioeconomic level. Conversely, an RII value less than 1 indicate that the oral health measure was more likely to be prevalent among those with a higher SEP level. In turn, SII is obtained from ordinary least squares regression models and

the estimate represents the hypothetical absolute difference in the prevalence of the outcome between bottom and top of the SEP hierarchy. Positive values of the SII indicate that prevalence of the outcome increases with lower levels of SEP. For both RII and SII, larger estimates signify larger inequalities.

In this thesis, the Relative Index of Inequality (RII) and the Slope Index of Inequality (SII) were estimated as the third step of analysis of oral health inequalities, to measure relative and absolute inequalities respectively. For comparisons of inequalities across welfare state regimes and between England and US, RII and SII were calculated for each combination of oral health measure and SEP indicator. The indices were used to present population weighted estimates of inequalities taking into account the size of the sample in each socioeconomic category.

As a first step to estimate the indices, a weighted score was derived for each SEP measure in all analyses. To derive the score, the categories of education, occupational social class, or SSS were organized hierarchically and then, based on the distribution of people in these categories, values between 1 and 0 were assigned to each category. The score corresponds to this continuous variable with values between 0 (highest SEP) and 1 (lowest SEP). The score was assigned based on the midpoint of the range in the cumulative distribution of participants in the given SEP category. For example, if the first category of education comprises 20% of the population, each person in this category was assigned a value of 0.1 (0.2/2), and if the second category comprises 30% of the population, persons in this category were assigned a value of 0.35 (0.2+[0.3/2]) and so forth. In this thesis, scores were derived to reflect the distribution of participants in SEP categories in each welfare regime, or country (for the England-US comparison).

The RII and SII were obtained by regressing the weighted score measure of SEP on the outcome of interest, adjusting for covariates. Generalised linear models were used to estimate the indices, specifying a binomial distribution (log-binomial regression) with a logarithmic link function for RII, and an identity link function for SII (365, 366, 375). However, not all analyses were carried out using log-binomial

regression models due to convergence issues. When problems of convergence appeared, RII and SII were estimated using robust Poisson and linear regression models respectively. These regression models have been previously used to estimate the indices, especially in analyses of survey data where issues of convergence with log-binomial models are common (39, 369). The type of regression used to derive the indices was consistent within each analysis and a clarification regarding this issue is presented in every results chapter.

For the comparison of oral health inequalities across welfare regimes, interaction effects between SEP measures and welfare regimes were calculated to test for significant differences in relative and absolute inequalities across regimes. Two-way interaction terms between each population weighted measure of SEP and the welfare regime variable were introduced in the models. The statistical significance of the coefficient on the interaction term is reported as part of the results.

### 4.3.4 Multilevel analysis

The use of a multilevel modelling strategy was considered appropriate in the context of this thesis to further explore the potential role of welfare state regimes in population oral health and oral health inequalities. Therefore, in the second stage of analysis, a multilevel analysis was carried out using data from the Eurobarometer survey. This analysis aimed to 1) assess the influence of welfare state regime (a country-level characteristic) on the variation in oral health between European countries and 2) evaluate how the oral health of people with different SEP level was influenced by living in five different welfare state regimes.

For this multilevel analysis, the outcomes were the three previously described oral health measures available in the Eurobarometer survey: no functional dentition, edentulousness, and oral impacts on daily life. The individual-level explanatory variables were demographic characteristics (age, gender, marital status) and SEP measures (education and occupational social class). Subjective social status was not included in the multilevel analysis given the results obtained in the first stage of

analysis where many estimates of association between SSS and oral health measures were not significant. The country-level explanatory variables were the five welfare state regimes, and two variables that were included in the last model to account for country differences in economic growth and development: GDP per capita (at purchasing power parity) and GDP annual growth rate (%). Data on GDP per capita and GDP growth rate were derived from the EU statistics and measured as five-year averages (2005-2009) (376, 377).

**Multilevel modelling**

Multilevel regression models are suited to take into account similarities among individuals (or individual data points) clustered in higher level units. The concept of clustering refers to the fact that individuals randomly selected from the same group tend to be more similar to each other, regarding the study outcome, than individuals selected from different groups (378, 379). Multilevel regression models were used in this analysis to account for similarities in oral health among people living in the same country. In addition, multilevel regression analyses allow modelling oral health as a function of explanatory variables at individual and country levels, and to partition the variance in oral health into two components: variance due to differences between individuals and variance due to differences between countries.

Estimates of the residual variance at different levels were obtained due to the fact that a multilevel model splits the error (or residual) into components according to the levels in the data structure. This is, a two-level regression model includes individual residuals ($e_{ij}$) and residuals related to the higher level unit in which they are nested (country-level residuals, $u_j$). Then, the equation of a basic linear two-level model with no explanatory variables can be written as:

$$y_{ij} = \beta_0 + u_j + e_{ij} \qquad (1)$$

where $y_{ij}$ is the value of the outcome (*y)* for the *i* th individual in the *j* th country, and $\beta_0$ is the overall intercept. In this model the intercept is allowed to vary

randomly across countries, with the intercept for a country *j* being equal to $\beta_0 + u_j$. When adding an individual-level explanatory variable ($x_{1ij}$) and a country-level explanatory variable ($x_{2j}$) to the model, the equation can be written as:

$$y_{ij} = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2j} + u_j + e_{ij} \quad (2)$$

where $\beta_1$ and $\beta_2$ are the coefficients of the relationship between the explanatory variables and the outcome. Since the intercept varies randomly across level-2 units (countries), these models are called *random intercept models*.

For binary outcomes, instead of the linear model described above, a modified multilevel regression model has to be used. Although following the same general structure of the linear model, the model for binary outcomes has to be modified by including a function that 'links' the probability of the outcome happening or not ($\pi_{ij}$) with the parameters. The link function more frequently used is the logit function and a model modified in that way is then called multilevel logistic regression model. After this transformation in the multilevel model, it is no longer possible to estimate the variance of the individual residuals from the data. To deal with this issue, the latent variable approach (33, 177, 380) specifies a distribution of the individual residuals ($e_{ij}$) and fixes a value for the variance at individual level ($\sigma^2_e$). If a logistic distribution of $e_{ij}$ is assumed, the value of the variance at individual level is fixed at $\pi^2/3 = 3.29$ (because $\pi^2/3$ is the variance of the logistic distribution). In turn, the country-level residuals ($u_j$) are assumed to be normally distributed and the value of the variance at country level ($\sigma^2_u$) is obtained by fitting the model.

For illustration purposes, the equation of a two-level random intercept model for binary outcomes using logit as link function and including one explanatory variable at each level, is shown below:

$$\log\left[\frac{\pi_{ij}}{1-\pi_{ij}}\right] = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2j} + u_j \quad (3)$$

As the three oral health outcomes included in this analysis were binary, multilevel logistic regression models with the latent variable approach described above were applied. Therefore, being $\sigma^2_u$ the variance at country level, the following formulas were used to estimate the proportion of variance attributable to each level:

$$\% \text{ of total variance attributed to individual level} = \left[\frac{3.29}{(3.29 + \sigma^2_u)}\right] \times 100 \qquad (4)$$

$$\% \text{ of total variance attributed to country level (VPC)} = \left[\frac{\sigma^2_u}{(3.29 + \sigma^2_u)}\right] \times 100 \qquad (5)$$

VPC: variance partition coefficient

Since this analysis also aimed to assess how the oral health of those with different SEP levels (individual characteristic) was influenced by residing in the five welfare regime types (characteristic of countries), potential interaction effects between SEP and welfare state regimes were examined. In regression models, interaction effects allow for the possibility that the relationship between one explanatory variable and the outcome depends on the value of another explanatory variable. To assess interaction effects, the product of the interacting variables (interaction term) is included in the model as explanatory variable. In multilevel regression models, it is possible to include interaction effects between variables regardless of the level at which they are defined. An interaction between variables defined at different levels is called a cross-level interaction (378). In this analysis, cross-level interaction terms between SEP and welfare state regimes were analysed for each oral health outcome.

Analyses were initially performed using the generalised linear latent and mixed model procedure in Stata (GLLAM commands) with a log link function to obtain PRs. However, this method was not suitable for the data, as models did not converge. Issues of convergence are common when using a log link and are usually the result of predicted probabilities out of the interval [0, 1]. Therefore, all multilevel analyses

were conducted using the Markov chain Monte Carlo (MCMC) estimation procedure with starting values from the 2nd order penalised (PQL2) method. The MCMC is preferred over alternative procedures for models with binary outcomes such as quasi-likelihood methods because the later could give biased estimates, particularly when level 2 units have small sample sizes (33, 328, 381, 382). In MCMC, the simulation procedure to get estimates is divided into two parts, pre- and post-convergence, where the pre-convergence part, or 'burn-in', is discarded and the post-convergence part is used for inference. The number of iterations used in the two parts should be enough to get accurate estimates. In this analysis, a burn in of 5000 iterations, and a chain length of 50,000 iterations was used because increasing the number of initial iterations or running the chain for longer (more iterations) did not change any estimates appreciably. The Deviance Information Criterion (DIC) diagnostic was used to compare the goodness-of-fit of each model. The DIC diagnostic can be used to compare models since it includes measures of the 'fit' and 'complexity' of each model. In addition, because the DIC accounts for the number of parameters in the models, DIC values are directly comparable and any decrease in DIC suggests a better model (383). All multilevel models were fitted in MLwiN 2.27 from within Stata using the *runmlwin* command (382).

For each study outcome, a sequence of multilevel logistic regression models were fitted in the order described below:

1. Null or empty model (model 1): the first step of the analysis was fitting a two-level random intercept model without using any explanatory variables. This model provides a baseline estimation of the country-level variance in oral health (variance attributed to country level, $\sigma^2_u$). Based on the country-level variance obtained from the model, it was also possible to quantify the proportion of the variance in the outcome that existed at the country level.

   As a sensitivity analysis, the country-level variance was derived using different estimation procedures suggested in the statistics literature for multilevel models with binary outcomes (380, 381). The comparison

between estimates allowed testing the sensitivity of the analysis to the different methods. Estimates from the method of maximum likelihood via numerical integration were derived in Stata using the *xtmelogit* commad, while estimates from the quasi-likelihood and MCMC methods were derived in MLwiN from within Stata using the *runmlwin* command (382).

2. Model with individual-level variables (model 2): in a second step, a two-level random intercept model was fitted including individual-level explanatory variables. These individual explanatory variables were demographic characteristics (age, gender and marital status) and SEP measures (education and occupational social class). Model 2 provides information on how much of the variation in oral health across countries (country-level variance) is explained by individual-level characteristics. In addition, this model shows how the oral health outcomes vary by means of the individual characteristics.

3. Model with individual-level and welfare regime variables (model 3): next, the effect of welfare regime was analysed, taking into account individual-level characteristics. Dummy welfare regime variables were introduced using the Scandinavian regime as the reference category. The variance components (individual and country level) given by this model showed also whether welfare state regime contributes to explaining the variation in oral health across countries when individual characteristics are accounted for, which is the main interest of this analysis.

4. Model with individual, welfare regime and economic development variables (model 4): at this stage, the country-level variables of economic development (GDP per capita and GDP growth rate) were added to model 3 to determine whether any association between welfare regime and oral health was robust to adjusting for these variables. This is a fully adjusted model for all selected individual- and country-level characteristics of interest.

5. Models with cross-level interaction terms (models 5a and 5b): finally, two additional models were fitted in order to assess how the oral health of those with different SEP level was influenced by residing in the five welfare regime types. Following an approach previously used in studies on welfare regimes and health (177, 212, 217), these models included cross-level interaction terms between SEP and welfare regimes while adjusting for all individual- and country-level variables. The interaction terms between each SEP measure and the welfare regime dummy variables were introduced with the highest SEP group in the Scandinavian welfare regime as the reference category. As one model was fitted for each SEP measure, model 5a included the interactions between welfare regime and education while model 5b included interactions between welfare regime and occupational social class.

*Estimating the associations between individual- and country-level variables and oral health*

For each multilevel model, odds ratios with 95% confidence intervals were calculated to assess associations between the oral health outcomes and the individual and country-level variables. This is usually called the "fixed effects" component in multilevel modelling (378).

*Exploring the variance in oral health*

The proportion of total variance that is attributable to each level was estimated for all models using the latent variable approach (see above, formulas 4 and 5). To further quantify the country-level variance with an odds ratio approach, the median odds ratio (MOR) was estimated (384, 385). The MOR can be interpreted as the increased odds of the outcome that a person would have if moving from one country with lower odds of the outcome to a country with higher odds of the outcome. If two persons with the same covariates are randomly chosen from different countries, the MOR would be the median odds ratio between the person with higher probability of the outcome and the person with lower probability of the

outcome (384, 385). 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 (384). As suggested by Merlo et al. (384, 385), the MOR was computed using the formula:

$$\mathrm{MOR} = \exp\left[\sqrt{(2 \times \sigma^2_{u})} \times 0.6745\right] \quad (6)$$

where $\sigma^2_u$ is the variance at country level and 0.6745 is the 75$^{th}$ centile of the cumulative distribution function of the normal distribution with mean 0 and variance 1. Details about the theoretical derivation of the formula can be found elsewhere (385, 386). The 95% credible interval (CrI) for the MOR was derived by computing MORs for the 2.5$^{th}$ and 97.5$^{th}$ centiles of the distribution of the variance at country level (384).

Results of this multilevel modelling strategy are presented in Chapter 7.

### 4.3.5 Sensitivity analyses

Four sensitivity analyses were conducted in this thesis. First, estimates of prevalence ratios were compared to odds ratios to examine differences in the magnitude of the association between oral health measures and SEP indicators given the relatively high prevalence of the outcomes. This sensitivity analysis was carried out for models assessing the association between oral health and SEP at the first and third stages of this project, i.e., comparison of oral health inequalities across welfare regimes, and between England and US. Second, in certain analyses where RII and SII were derived using log-binomial models, the indices were also calculated using the alternative methods of robust Poisson and linear regression to compare the estimates obtained from the two methods. This comparison was performed to test the robustness of the results, and also to assess whether estimates of RII and SII derived from the alternative methods could be considered similar to those that would have been obtained from log-binomial regression

models had they achieved convergence. Third, in the multilevel analysis, estimates of the country-level variance were compared when using five different estimation procedures suggested for multilevel models with binary outcomes. Fourth, in the England-US comparison, all models were also carried out restricting the sample to the White population to assess if the results were sensitive to this specification. Results of these sensitivity analyses are mentioned at each relevant result chapter (Chapters 5 to 8).

## 4.4 Sample sizes and missing data

The selection of the analytical samples used at each stage of this thesis took into account characteristics of the oral health measures, SEP indicators, covariates, and requirements of the estimates (for example, RII and SII). The size of samples varied according to the inclusion criteria applied as well as variables involved in analyses. Descriptive statistics for each of the variables used in the analyses are given in the relevant subsequent chapters.

**Analyses based on the Eurobarometer survey**

For analyses based on the Eurobarometer survey, the analytical sample was first limited to individuals aged 20 years and over who were interviewed in countries classified in the five welfare regimes considered. Participants aged less than 20 were excluded because among them, a very low percentage was categorized in the highest levels of education and occupation compared to the whole eligible sample. This is related to the fact that many participants younger than 20 years were still studying and therefore, including them in analyses based on contemporary educational attainment and occupation could have introduced some bias in the measurement of SEP.

For this analytical sample of the Eurobarometer survey (n=20,689), sample sizes by countries are shown in Table 4.5, and the pattern of missing data is presented in Table 4.6.

Table 4.5 - Analytical sample by countries grouped in welfare regimes, Eurobarometer 72.3, 2009 (Participants aged ≥20 years)

| **Welfare regime** | **Country** | **Sample size** |
|---|---|---|
| Scandinavian (n=2,958) | Sweden | 968 |
| | Finland | 974 |
| | Denmark | 1016 |
| Bismarckian (n=5,788) | Austria | 967 |
| | Belgium | 955 |
| | France | 962 |
| | Germany | 1478 |
| | Luxemburg | 486 |
| | Netherlands | 940 |
| Anglo-Saxon (n=2,237) | UK | 1291 |
| | Ireland | 946 |
| Southern (n=3,859) | Greece | 959 |
| | Italy | 982 |
| | Portugal | 971 |
| | Spain | 947 |
| Eastern (n=5,847) | Czech Republic | 1027 |
| | Estonia | 945 |
| | Hungary | 986 |
| | Poland | 959 |
| | Slovakia | 956 |
| | Slovenia | 974 |
| Total | | 20,689 |

In this analytical sample, the number of participants with missing data was fairly small relative to the total size of the sample (Table 4.6). The variables with missing data were marital status, education, subjective social status, and number of teeth. For all these variables the missingness was less than 5%. Various authors have argued that in large samples there is little concern when missing data are less than 5%. In those cases, the use of complete case analysis approach is accepted or even recommended (387-390). Taking that into account, no imputation of missing data was carried out.

Table 4.6 - Missing data for study variables, Eurobarometer 72.3, 2009

| Variables | Number of missing cases | Percentage of total cases |
|---|---|---|
| **Demographics and SEP** | | |
| Age | 0 | 0.00 |
| Gender | 0 | 0.00 |
| Marital status | 28 | 0.14 |
| Education | 354 | 1.71 |
| Occupation | 0 | 0.00 |
| Subjective social status | 716 | 3.46 |
| **Oral health measures** | | |
| Measures based on number of teeth (No functional dentition and edentulousness) | 276 | 1.33 |
| Oral impacts on daily life | 0 | 0.00 |

*Samples for analyses in Chapters 5 and 6*

The analyses in Chapter 5 are focused on inequalities in no functional dentition and edentulousness across welfare state regimes. Because there was a very low prevalence of these two outcomes among young adults, only individuals aged 45 years and over were included in analyses of these variables. Additionally, only persons with at least one natural tooth were considered for analyses of no functional dentition since that outcome is based on number of natural teeth. From the sample of 12,516 adults aged 45 years and over, those with missing data on number of natural teeth were excluded. Then, adults with missing data on marital status and finally, exclusions were applied for models of each SEP indicator (Figure 4.1). Analyses were carried out separately for each SEP indicator and only subjects with complete data on the outcome and covariates were included in the models. The analytical samples for this set of analyses were 12,054 for models with education as SEP measure, 11,796 for SSS, and 10,632 for occupational social class.

Chapter 6 includes similar analyses to those in Chapter 5, but focuses on oral impacts on daily life as the outcome of interest. Individuals aged 20 years and over were included in this set of analysis. Following the same rationale described for Chapter 5, only subjects with complete data on the variables included in models for each SEP measure were considered (Figure 4.2). Analytical samples were 20,311 for models with education as SEP measure, 19,951 for SSS, and 16,819 for occupational social class.

In both chapters, 5 and 6, models for occupational social class did not include students, unemployed people, homemakers, and subjects who never did any paid job. These groups were excluded because conceptually these categories do not follow a hierarchical relationship with the other categories of occupational social class. Therefore, it would not have been appropriate to include them when assessing occupational gradients or when using the RII and SII as these indices require a SEP measure with a hierarchical classification. Whereas the UK three-category NS-SEC has been recognized as an occupational classification where some hierarchy can be assumed (79), that is not the case for the categories of homemakers, unemployed, and students.

Figure 4.1 - Sample sizes for analyses in Chapter 5

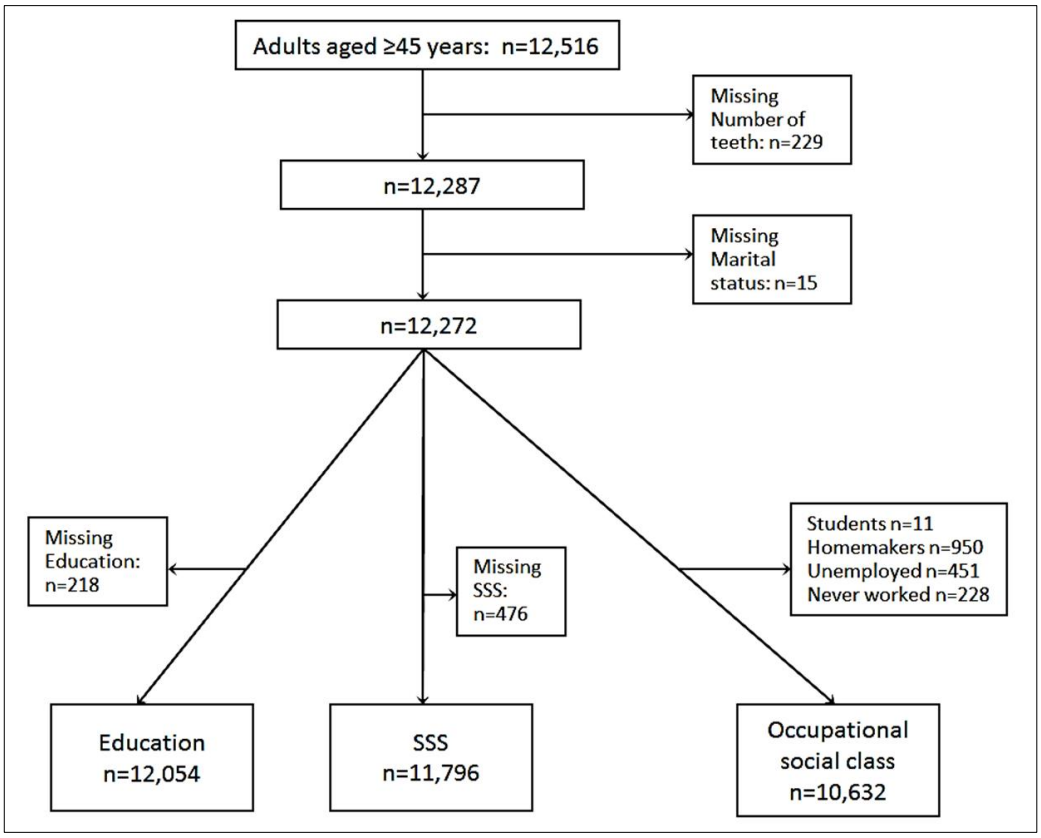
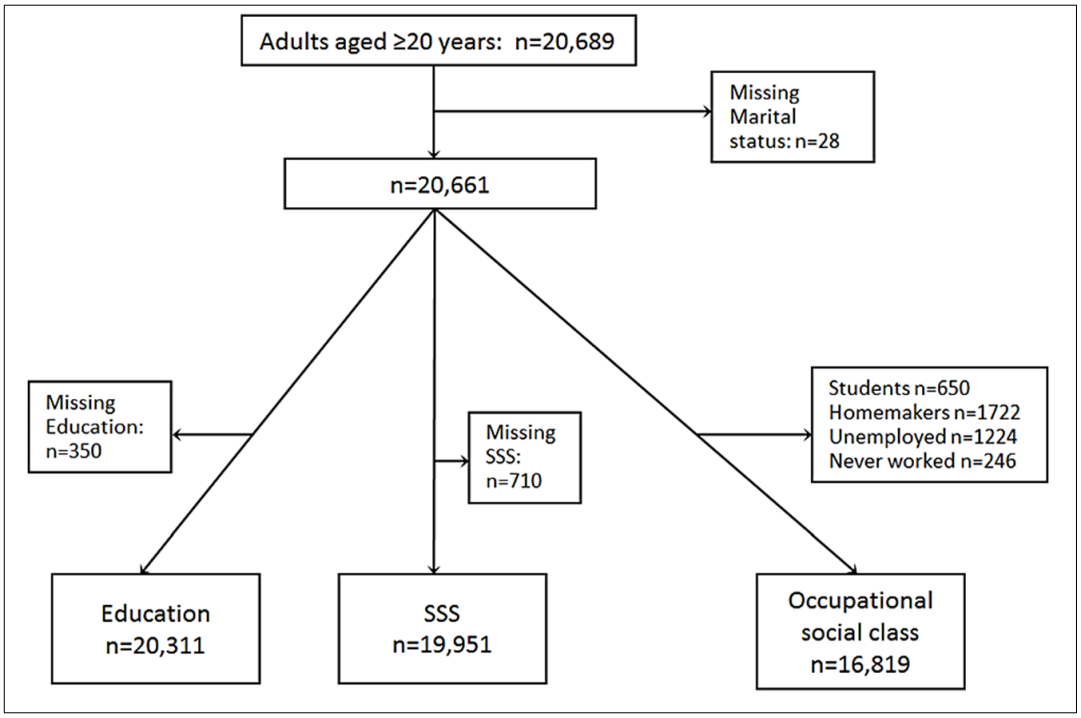


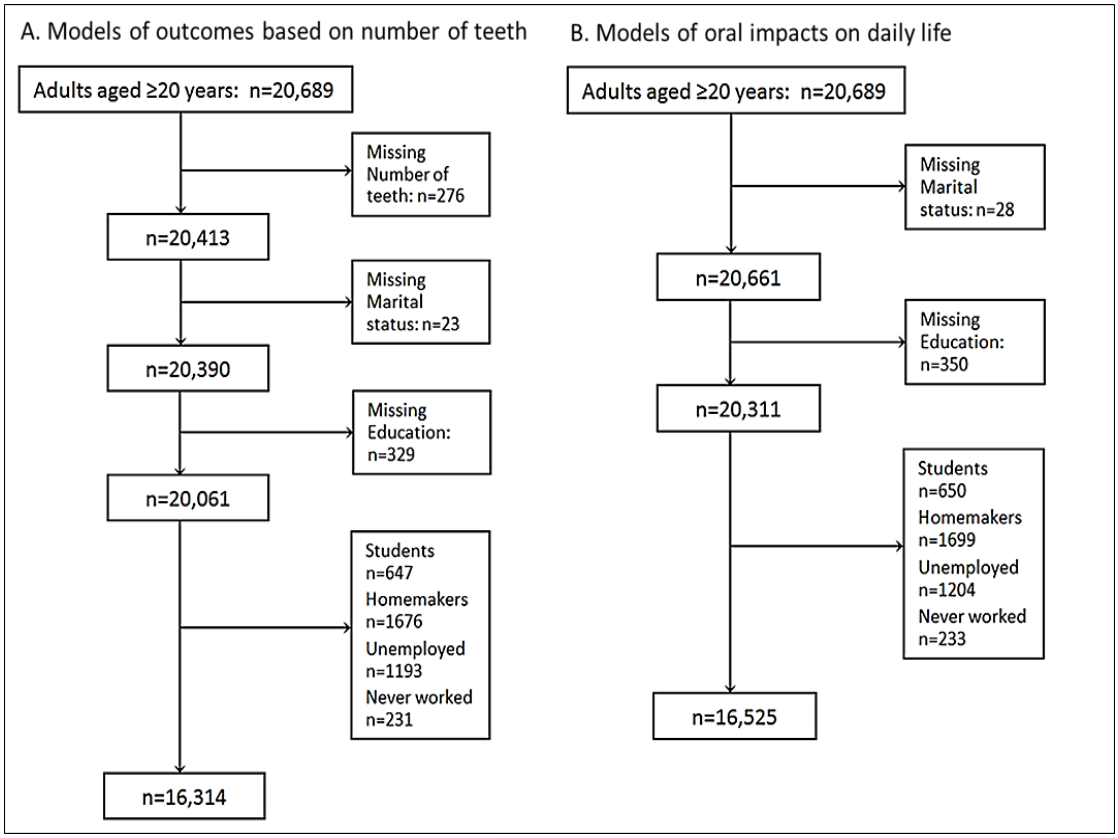

Figure 4.2 - Sample sizes for analyses in Chapter 6



*Samples for analyses in Chapter 7*

Chapter 7 contains results of the multilevel analysis. For this chapter, models were gradually fitted with a final fully-adjusted model which included all individual and country-level variables. As in this modelling strategy the comparison of the estimates (particularly the country-level variance) across models for each oral health outcome was very important, only adults with complete data on the study variables were included in the models (complete-case analyses). Exclusion criteria were applied consistently with those previously described for Chapters 5 and 6. The final analytical sample was 16,314 for the two outcomes based on number of teeth and 16,525 for oral impacts on daily life (Figure 4.3).

Figure 4.3 - Sample sizes for analyses in Chapter 7



**Analyses based on the ADHS 2009 and NHANES 2005-08 surveys**

*(Analyses in Chapter 8)*

For the comparison on educational inequalities in oral health between England and the US, participants aged 25 years and older were selected from the ADHS 2009 and NHANES 2005-08 surveys. Subjects aged less than 25 years were not considered in analyses since the data showed that among them, there was a very large proportion in lower levels of education. This again, is a reflection of the larger proportion of people in their early twenties who might be still studying and then, have not attained their highest level of education. Moreover, as the average age to graduate from university in the US is higher than in England (391, 392), this threshold of age help to make more precise comparisons based on educational attainment. In the two surveys, all study variables showed less than 1% of missing data (Table 4.7). Considering this very small percentage and the reasons presented earlier about dealing with missing data of less than 5% in large samples, imputation was not carried out in the study.

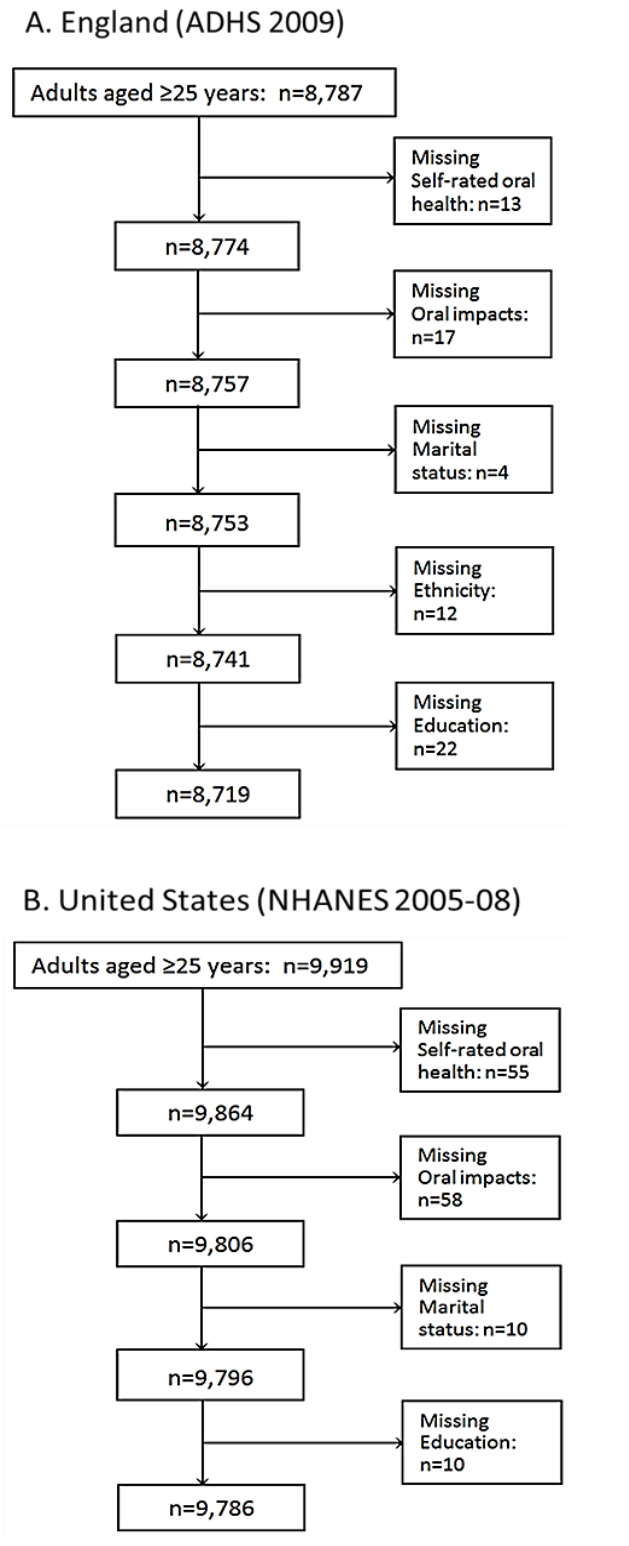
Complete-case analyses were carried out, so adults with complete information on the outcome and covariates were included in the models. This led to analytical samples of 8,719 adults for England and 9,786 adults for the US (Figure 4.4). For analysis of the outcome of number of missing teeth, in the US only information for dentate adults who completed the clinical examination was considered to make data comparable with England.

Table 4.7 - Missing data for study variables, ADHS 2009 and NHANES 2005-08

| Variables | Number (%) | |
|---|---|---|
| | England ADHS 2009 (n=8,787) | United States NHANES 2005-08 (n=9,919) |
| **Demographics and SEP** | | |
| Age | 0 (0) | 0 (0) |
| Gender | 0 (0) | 0 (0) |
| Marital status | 5 (0.06) | 11 (0.11) |
| Ethnicity (White vs. Non-White) | 18 (0.21) | 0 (0) |
| Educational level | 27 (0.31) | 16 (0.16) |
| **Oral health measures** | | |
| Self-rated oral health | 13 (0.15) | 55 (0.55) |
| Reporting ≥1 oral impact | 18 (0.21) | 60 (0.61) |
| | England (n=5,072)* | US (n=7,767)* |
| Number of missing teeth (among dentate participants) | 0 (0) | 0 (0) |

* Dentate participants who completed clinical exam

Figure 4.4 - Sample sizes for analyses in Chapter 8




**Note:** All statistical analyses in this project were carried out using Stata v.12, and multilevel models were fitted in MLwiN 2.27 from within Stata v.12.

# Chapter 5 - Socioeconomic inequalities in no functional dentition and edentulousness across welfare state regimes

## 5.1 Introduction

In this chapter, oral health and oral health inequalities across welfare state regimes are examined with no functional dentition and edentulousness as the outcomes of interest. Analyses in this chapter address objectives 1 and 3 of this thesis. Using the Eurobarometer survey as data source, the analytical strategy followed the three main steps used in this thesis for examining oral health inequalities (see Chapter 4, section 4.3). As a first step, population oral health estimates were compared across welfare regimes using age-standardized prevalence rates. The direct method of standardization was used with the age distribution of whole sample of European countries as the standard. Second, the relationship between SEP indicators and oral health outcomes was explored by comparing age-standardised prevalence rates between categories of SEP and by fitting robust Poisson models to estimate PRs. Third, relative and absolute inequalities were assessed with the RII and the SII. As issues of convergence appeared with log-binomial models, RII and SII were estimated using robust Poisson and linear regression models respectively (see Chapter 4, section 4.3.3). All regression models were adjusted for demographic characteristics of age, gender and marital status. In addition, all estimates were weighted to obtain robust standard errors and population-based estimates.

As described in Chapter 4, the main analytical sample used in analyses for this chapter consisted of adults aged 45 years and over with complete data on number of teeth and covariates of age, gender, and marital status (n=12,272). Before other analysis-specific exclusions were applied for each SEP indicator, this main analytical sample was used for descriptive statistics and estimation of age-standardized prevalence rates by welfare state regime. Then, specific analyses were conducted according to each measure of SEP. These analyses were the estimation of

prevalence rates across categories of SEP and the regression models to derive PRs, RII and SII. For these analyses, excluded participants were those with missing data on the particular SEP variable or, for analyses by occupation, those classified in occupational categories of students, unemployed, homemakers or subjects who never did any paid job. Reasons to exclude those subjects were previously discussed (sections 4.2.1.2 and 4.4), and are related to the fact that it is not conceptually appropriate to establish a hierarchical relationship between those categories and the other three categories from the NS-SEC. The samples for analyses by SEP were 12,054 (education), 11,796 (SSS), and 10,632 (occupational social class).

## 5.2 Descriptive statistics

Table 5.1 shows descriptive statistics of study variables used in this chapter. The information is presented as weighted percentages for each welfare regime. Demographic characteristics showed fairly similar age profiles across regimes, although the Eastern regime had a slightly younger population. Regarding gender composition, the proportion of women was above 50% in all welfare regimes with a larger female/male gap in the Eastern regime and lower in the Anglo-Saxon. The distribution by categories of marital status showed that the majority of this population were married or cohabiting and a small proportion were single. Compared with other regimes, the Anglo-Saxon presented a higher percentage of single people (more than double compared with the Eastern) and lower percentage of adults married or cohabiting.

The distribution of people in socioeconomic categories revealed certain differences by welfare state regimes. For example, while in the Scandinavian regime more than 60% of participants were in the highest level of education, in other regimes less than 25% of adults were in that educational level. There were also differences by occupational social class. Whereas around 16% of subjects in the Southern and Eastern regimes were in managerial or professional occupations, this percentage was almost as twice as high in the Anglo-Saxon, Bismarckian and Scandinavian. Finally, the subjective measure of SEP showed a high concentration of people in the

intermediate categories and lower percentages in the two extremes levels. By welfare regimes, adults in the Scandinavian were more likely to place themselves in the highest rank and those in the Eastern regime to choose the lowest rank.

Weighted percentages of oral health outcomes were included in Table 5.1 for completeness of the sample description only. Comparisons of these outcomes across welfare regimes will be discussed in the next section based on age-standardized prevalence rates.

Table 5.1 - Descriptive statistics by welfare regime, Eurobarometer 2009 (Adults aged ≥45 years)

| Variables | Weighted percentage | | | | |
|---|---|---|---|---|---|
| | Scandinavian (n= 2,025) | Anglo-Saxon (n= 1,296) | Bismarckian (n= 3,410) | Southern (n= 2,058) | Eastern (n= 3,483) |
| Age (years) | | | | | |
| 45 – 54 | 31.84 | 32.26 | 33.75 | 30.81 | 36.23 |
| 55 – 64 | 30.27 | 28.55 | 26.36 | 27.17 | 29.90 |
| ≥ 65 | 37.89 | 39.19 | 39.90 | 42.01 | 33.88 |
| Gender | | | | | |
| Male | 47.14 | 48.58 | 46.64 | 46.93 | 44.40 |
| Female | 52.86 | 51.42 | 53.36 | 53.07 | 55.60 |
| Marital status | | | | | |
| Married/cohabiting | 63.31 | 57.90 | 69.54 | 71.26 | 64.29 |
| Divorced/ widowed | 24.66 | 27.21 | 21.97 | 20.66 | 28.38 |
| Single | 12.03 | 14.90 | 8.48 | 8.08 | 7.33 |
| Education (Age when completed full-time education) | | | | | |
| 20 years and older | 60.95 | 17.34 | 23.56 | 12.72 | 18.41 |
| 16 - 19 years | 23.60 | 44.87 | 44.36 | 29.45 | 59.11 |
| Up to 15 years | 15.45 | 37.79 | 32.07 | 57.83 | 22.48 |
| Occupational class | | | | | |
| Managers and professionals | 34.01 | 28.48 | 30.31 | 16.24 | 15.94 |
| Intermediate | 24.51 | 25.81 | 23.01 | 29.44 | 23.56 |
| Manual workers | 41.48 | 45.71 | 46.68 | 54.33 | 60.49 |
| Subjective social status | | | | | |
| Highest rank | 21.52 | 12.98 | 8.50 | 6.17 | 7.01 |
| Second highest rank | 51.22 | 48.46 | 38.67 | 47.04 | 28.00 |
| Second lowest rank | 24.02 | 35.09 | 44.30 | 40.95 | 49.44 |
| Lowest rank | 3.24 | 3.47 | 8.53 | 5.84 | 15.55 |
| No functional dentition | 25.08 | 40.00 | 42.60 | 40.55 | 65.75 |
| Edentulousness | 7.06 | 13.84 | 11.79 | 11.14 | 20.73 |

## 5.3 Prevalence rates of oral health measures

This section presents the prevalence rates of the two oral health measures by country and welfare regime. Estimates by welfare regime were derived for the full sample in each regime and also stratified by gender. Age standardized prevalence rates of no functional dentition and edentulousness in the 21 countries considered in this study are presented in Table 5.2. These results showed that the smallest prevalence rates of the two outcomes were found in Sweden with 14.4% for no functional dentition and 2.9% for edentulousness. In contrast, the highest prevalence rates were observed in Hungary for no functional dentition (72.7%) and in Poland for edentulousness (26.7%). These results also indicated that there were differences in the prevalence of oral health measures within clusters of countries by welfare regimes. As examples, the prevalence rates of edentulousness in the Scandinavian cluster varied from 2.9% in Sweden to 12% in Finland, and within the Bismarckian cluster, from 10% in France to 20.6% in Belgium (Table 5.2).

Estimates of prevalence rates by welfare state regime showed that edentulousness and no functional dentition were significantly less prevalent in the Scandinavian regime and significantly more prevalent in the Eastern, in comparison with the other regimes (Figures 5.1 and 5.2). The gap between the Eastern and the Scandinavian regimes in the prevalence of no functional dentition exceeded 40%, with an estimate of 64.1% in the Eastern and 20.9% in the Scandinavian. The prevalence rates of edentulousness were 23% and 7.1% respectively. In the three additional regimes, the prevalence of the two oral health measures were between those in the Eastern and Scandinavian, with the Anglo-Saxon showing a slightly lower prevalence of no functional dentition and a marginally higher prevalence of edentulousness, compared with the Southern and Bismarckian regimes. Values obtained for prevalence rates by welfare regimes are presented in Table 5.3.

When estimates were stratified by gender, some significant differences between women and men appeared in the Anglo-Saxon and Eastern regimes. Specifically, the prevalence of no functional dentition in the Anglo-Saxon regime was significantly

lower for women (25%, 95%CI: 20.6-29.4) than for men (39.6%, 95%CI: 33.9-45.3) (Figure 5.3 and Table 5.4). Conversely, the prevalence of edentulousness in the Eastern welfare regime tended to be higher for women (25.2%, 95%CI: 22.7-27.7) compared with men (20.3%, 95%CI: 17.1-23.4) (Figure 5.4 and Table 5.5). Tables 5.4 and 5.5 present the exact estimates obtained for the prevalence rates by welfare regimes and gender.

Table 5.2 - Age standardized prevalence rates of no functional dentition and edentulousness in countries grouped by welfare regime (Adults aged ≥45 years)

| Country | n | No functional dentition (%) | Edentulousness (%) |
|---|---|---|---|
| **Scandinavian** | | | |
| Sweden | 671 | 14.40 | 2.94 |
| Finland | 685 | 31.49 | 12.03 |
| Denmark | 669 | 23.26 | 9.30 |
| **Anglo-Saxon** | | | |
| UK | 811 | 31.55 | 13.17 |
| Ireland | 485 | 41.44 | 20.42 |
| **Bismarckian** | | | |
| Austria | 488 | 49.16 | 16.05 |
| Belgium | 553 | 43.03 | 20.63 |
| France | 582 | 34.71 | 10.02 |
| Germany | 927 | 38.50 | 10.65 |
| Luxemburg | 286 | 37.16 | 14.23 |
| Netherlands | 574 | 32.15 | 17.99 |
| **Southern** | | | |
| Greece | 494 | 41.67 | 14.20 |
| Italy | 464 | 36.33 | 10.49 |
| Portugal | 548 | 47.82 | 18.10 |
| Spain | 552 | 34.37 | 11.75 |
| **Eastern** | | | |
| Czech Republic | 608 | 47.54 | 18.01 |
| Estonia | 549 | 58.45 | 13.69 |
| Hungary | 635 | 72.69 | 21.13 |
| Poland | 570 | 68.29 | 26.72 |
| Slovakia | 512 | 57.81 | 21.55 |
| Slovenia | 609 | 61.19 | 17.45 |

Note: the prevalence rates of oral health outcomes were weighted and age-standardized.

Figure 5.1 - Age-standardized prevalence of no functional dentition by welfare regime (Dentate participants aged ≥45 years)

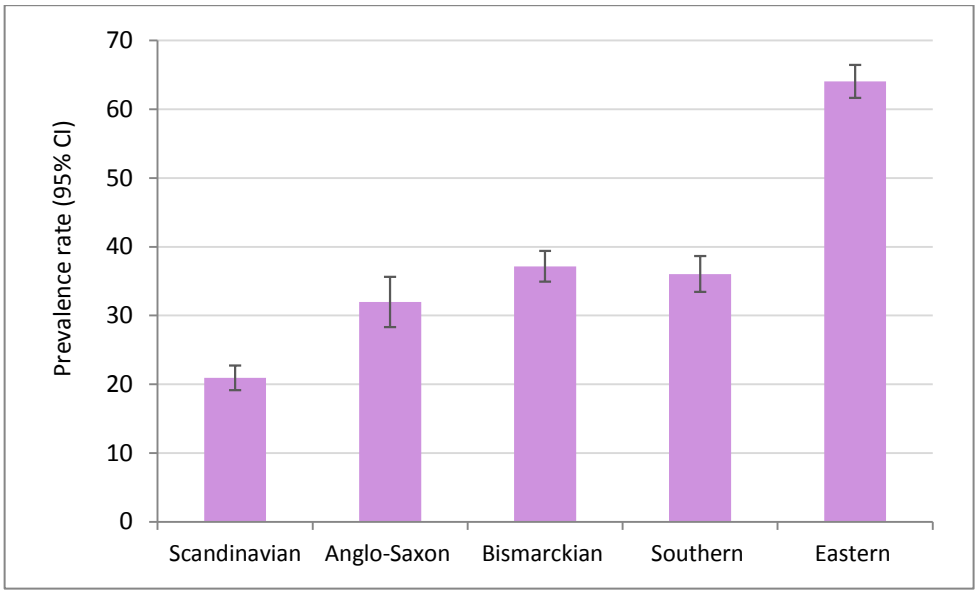



Figure 5.2 - Age-standardized prevalence of edentulousness by welfare regime (Participants aged ≥45 years)

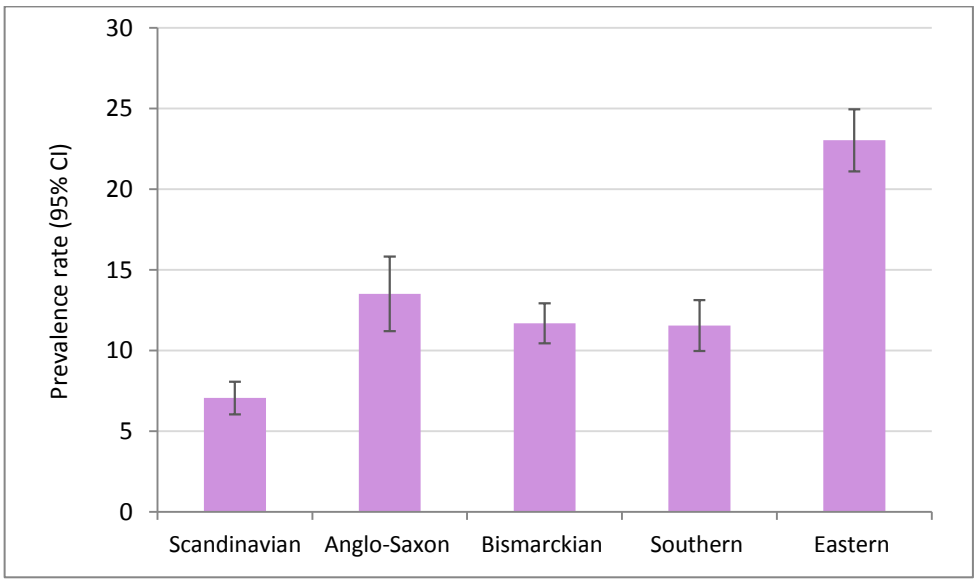



Table 5.3 - Age-standardized prevalence rates of no functional dentition and edentulousness by welfare regime

| | No functional dentition | | Edentulousness | |
|---|---|---|---|---|
| | Prevalence rate | 95% CI | Prevalence rate | 95% CI |
| Scandinavian | 20.94 | 19.15, 22.73 | 7.06 | 6.05, 8.07 |
| Anglo-Saxon | 31.99 | 28.34, 35.64 | 13.52 | 11.20, 15.83 |
| Bismarckian | 37.15 | 34.92, 39.98 | 11.69 | 10.45, 12.94 |
| Southern | 36.05 | 33.44, 38.65 | 11.55 | 9.97, 13.13 |
| Eastern | 64.06 | 61.67, 66.45 | 23.03 | 21.10, 24.95 |

Figure 5.3 - Age-standardized prevalence of no functional dentition by welfare regime and gender (Dentate participants aged ≥45 years)

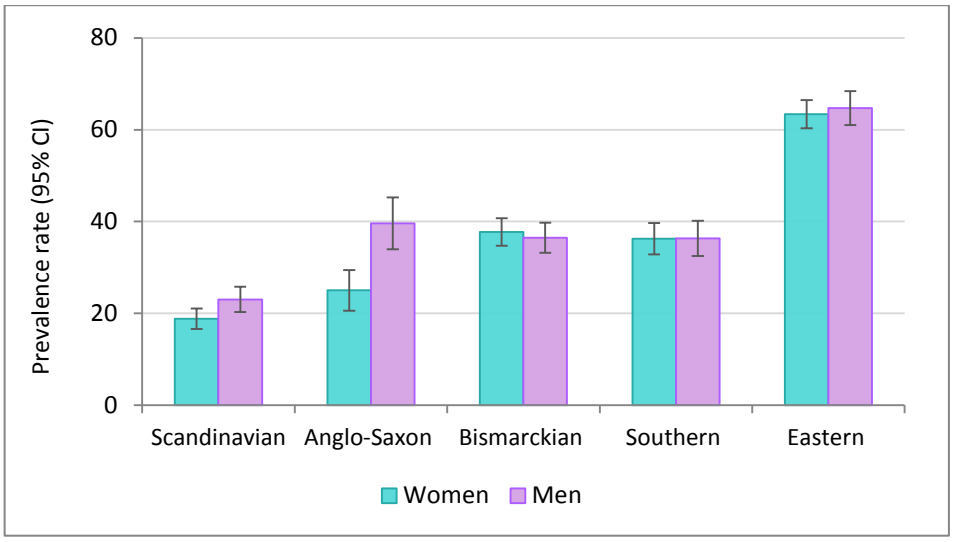



Figure 5.4 - Age-standardized prevalence of edentulousness by welfare regime and gender (Participants aged ≥45 years)

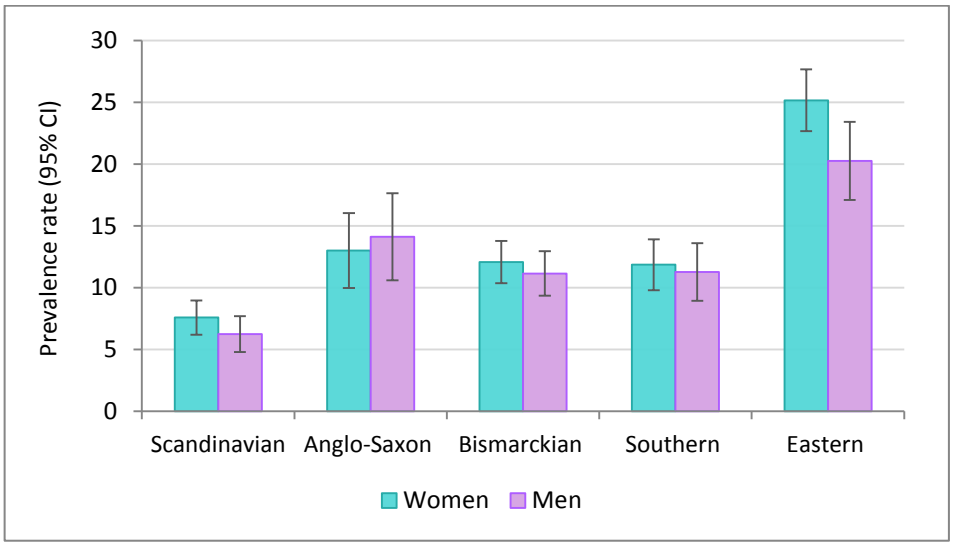



Table 5.4 - Age-standardized prevalence of no functional dentition by welfare regime and gender (Dentate participants aged ≥45 years)

| | Women | | Men | |
|---|---|---|---|---|
| | Prevalence rate | 95% CI | Prevalence rate | 95% CI |
| Scandinavian | 18.81 | 16.57, 21.05 | 23.03 | 20.26, 25.80 |
| Anglo-Saxon | 25.01 | 20.60, 29.41 | 39.60 | 33.94, 45.27 |
| Bismarckian | 37.69 | 34.70, 40.69 | 36.47 | 33.17, 39.76 |
| Southern | 36.26 | 32.84, 39.69 | 36.32 | 32.46, 40.18 |
| Eastern | 63.41 | 60.34, 66.49 | 64.72 | 61.04, 68.40 |

Table 5.5 - Age-standardized prevalence of edentulousness by welfare regime and gender (Participants aged ≥45 years)

| | Women | | Men | |
|---|---|---|---|---|
| | Prevalence rate | 95% CI | Prevalence rate | 95% CI |
| Scandinavian | 7.59 | 6.20, 8.97 | 6.25 | 4.80, 7.69 |
| Anglo-Saxon | 13.00 | 9.97, 16.03 | 14.11 | 10.59, 17.64 |
| Bismarckian | 12.08 | 10.36, 13.79 | 11.15 | 9.35, 12.95 |
| Southern | 11.86 | 9.80, 13.92 | 11.26 | 8.93, 13.59 |
| Eastern | 25.16 | 22.66, 27.67 | 20.25 | 17.09, 23.41 |

## 5.4 Relationship between SEP and oral health

The analyses reported in this section examined the relationship between oral health and SEP using two measures. The first one is age standardised prevalence rate by socioeconomic group for each indicator of SEP. The second is the prevalence ratio derived from robust Poisson regression models. In those models, oral health was the outcome, the SEP indicator was the categorical explanatory variable (using the highest level of SEP as the reference category), and age, gender and marital status were introduced as covariates.

**Prevalence rates of oral health measures by SEP**

Age standardised prevalence rates of no functional dentition by socioeconomic groups revealed a general pattern of social gradients in the five welfare regimes analysed. Explicitly, the proportion of adults with less than 20 teeth was higher at each consecutive lower level of education, occupation and subjective social status (Figure 5.5). The only slight exception to this pattern was observed in the Bismarckian regime, where the prevalence of no functional dentition was almost identical in the intermediate and manual categories of occupational social class (Figure 5.5 and Table 5.6). The observed educational and occupational gradients in no functional dentition were steeper in the Eastern regime, while the gradients by subjective social status appeared steeper in the Southern and Anglo-Saxon regimes.

These results of no functional dentition also showed that adults in the lowest socioeconomic levels tended to fare better (lower prevalence) in the Scandinavian regime compared to their counterparts in other European welfare regimes. That was particularly clear for occupational social class, with Scandinavian manual workers showing a significantly lower prevalence rate than manual workers in any other regime. In contrast, Eastern adults in the lowest educational and occupational groups exhibited significantly higher prevalence rates than those in equivalent socioeconomic groups in the other four regimes. These comparisons across welfare regimes, based on the absolute health of those in low socioeconomic levels, are also informative in analyses of health inequalities, as has been suggested by Bambra (393). She stated that welfare regimes should be assessed not only on their capacity to reduce relative inequalities, but also on their ability to improve and maintain the health status of those at the bottom of the social hierarchy (393).

Turning to findings for edentulousness, reported prevalence rates gradually increased for adults in lower educational and occupational categories, also following a pattern of social gradients. This pattern in the socioeconomic distribution of total loss of teeth was found across different welfare regimes, with only one exception. The different shape appeared in the Southern regime where the proportion of edentulous adults was higher for those in the highest level of education than those in the intermediate level (Figure 5.6). It is worth mentioning that the confidence interval of the estimate for the highest level of education was very wide since only 9 adults in this group of the Southern regime were edentulous. The observed gradients in edentulousness by education and occupational social class looked steeper in the Anglo-Saxon regime. A social gradient in edentulousness by levels of SSS was also identified, but only in the Scandinavian regime. In the other welfare regimes, the prevalence of edentulousness by SSS showed either a U-shaped or a J-shaped pattern. Similar to the above mentioned findings for no functional dentition, prevalence rates of edentulousness among adults in the lowest socioeconomic groups were relatively smaller in the Scandinavian regime than in the alternative welfare regimes. In the same socioeconomic groups, larger prevalence rates were consistently observed in the Eastern regime.

Figure 5.5 - Age-standardized prevalence of no functional dentition by welfare regime and each SEP measure (Dentate participants aged ≥45 years)

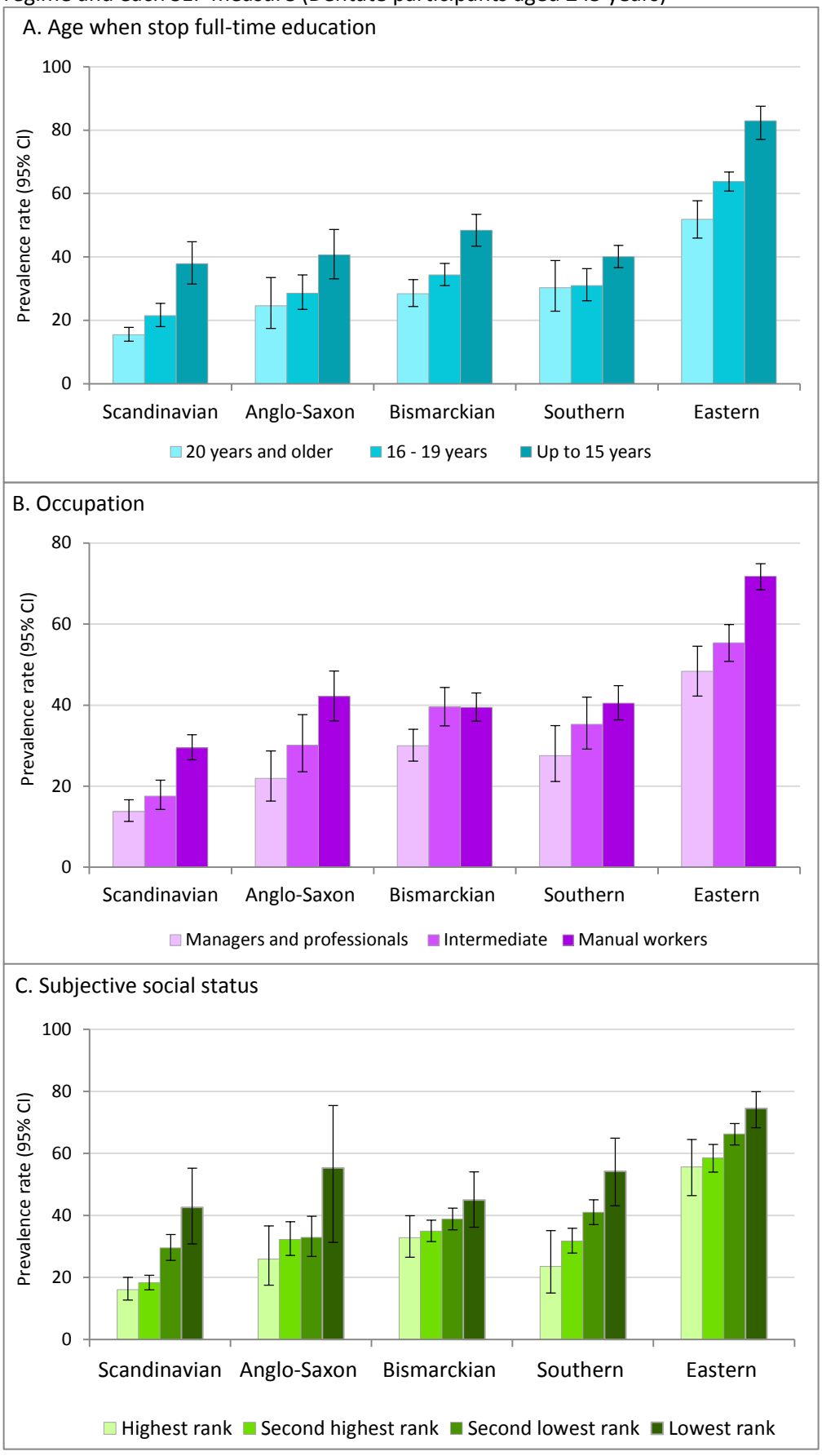


Table 5.6 - Age-standardized prevalence of no functional dentition by welfare state regime and SEP (Dentate participants aged ≥45 years)

| Socioeconomic position | Welfare state regime | | | | |
|---|---|---|---|---|---|
| | Scandinavian | Anglo-Saxon | Bismarckian | Southern | Eastern |
| | Prevalence rate (95% CI) | | | | |
| Education (Age when stop full-time education) | | | | | |
| 20 years and older | 15.45 (13.38, 17.79) | 24.57 (17.40, 33.48) | 28.42 (24.37, 32.86) | 30.27 (22.85, 38.89) | 51.88 (45.95, 57.75) |
| 16 - 19 years | 21.46 (18.04, 25.34) | 28.58 (23.44, 34.35) | 34.36 (30.94, 37.94) | 30.98 (26.14, 36.27) | 63.85 (60.75, 66.83) |
| Up to 15 years | 37.89 (31.44, 44.80) | 40.64 (33.06, 48.69) | 48.42 (43.40, 53.48) | 40.06 (36.61, 43.62) | 82.94 (77.06, 87.56) |
| Occupational class | | | | | |
| Managers and professionals | 13.76 (11.30, 16.67) | 21.91 (16.35, 28.72) | 29.96 (26.16, 34.07) | 27.52 (21.17, 34.93) | 48.36 (42.24, 54.53) |
| Intermediate | 17.56 (14.24, 21.47) | 30.11 (23.52, 37.64) | 39.51 (34.86, 44.36) | 35.29 (29.12, 42.00) | 55.40 (50.82, 59.89) |
| Manual workers | 29.48 (26.48, 32.68) | 42.16 (36.13, 48.44) | 39.47 (36.02, 43.03) | 40.50 (36.36, 44.78) | 71.80 (68.48, 74.90) |
| Subjective social status | | | | | |
| Highest rank | 16.03 (12.71, 20.02) | 25.94 (17.50, 36.63) | 32.84 (26.50, 39.88) | 23.58 (14.95, 35.14) | 55.62 (46.40, 64.46) |
| Second highest rank | 18.23 (15.96, 20.73) | 32.28 (27.06, 37.99) | 34.94 (31.57, 38.48) | 31.72 (27.87, 35.84) | 58.52 (53.98, 62.92) |
| Second lowest rank | 29.51 (25.49, 33.88) | 32.93 (26.78, 39.72) | 38.79 (35.37, 42.32) | 41.00 (37.04, 45.08) | 66.27 (62.75, 69.62) |
| Lowest rank | 42.56 (30.81, 55.21) | 55.33 (31.31, 75.43) | 44.99 (36.23, 54.08) | 54.20 (43.10, 64.90) | 74.52 (68.31, 79.87) |

Figure 5.6 - Age-standardized prevalence of edentulousness by welfare regime and each SEP measure (Participants aged ≥45 years)

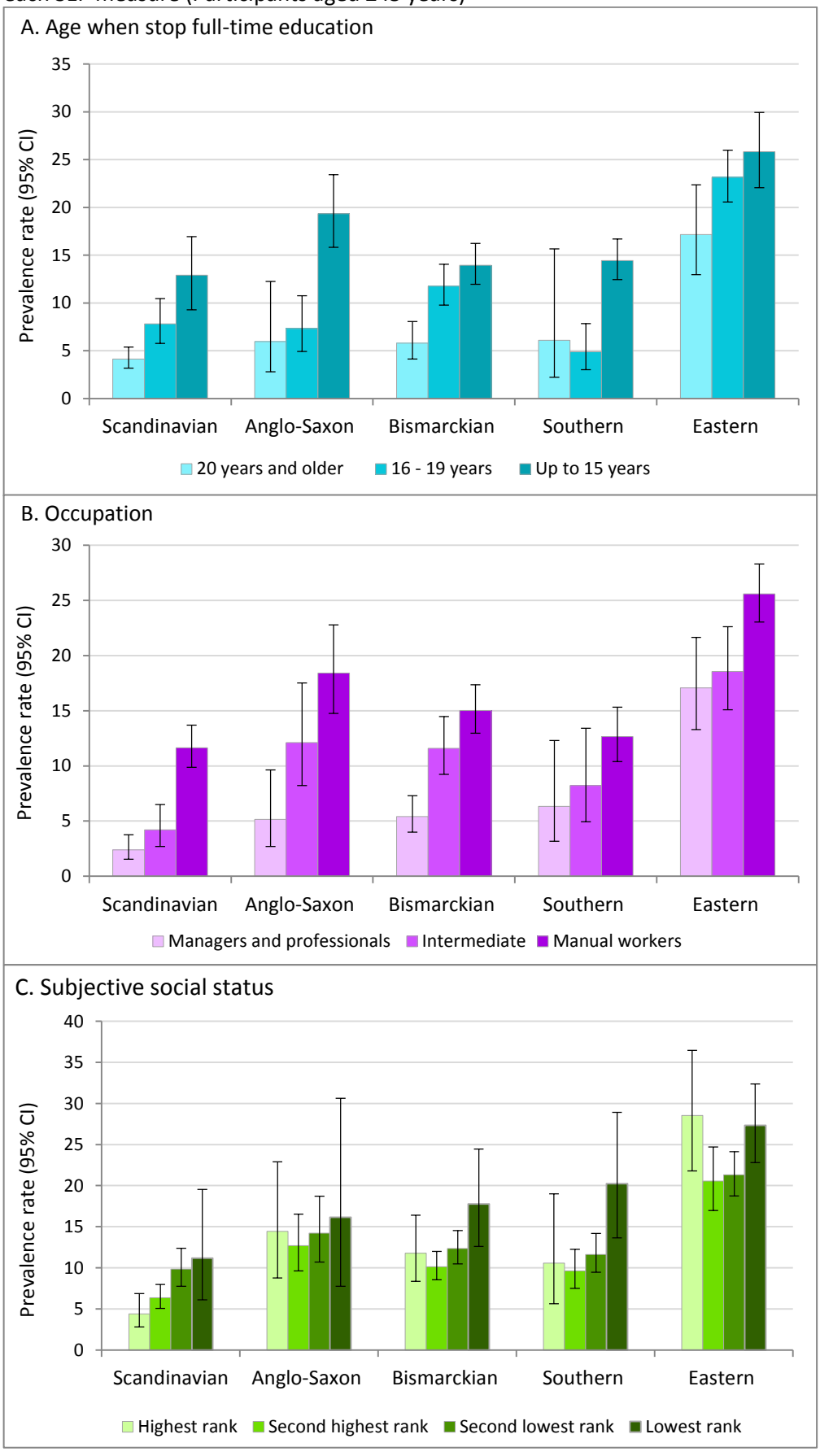


Table 5.7 - Age-standardized prevalence of edentulousness by welfare state regime and SEP (Participants aged ≥45 years)

| Socioeconomic position | Welfare state regime | | | | |
|---|---|---|---|---|---|
| | Scandinavian | Anglo-Saxon | Bismarckian | Southern | Eastern |
| | Prevalence rate (95% CI) | | | | |
| Education (Age when stop full-time education) | | | | | |
| 20 years and older | 4.15 (3.19, 5.39) | 5.96 (2.79, 12.25) | 5.79 (4.13, 8.06) | 6.11 (2.23, 15.67) | 17.15 (12.96, 22.36) |
| 16 - 19 years | 7.81 (5.78, 10.47) | 7.32 (4.92, 10.75) | 11.76 (9.78, 14.07) | 4.89 (3.02, 7.83) | 23.16 (20.56, 25.98) |
| Up to 15 years | 12.91 (9.72, 16.95) | 19.35 (15.84, 23.42) | 13.96 (11.95, 16.24) | 14.44 (12.44, 16.71) | 25.82 (22.08, 29.94) |
| Occupational class | | | | | |
| Managers and professionals | 2.40 (1.54, 3.75) | 5.15 (2.69, 9.64) | 5.42 (4.00, 7.31) | 6.33 (3.16, 12.29) | 17.06 (13.28, 21.64) |
| Intermediate | 4.22 (2.71, 6.50) | 12.11 (8.22, 17.51) | 11.60 (9.24, 14.47) | 8.23 (4.94, 13.40) | 18.55 (15.09, 22.60) |
| Manual workers | 11.64 (9.86, 13.69) | 18.43 (14.75, 22.78) | 15.01 (12.95, 17.34) | 12.65 (10.39, 15.33) | 25.58 (23.03, 28.30) |
| Subjective social status | | | | | |
| Highest rank | 4.41 (2.81, 6.87) | 14.45 (8.77, 22.89) | 11.79 (8.35, 16.39) | 10.57 (5.62, 19.00) | 28.54 (21.78, 36.44) |
| Second highest rank | 6.36 (5.07, 7.96) | 12.69 (9.63, 16.54) | 10.14 (8.55, 11.99) | 9.62 (7.51, 12.24) | 20.56 (16.96, 24.71) |
| Second lowest rank | 9.83 (7.76, 12.38) | 14.23 (10.69, 18.70) | 12.35 (10.47, 14.52) | 11.62 (9.46, 14.19) | 21.31 (18.73, 24.14) |
| Lowest rank | 11.17 (6.11, 19.53) | 16.16 (7.76, 30.63) | 17.77 (12.61, 24.44) | 20.23 (13.65, 28.90) | 27.33 (22.80, 32.38) |

**Association between oral health and SEP using prevalence ratios**

Prevalence ratios of no functional dentition adjusted for age, gender and marital status are provided by all SEP indicators in Table 5.8. There was evidence of associations between no functional dentition and all measures of SEP, although some estimates were not statistically significant. The associations were on the expected direction whereby adults in lower socioeconomic positions had higher PRs than those in higher categories of education, occupation and SSS. There were two minor exceptions in the intermediate educational group in the Southern regime and the second highest SSS group in the Eastern, where PRs took a value of 0.99. PRs by level of education were higher for adults who finished full-time education at 15 years or below compared to those who finished at 20 years or above in all regimes. However, the estimate was not significant in the Southern regime. PRs by occupation social class showed that subjects in manual occupations had higher PRs of no functional dentition than those in professional/managerial positions across welfare regimes. Subjects in intermediate occupations had higher PRs than professionals/managers, but associations were significant only in the Anglo-Saxon and Bismarckian regimes, with PRs of 1.50 (95%CI: 1.01-2.21) and 1.34 (95%CI: 1.11-1.62) respectively. Associations with SSS showed a general picture of increasing PRs at consecutive lower SSS levels. However, estimates were not consistently significant and the test for trend was non-significant in the Anglo-Saxon regime. All the other tests for trend were significant ($p<0.05$). The strength of the associations between the three SEP measures and no functional dentition appeared stronger in the Scandinavian regime.

PRs of edentulousness by SEP in different European welfare regimes are shown in Table 5.9. Although there were some non-significant PRs, these results revealed a general picture of strong and graded associations between edentulousness and both education and occupation. Participants in lower levels of education had consistently higher PRs than their counterparts in the highest level. The only exception, as observed for no functional dentition, was in the Southern regime where the intermediate educational group did not show a higher PR than the reference category. In terms of occupation, associations followed the expected

direction and were stronger in magnitude than those for no functional dentition. However, estimates for intermediate occupations were only significant in the Anglo-Saxon and Bismarckian regimes. PRs of edentulousness by SSS were mostly non-significant and sometimes in the unexpected direction (Table 5.9). The only two significant estimates were for the lowest (PR: 2.31, 95%CI: 1.09-4.92) and second lowest ranks (PR: 2.13, 95%CI: 1.28-3.55) in the Scandinavian regime. Tests for trend were significant ($p<0.05$) in all regimes by education and occupation, and in the Scandinavian, Bismarckian and Southern regimes by SSS.

*Sensitivity analysis*

PRs were compared to ORs to explore differences in the size of the associations between oral health and SEP given the high prevalence levels (>10%) of the oral health outcomes. Logistic regression models were used to derive the ORs. Results showed that ORs overestimated the magnitude of the associations compared to PRs (Tables A2.1 and A2.2 in Appendix 2). The difference between PRs and ORs was larger for no functional dentition, the oral health outcome with higher prevalence rates. In general, the associations between SEP indicators and oral health outcomes showed the same direction and significance level whether using PRs or ORs.

Table 5.8 - Regression analysis of the association between no functional dentition and SEP measures by welfare state regime

| Socioeconomic position | Welfare state regime | | | | |
|---|---|---|---|---|---|
| | Scandinavian | Anglo-Saxon | Bismarckian | Southern | Eastern |
| | Prevalence ratio (95% CI) | | | | |
| Education<br>(Age when stop full-time education) | | | | | |
| 20 years and older (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 16 - 19 years | 1.38 (1.10, 1.75) | 1.18 (0.80, 1.76) | 1.28 (1.05, 1.55) | 0.99 (0.70, 1.42) | 1.28 (1.08, 1.51) |
| Up to 15 years | 2.25 (1.82, 2.77) | 1.62 (1.11, 2.35) | 1.73 (1.43,2.10) | 1.35 (0.98, 1.86) | 1.66 (1.41, 1.96) |
| *p*-value for trend | <0.001 | 0.004 | <0.001 | 0.006 | <0.001 |
| Occupational class | | | | | |
| Managers and professionals (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Intermediate | 1.30 (0.97, 1.73) | 1.50 (1.01, 2.21) | 1.34 (1.11, 1.62) | 1.46 (0.99, 2.15) | 1.15 (0.95, 1.40) |
| Manual workers | 2.23 (1.78, 2.79) | 1.99 (1.44, 2.76) | 1.35 (1.13, 1.60) | 1.79 (1.25, 2.56) | 1.60 (1.35, 1.90) |
| *p*-value for trend | <0.001 | <0.001 | 0.001 | 0.001 | <0.001 |
| Subjective social status | | | | | |
| Highest rank (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Second highest rank | 1.15 (0.88, 1.49) | 1.26 (0.84, 1.90) | 1.08 (0.85, 1.36) | 1.32 (0.80, 2.19) | 0.99 (0.77, 1.28) |
| Second lowest rank | 1.89 (1.44, 2.48) | 1.26 (0.83, 1.92) | 1.23 (0.98, 1.55) | 1.76 (1.07, 2.89) | 1.18 (0.92, 1.52) |
| Lowest rank | 2.85 (1.93, 4.22) | 2.11 (1.12, 3.99) | 1.38 (1.01, 1.87) | 2.27 (1.33, 3.88) | 1.31 (1.01, 1.69) |
| *p*-value for trend | <0.001 | 0.131 | 0.008 | <0.001 | <0.001 |

Table 5.9 - Regression analysis of the association between edentulousness and SEP measures by welfare state regime

| Socioeconomic position | Welfare state regime | | | | |
|---|---|---|---|---|---|
| | Scandinavian | Anglo-Saxon | Bismarckian | Southern | Eastern |
| | Prevalence ratio (95% CI) | | | | |
| Education<br>(Age when stop full-time education) | | | | | |
| 20 years and older (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 16 - 19 years | 1.90 (1.27, 2.85) | 1.36 (0.58, 3.20) | 2.05 (1.39, 3.03) | 0.83 (0.29, 2.36) | 1.45 (1.03, 2.05) |
| Up to 15 years | 2.80 (1.93, 4.06) | 3.20 (1.46, 6.98) | 2.44 (1.67, 3.57) | 3.00 (1.18, 7.64) | 1.53 (1.07, 2.19) |
| *p*-value for trend | <0.001 | <0.001 | <0.001 | <0.001 | 0.022 |
| Occupational class | | | | | |
| Managers and professionals (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Intermediate | 1.68 (0.90, 3.12) | 2.63 (1.22, 5.66) | 2.11 (1.43, 3.12) | 1.64 (0.63, 4.25) | 1.00 (0.72, 1.38) |
| Manual workers | 4.77 (2.97, 7.64) | 3.71 (1.92, 7.17) | 2.67 (1.88, 3.77) | 2.43 (1.04, 5.64) | 1.45 (1.11, 1.90) |
| *p*-value for trend | <0.001 | <0.001 | <0.001 | 0.017 | 0.001 |
| Subjective social status | | | | | |
| Highest rank (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Second highest rank | 1.42 (0.86, 2.34) | 0.87 (0.51, 1.48) | 0.92 (0.63, 1.35) | 1.04 (0.48, 2.28) | 0.71 (0.49, 1.03) |
| Second lowest rank | 2.13 (1.28, 3.55) | 0.93 (0.54, 1.60) | 1.08 (0.73, 1.59) | 1.28 (0.59, 2.79) | 0.75 (0.53, 1.05) |
| Lowest rank | 2.31 (1.09, 4.92) | 1.19 (0.42, 3.36) | 1.53 (0.94, 2.49) | 2.22 (0.94, 5.25) | 0.90 (0.63, 1.29) |
| *p*-value for trend | <0.001 | 0.886 | 0.032 | 0.018 | 0.604 |

## 5.5 Relative and absolute inequalities using the RII and SII

Relative and absolute inequalities in oral health outcomes were assessed with the Relative and Slope Indices of Inequality. Robust Poisson regression models were fitted to estimate the RIIs and linear regression models to derive the SII. Estimations were adjusted for age (10-year intervals categorical variable), gender (binary variable) and marital status (3 levels categorical variable). RII conveys the ratio of no functional dentition or edentulousness of the lowest SEP level to the highest SEP level. Scores on the RII larger than one show inequalities and larger scores indicate larger socioeconomic inequalities in oral health. Meanwhile, SII expresses the absolute percentage difference in prevalence of the oral health outcome between those in the hypothetical best and worst socioeconomic circumstances. The SII was obtained by multiplying regression coefficients by 100. A positive SII indicates that prevalence increased with lower levels of SEP. Larger values of SII signify larger absolute inequalities (see Chapter 4, section 4.3.3).

Tables 5.10 and 5.11 present the RII and SII for the outcomes of no functional dentition and edentulousness respectively. These results showed that in all regimes there were significant educational and occupational inequalities in both relative (RII) and absolute (SII) terms. Inequalities by SSS did not present the same consistent pattern. In addition, estimates were not significant in the Anglo-Saxon regime for the two oral health outcomes and in the Eastern regime for edentulousness.

Findings for RII indicated that relative socioeconomic inequalities in no functional dentition tended to be higher in the Scandinavian welfare regime compared to other regimes. This is consistent with results of the prevalence ratios which showed that associations between the three SEP measures and no functional dentition were stronger in Scandinavian countries. Analysis using RII revealed, however, that differences across regimes in the magnitude of relative inequalities were only significant (at $p<0.05$) for education, but not for occupation or SSS, as can be seen

from the significance level of interaction terms between each SEP indicator and welfare regime clusters (Table 5.10). Therefore, it can be concluded that relative educational inequalities in no functional dentition were larger in the Scandinavian welfare regime.

With respect to absolute inequalities in no functional dentition, all SII estimates had positive values indicating larger prevalence of the outcome at lower levels of SEP. The magnitude of these inequalities varied significantly across welfare regimes for occupation and SSS. The largest absolute inequality by occupation was observed in the Eastern regime. In this regime the SII by occupation was 41.43 (95%CI: 30.68, 52.18) which represents the adjusted difference in no functional dentition between the two extremes of the occupational hierarchy. Unsurprisingly, that finding matches the observed pattern of age-standardized prevalence rates by SEP where occupational gradients in no functional dentition were steeper in the Eastern regime. The lowest absolute occupational inequalities were in the Bismarckian regime with a SII estimate of 13.83 (95%CI: 5.35, 22.31). Absolute inequalities in no functional dentition also differed across welfare regimes by SSS, with the Southern regime showing the largest SII, the Bismarckian the lowest significant, and the Anglo-Saxon an even lower non-significant SII (Table 5.10).

Table 5.10 - Relative and absolute inequalities in no functional dentition by welfare regime

| | Socioeconomic position measure | | |
|---|---|---|---|
| | Education | Occupational class | Subjective social status |
| **Relative inequalities** | RII (95% CI) | RII (95% CI) | RII (95% CI) |
| Scandinavian | 3.37 (2.38, 4.77)** | 3.87 (2.71, 5.53)** | 2.94 (2.06, 4.18)** |
| Anglo-Saxon | 1.98 (1.27, 3.11)** | 2.86 (1.79, 4.58)** | 1.36 (0.85, 2.19) |
| Bismarckian | 2.16 (1.68, 2.78)** | 1.51 (1.18, 1.95)** | 1.41 (1.10, 1.82)** |
| Southern | 1.81 (1.23, 2.64)** | 2.05 (1.35, 3.12)** | 2.11 (1.54, 2.90)** |
| Eastern | 1.90 (1.57, 2.31)** | 2.17 (1.75, 2.70)** | 1.46 (1.20, 1.77)** |
| *p*-value[a] | <0.001 | 0.955 | 0.295 |
| **Absolute inequalities** | SII (95% CI) | SII (95% CI) | SII (95% CI) |
| Scandinavian | 27.64 (19.58, 35.71)** | 25.97 (19.45, 32.50)** | 19.97 (13.29, 26.66)** |
| Anglo-Saxon | 23.06 (8.30, 37.83)** | 32.60 (18.67, 46.53)** | 8.48 (-5.53, 22.49) |
| Bismarckian | 27.39 (18.71, 36.07)** | 13.83 (5.35, 22.31)** | 11.27 (2.83, 19.71)** |
| Southern | 17.55 (6.81, 28.30)** | 20.57 (9.04, 32.11)** | 25.13 (14.69, 35.58)** |
| Eastern | 37.94 (27.06, 48.82)** | 41.43 (30.68, 52.18)** | 20.98 (10.25, 31.70)** |
| *p*-value[a] | 0.296 | 0.029 | <0.001 |

* p<0.05, **p<0.01
RII: Relative Index of Inequality, SII: Slope Index of Inequality
[a] *p*-value of the interaction between each SEP score and welfare regime

Findings for relative inequalities in edentulousness showed important variability in RII across the three SEP indicators and welfare regimes. Additionally, the very low prevalence of edentulousness in some socioeconomic categories within regimes, such as managerial and professional occupations in the Scandinavian regime, resulted in very wide confidence intervals for certain RII estimates. The magnitude of relative inequalities in edentulousness was significantly different across welfare regimes for education and occupation, but not for SSS. The largest relative inequalities by education and occupation were found in the Southern and Scandinavian regimes respectively. For the same SEP indicators, the Eastern regime had the lowest RII estimates (Table 5.11). It is worth mentioning that these relatively smaller RIIs in the Eastern regime might be, to some extent, the consequence of a numerical artefact. Since that regime exhibited high prevalence

rates even among those in the highest levels of SEP, the estimated relative inequalities tended to be lower due to the very high starting point of comparison.

Differences across regimes in the magnitude of absolute inequalities (SII) in edentulousness were significant only for SSS. For this SEP measure, the Southern welfare regime had the largest SII while the Anglo-Saxon and Eastern had non-significant SIIs. Results of absolute inequalities for edentulousness also showed that there were consistently positive and significant estimates by education and occupation (SII values above zero). These educational and occupational inequalities, although not significantly different across regimes, tended to be higher in the Anglo-Saxon regime with SII estimates of 24.88 (95%CI 15.57, 34.18) for education and 22.39 (95%CI 13.66, 31.12) for occupational social class (Table 5.11).

These analyses on inequalities in edentulousness and no functional dentition were tested for gender interaction. Significant gender interactions were found for relative and absolute educational inequalities in no functional dentition with consistent larger inequalities among women (Table 5.12). For both women and men, the magnitude of RIIs was significantly different across regimes with larger relative inequality levels in the Scandinavian regime (similar to findings from the unstratified analysis). Gender-stratified results of both RII and SII showed larger and significant estimates in women while in men the indices were comparatively smaller and not significant in the Anglo-Saxon and Southern regimes.

Results of the interactions also showed that absolute inequalities in edentulousness by SSS varied by gender. When these estimates were stratified by gender, the only significant SIIs were those in the Scandinavian regime for both women and men (Table 5.13). In this regime, the SII for women was larger than for men.

Table 5.11 - Relative and absolute inequalities in edentulousness by welfare regime

| | Socioeconomic position measure | | |
|---|---|---|---|
| | Education | Occupational class | Subjective social status |
| **Relative inequalities** | RII (95% CI) | RII (95% CI) | RII (95% CI) |
| Scandinavian | 5.29 (2.89, 9.69)** | 14.85 (7.10, 31.07)** | 2.80 (1.57, 4.98)** |
| Anglo-Saxon | 6.10 (2.72, 13.70)** | 5.60 (2.61, 12.00)** | 1.06 (0.54, 2.08) |
| Bismarckian | 2.66 (1.75, 4.04)** | 3.74 (2.37, 5.91)** | 1.60 (1.02, 2.51)* |
| Southern | 11.79 (4.22, 32.93)** | 3.14 (1.21, 8.14)* | 2.16 (1.11, 4.22)* |
| Eastern | 1.52 (1.06, 2.17)* | 2.02 (1.37, 2.97)** | 1.13 (0.80, 1.62) |
| *p*-value[a] | <0.001 | 0.005 | 0.391 |
| **Absolute inequalities** | SII (95% CI) | SII (95% CI) | SII (95% CI) |
| Scandinavian | 14.03 (9.01, 19.06)** | 15.66 (11.90, 19.42)** | 6.79 (3.02, 10.57)** |
| Anglo-Saxon | 24.88 (15.57, 34.18)** | 22.39 (13.66, 31.12)** | 0.21 (-8.69, 9.11) |
| Bismarckian | 11.20 (6.67, 15.73)** | 13.69 (9.09, 18.30)** | 4.98 (0.06, 9.90)* |
| Southern | 15.20 (10.27, 20.14)** | 7.41 (1.71, 13.12)* | 7.58 (0.84, 14.33)* |
| Eastern | 9.49 (1.92, 17.05)* | 14.14 (7.20, 21.08)** | 2.36 (-4.48, 9.21) |
| *p*-value[a] | 0.371 | 0.422 | 0.024 |

* p<0.05, **p<0.01

RII: Relative Index of Inequality, SII: Slope Index of Inequality

[a] *p*-value of the interaction between each SEP score and welfare regime

Table 5.12 - Relative and absolute educational inequalities in no functional dentition by welfare regime and gender

| | Women | Men |
|---|---|---|
| **Relative inequalities** | RII (95% CI) | RII (95% CI) |
| Scandinavian | 3.53 (2.14, 5.84)** | 3.08 (1.90, 5.00)** |
| Anglo-Saxon | 3.12 (1.43, 6.77)** | 1.52 (0.87, 2.65) |
| Bismarckian | 2.74 (1.91, 3.92)** | 1.72 (1.21, 2.45)** |
| Southern | 2.09 (1.24, 3.53)** | 1.53 (0.88, 2.68) |
| Eastern | 2.31 (1.82, 2.93)** | 1.40 (1.01, 1.94)* |
| *p*-value[a] | <0.001 | 0.002 |
| | | |
| **Absolute inequalities** | SII (95% CI) | SII (95% CI) |
| Scandinavian | 27.70 (16.37, 39.02)** | 27.01 (15.64, 38.38)** |
| Anglo-Saxon | 32.02 (11.96, 52.08)** | 16.30 (-4.84, 37.45) |
| Bismarckian | 35.21 (23.20, 47.23)** | 19.43 (7.10, 31.76)** |
| Southern | 22.19 (7.57, 36.82)** | 12.46 (-3.26, 28.17) |
| Eastern | 48.34 (35.92, 60.75)** | 20.43 (0.65, 40.21)* |
| *p*-value[a] | 0.735 | 0.060 |

* p<0.05, **p<0.01
RII: Relative Index of Inequality, SII: Slope Index of Inequality
[a] *p*-value of the interaction between each SEP score and welfare regime

Table 5.13 - Absolute inequalities in edentulousness (SSS) by welfare regime and gender

| | Women | Men |
|---|---|---|
| **Absolute inequalities** | SII (95% CI) | SII (95% CI) |
| Scandinavian | 7.01 (1.39, 12.63)* | 6.19 (1.39, 10.99)* |
| Anglo-Saxon | 4.50 (-7.38, 16.38) | -3.15 (-16.87, 9.85) |
| Bismarckian | 5.13 (-1.84, 12.11) | 4.80 (-2.23, 11.83) |
| Southern | 8.94 (-1.19, 19.07) | 6.07 (-2.65, 14.80) |
| Eastern | 7.10 (-2.35, 16.54) | -3.04 (-12.78, 6.71) |
| *p*-value[a] | 0.015 | 0.535 |

* p<0.05, **p<0.01
RII: Relative Index of Inequality, SII: Slope Index of Inequality
[a] *p*-value of the interaction between each SEP score and welfare regime

## 5.6 Summary of main findings

- Age standardized prevalence rates of no functional dentition and edentulousness were consistently lower in the Scandinavian regime. Conversely, the two oral health measures were significantly more prevalent in the Eastern regime. Prevalence rates in the Anglo-Saxon, Bismarckian, and Southern regimes were between those in the Eastern and Scandinavian and not significant differences existed among these three regimes.
- Prevalence levels disaggregated by different dimensions of adults' SEP showed a general pattern of educational and occupational gradients in the five welfare regimes analysed. When comparing adults in the lowest socioeconomic categories across regimes, those in the Scandinavian regime tended to fare better (lower prevalence) than their counterparts in other welfare regimes. In the same socioeconomic groups, larger prevalence rates were consistently observed in the Eastern regime.
- In general, there were strong associations (PR) between the two oral health outcomes and the SEP measures of education and occupation. These associations were mostly on the expected direction whereby adults who were in lower educational and occupational levels had larger PRs than those in the highest levels. Associations with SSS were not consistently significant, particularly for edentulousness.
- There was evidence of significant educational and occupational inequalities in relative (RII) and absolute (SII) terms in all welfare regimes. Inequalities by SSS did not present the same consistent pattern.
- The comparison on the magnitude of inequalities across regimes showed a slightly complex picture with different findings according to the outcome, SEP indicator and nature of the inequalities (absolute and relative). The Scandinavian regime exhibited larger relative educational inequalities in no functional dentition and larger relative occupational inequalities in edentulousness. Also, the Southern regime showed larger absolute inequalities by SSS in the two outcomes and larger relative educational inequalities in

edentulousness. Finally, the Eastern regime had larger absolute occupational inequalities in no functional dentition.

- When significant gender interactions were found in absolute or relative inequalities, there were consistent larger inequalities among women.

# Chapter 6 - Socioeconomic inequalities in oral impacts across welfare state regimes

## 6.1 Introduction

This chapter presents the results of analyses on the prevalence and socioeconomic distribution of oral impacts in the five welfare state regimes. Similar to the previous chapter, objectives 1 and 3 of the thesis are addressed, but in this case focusing on the oral impacts outcome. Details of this outcome are given in Chapter 4, section 4.2.1.1, and are briefly summarized here. Oral impacts on daily life were assessed through seven questions of the Eurobarometer survey on the frequency of difficulties in daily life activities due to oral conditions during the last 12 months. The variable for these analyses was coded as a binary indicator which showed whether the participant had experienced any of the oral impacts either 'often' or 'from time to time'.

Following the same analytical strategy employed for the previous chapter, analyses on oral impacts involved three steps. First, age standardized prevalence rates of oral impacts were derived and compared between welfare regimes. Second, in each regime, the relationship between oral impacts and SEP measures was examined by comparing prevalence rates across SEP levels and by estimating PRs. PRs were obtained by regressing each categorical measure of SEP on the outcome of interest (oral impacts) using a robust Poisson regression model. Finally, the relative and slope indices of inequality were calculated to measure relative and absolute inequalities respectively. For analyses in this chapter, RII and SII were estimated using generalised linear models, specifying a binomial family distribution (log-binomial regression) with a logarithmic link function for RII, and an identity link function for SII. Again, all estimates were weighted and all models were adjusted for age, gender and marital status.

Analyses reported in this chapter were conducted on adults aged 20 years and over with no missing data on the outcome or demographic characteristics (n=20,661). Descriptive statistics and the comparison of prevalence rates across regimes are based on this sample. After applying the exclusion criteria for each SEP measure (see Chapter 4, section 4.4), the samples used in analyses by SEP were 20,311 for models with education, 19,951 for SSS, and 16, 819 for occupational social class.

## 6.2 Descriptive statistics

Descriptive statistics of variables used in this analysis are given in Table 6.1. In this sample of adults aged 20 years and over, the five welfare regimes had fairly comparable age distributions. Similar to the pattern observed in the previous chapter, the Eastern regime showed a slightly higher proportion of adults in the youngest range. In terms of gender distribution, just over half of the sample in every regime was female with proportions ranging from 51% in the Scandinavian to 53% in the Eastern. With respect to marital status, around two thirds of adults were married or cohabiting in all regimes except in the Anglo-Saxon where the proportion was a little smaller (60%). Related to this, being single was more common in the Anglo-Saxon than in other regimes.

The distribution of socioeconomic characteristics differed by welfare regime. There was a significantly larger proportion of adults who finished full-time education aged 20 years and over in the Scandinavian regime (67.2%) than in other regimes. Conversely, the Southern regime had the highest proportion of people in the lowest educational level. With respect to occupational social class, some differences were also found between regimes. Particularly, being in the managerial or professional occupations was more common among adults in the Scandinavian, Bismarckian and Anglo-Saxon regimes than among those in the Southern and Eastern. As far as subjective social status is concerned, and in agreement with the pattern observed for this measure in the previous chapter, adults in all welfare regimes were more likely to choose intermediate levels rather than very high or very low ranks. Although that was a common pattern in all regimes, certain differences in the

distribution of SSS were observed. Most notably, one fifth of adults in the Scandinavian regime saw themselves in steps 8-10 of the social ladder (the highest rank in this study) while this proportion was 13% or less in the other welfare regimes. In addition, the Scandinavian, Anglo-Saxon and Southern regimes had the joint lowest proportion of adults placing themselves in the lowest social rank (4%).

Table 6.1 also presents weighted percentages of oral impacts for each welfare regime. However, the discussion about differences in oral impacts across regimes is presented in the following section based on age-standardized prevalence rates.

Table 6.1 - Descriptive statistics by welfare regime, Eurobarometer 2009 (Adults aged ≥20 years)

| Variables | Weighted percentage | | | | |
|---|---|---|---|---|---|
| | Scandinavian (n= 2,958) | Anglo-Saxon (n= 2,229) | Bismarckian (n= 5,788) | Southern (n= 3,853) | Eastern (n= 5,833) |
| Age (years) | | | | | |
| 20 - 29 | 14.29 | 18.78 | 16.26 | 14.92 | 20.07 |
| 30 - 39 | 18.36 | 17.55 | 16.16 | 21.45 | 19.93 |
| 40 - 49 | 17.98 | 18.82 | 18.76 | 20.15 | 16.27 |
| 50 - 59 | 17.16 | 14.72 | 17.98 | 13.77 | 18.47 |
| 60 - 69 | 17.89 | 14.12 | 14.34 | 16.32 | 13.31 |
| ≥ 70 | 14.32 | 16.02 | 16.51 | 13.39 | 11.94 |
| Gender | | | | | |
| Male | 48.98 | 48.20 | 47.80 | 47.79 | 46.77 |
| Female | 51.02 | 51.80 | 52.20 | 52.21 | 53.23 |
| Marital status | | | | | |
| Married/cohabiting | 63.62 | 59.95 | 68.45 | 65.40 | 65.78 |
| Divorced/ widowed | 16.49 | 16.70 | 14.78 | 13.17 | 17.57 |
| Single | 19.89 | 26.35 | 16.77 | 21.43 | 16.65 |
| Education (Age when completed full-time education) | | | | | |
| 20 years and older | 67.19 | 26.00 | 33.25 | 23.55 | 28.69 |
| 16 - 19 years | 22.92 | 50.51 | 45.66 | 37.46 | 57.85 |
| Up to 15 years | 9.89 | 23.49 | 21.09 | 38.99 | 13.46 |
| Occupational class | | | | | |
| Managers/professionals | 33.11 | 29.08 | 28.41 | 16.15 | 17.96 |
| Intermediate | 25.27 | 26.08 | 24.27 | 33.68 | 29.30 |
| Manual workers | 41.62 | 44.83 | 47.32 | 50.17 | 52.74 |
| Subjective social status | | | | | |
| Highest rank | 20.25 | 12.88 | 8.37 | 7.69 | 8.96 |
| Second highest rank | 52.08 | 49.39 | 39.49 | 48.91 | 34.28 |
| Second lowest rank | 23.82 | 34.19 | 43.82 | 39.01 | 45.56 |
| Lowest rank | 3.85 | 3.54 | 8.32 | 4.40 | 11.20 |
| Oral impacts on daily life [a] | 18.44 | 23.09 | 19.87 | 30.81 | 25.14 |

[a] Experienced any oral impact 'often' or 'from time to time'

## 6.3 Prevalence rates of oral impacts

In this section, age standardized prevalence rates of oral impacts on daily life are presented by country and welfare regime. In each regime, prevalence rates were calculated for the total population and also separately for women and men. Prevalence rates were directly standardised to ten-year age groups using the pooled age distribution of all European countries.

Table 6.2 shows the prevalence of oral impacts on daily life by countries clustered according to their welfare regime. Prevalence rates ranged from 14% in Denmark to 34.5% in Estonia. In addition to Denmark, low prevalence was also observed in Germany and The Netherlands, both with a prevalence rate of 16%. At the other end of the spectrum and with prevalence levels higher than 31%, Austria, Italy and Spain joined Estonia in the group of countries with larger prevalence rates of oral impacts on daily life. Similar to the pattern observed in the previous chapter for edentulousness and no functional dentition, there were differences in prevalence rates of oral impacts within groups of countries by welfare regime. This variation within regimes was particularly clear in this case for the Bismarckian group.

The age standardized prevalence rates of oral impacts by welfare regimes are presented in Figure 6.1 and Table 6.3. These data showed that, compared to the other welfare regimes, the Southern regime had a significantly higher prevalence rate of oral impacts. In this regime, almost one third of adults reported having experienced at least one oral impact 'often' or 'from time to time' in the last 12 months. In contrast, in the Scandinavian and Bismarckian regimes oral impacts were less prevalent than in other regimes. Prevalence rates were significantly smaller in the Scandinavian regime compared to all other regimes, apart from the Bismarckian. Results by gender indicated that prevalence of oral impacts tended to be higher for women in all welfare regimes (Figure 6.2 and Table 6.4). The difference between women and men was significant in two regimes, the Bismarckian (22.2%; 95%CI: 20.4-24.2 in women vs. 17.5%; 95%CI: 15.6-19.5 in

men) and the Eastern (29.4%; 95%CI: 27.2-31.7 in women vs. 23.1%; 95%CI: 20.6-25.8 in men).

Table 6.2 - Age standardized prevalence rates of oral impacts in countries grouped by welfare regime (Adults aged ≥20 years)

| Country | n | Oral impacts [a] (%) |
|---|---|---|
| **Scandinavian** | | |
| Sweden | 968 | 18.20 |
| Finland | 974 | 23.73 |
| Denmark | 1016 | 14.14 |
| **Anglo-Saxon** | | |
| UK | 1290 | 23.27 |
| Ireland | 939 | 19.07 |
| **Bismarckian** | | |
| Austria | 967 | 31.27 |
| Belgium | 955 | 22.49 |
| France | 962 | 24.64 |
| Germany | 1478 | 15.74 |
| Luxemburg | 486 | 28.31 |
| Netherlands | 940 | 16.04 |
| **Southern** | | |
| Greece | 959 | 26.14 |
| Italy | 979 | 33.29 |
| Portugal | 969 | 29.01 |
| Spain | 946 | 31.73 |
| **Eastern** | | |
| Czech Republic | 1027 | 27.88 |
| Estonia | 942 | 34.46 |
| Hungary | 986 | 27.85 |
| Poland | 954 | 25.72 |
| Slovakia | 952 | 24.71 |
| Slovenia | 972 | 22.45 |

Note: the prevalence of oral impacts was weighted and age-standardized.
[a] Experienced any oral impact 'often' or 'from time to time'

Figure 6.1 - Age-standardized prevalence of oral impacts by welfare regime (Participants aged ≥20 years)

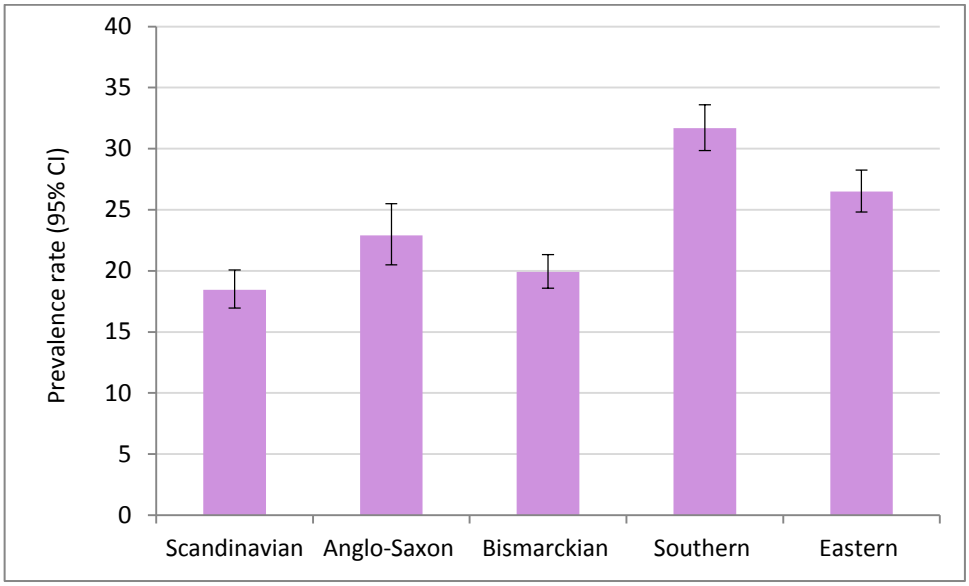



Table 6.3 - Age-standardized prevalence of oral impacts by welfare regime

| | Prevalence rate | 95% CI |
|---|---|---|
| Scandinavian | 18.46 | 16.95, 20.07 |
| Anglo-Saxon | 22.91 | 20.50, 25.51 |
| Bismarckian | 19.91 | 18.58, 21.32 |
| Southern | 31.69 | 29.84, 33.59 |
| Eastern | 26.50 | 24.82, 28.24 |

Figure 6.2 - Age-standardized prevalence of oral impacts by welfare regime and gender (Participants aged ≥20 years)

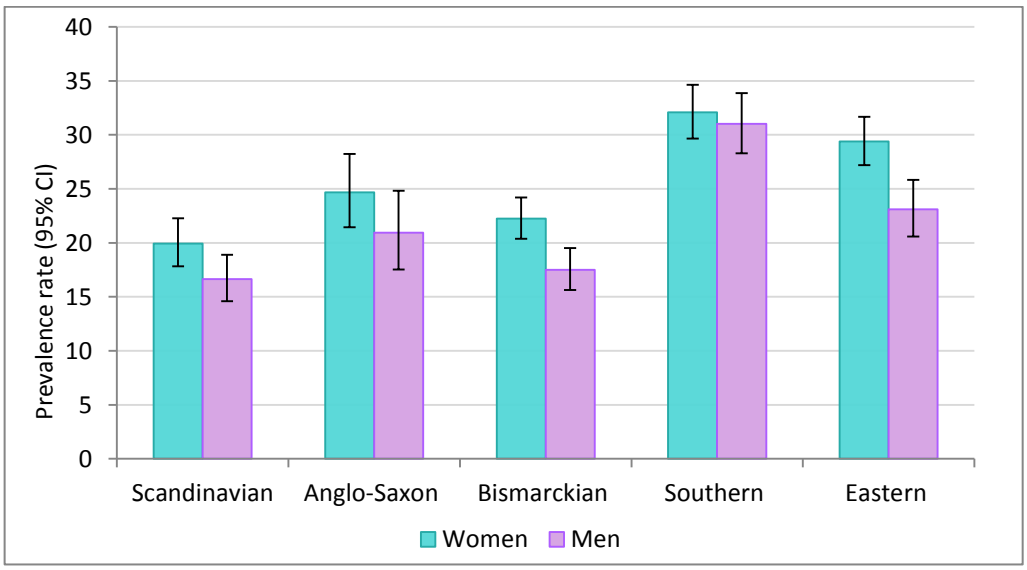


Table 6.4 - Age-standardized prevalence of oral impacts by welfare regime and gender

| | Women | | Men | |
|---|---|---|---|---|
| | Prevalence rate | 95% CI | Prevalence rate | 95% CI |
| Scandinavian | 19.94 | 17.81, 22.26 | 16.63 | 14.59, 18.89 |
| Anglo-Saxon | 24.68 | 21.44, 28.22 | 20.94 | 17.53, 24.83 |
| Bismarckian | 22.23 | 20.36, 24.21 | 17.50 | 15.64, 19.52 |
| Southern | 32.09 | 29.66, 34.63 | 31.00 | 28.28, 33.85 |
| Eastern | 29.39 | 27.19, 31.68 | 23.11 | 20.58, 25.84 |

## 6.4 Relationship between SEP and oral impacts

The purpose of this section is to explore the relationship between socioeconomic indicators and the measure of oral impacts used in this analysis. For each welfare regime this relationship was examined in two ways. The first one consisted of estimating age standardized prevalence rates by categories of education, occupation and SSS. The second one involved the calculation of prevalence ratios by fitting multivariable regression models. Specifically, robust Poisson regression models were used with oral impacts as outcome, the SEP measure as the explanatory variable, and gender, age and marital status as covariates.

**Prevalence rates of oral impacts by SEP**

Prevalence rates of oral impacts by levels of education, occupation and SSS are given in Figure 6.3 and Table 6.5. These estimates showed a mixed picture with some differences according to the SEP indicator and welfare regime. When education was used as the SEP measure, the prevalence of oral impacts increased at lower educational levels in all regimes except the Scandinavian (Table 6.5). In this regime, oral impacts were less prevalent among adults in the lowest level of education than among those in the intermediate level. A particularly clear and steep educational gradient in oral impacts was observed in the Anglo-Saxon regime. For occupational social class, the Eastern regime exhibited a U-shaped pattern whereas the Scandinavian, Anglo-Saxon and Southern showed a pattern of occupational

gradients. These occupational gradients were steeper in the Southern and Scandinavian regimes. Finally, for the SEP indicator of SSS, prevalence of oral impacts followed a J-shape pattern in the Southern and Eastern regimes and a graded pattern in the other three welfare regimes.

When the prevalence of oral impacts was compared across welfare regimes only considering adults in the lowest socioeconomic levels, findings revealed that those in the Bismarckian regime tended to do better than those in other regimes. Conversely, adults with the lowest level of education, manual workers and those who rated themselves in the lowest socioeconomic position, reported oral impacts more frequently in the Southern regime than in any other welfare regime (Table 6.5).

Figure 6.3 - Age-standardized prevalence of oral impacts by welfare regime and each SEP measure (Participants aged ≥20 years)

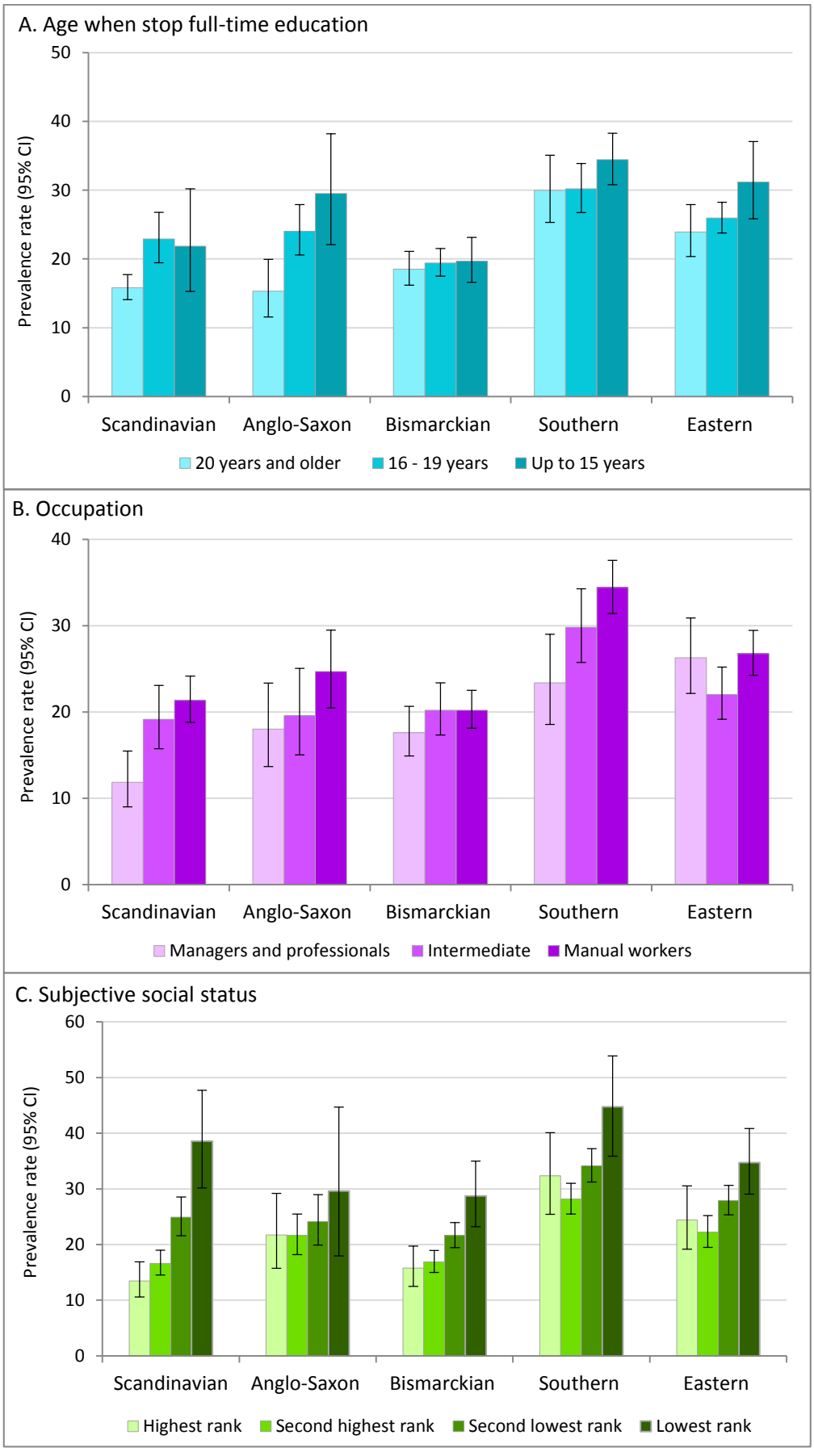


Table 6.5 - Age-standardized prevalence of oral impacts by welfare regime and SEP (Participants aged ≥20 years)

| Socioeconomic position | Welfare state regime | | | | |
|---|---|---|---|---|---|
| | Scandinavian | Anglo-Saxon | Bismarckian | Southern | Eastern |
| | Prevalence rate (95% CI) | | | | |
| Education (Age when stop full-time education) | | | | | |
| 20 years and older | 15.81 (14.07, 17.72) | 15.30 (11.57, 19.95) | 18.51 (16.18, 21.11) | 29.97 (25.32, 35.08) | 23.93 (20.36, 27.90) |
| 16 - 19 years | 22.90 (19.44, 26.78) | 24.05 (20.57, 27.92) | 19.43 (17.49, 21.53) | 30.18 (26.74, 33.86) | 25.94 (23.77, 28.24) |
| Up to 15 years | 21.84 (15.28, 30.21) | 29.51 (22.08, 38.21) | 19.68 (16.61, 23.15) | 34.44 (30.80, 38.26) | 31.19 (25.85, 37.07) |
| Occupational class | | | | | |
| Managers and professionals | 11.86 (9.01, 15.46) | 18.00 (13.67, 23.33) | 17.60 (14.91, 20.66) | 23.37 (18.54, 29.01) | 26.28 (22.15, 30.88) |
| Intermediate | 19.15 (15.75, 23.07) | 19.56 (15.02, 25.06) | 20.19 (17.34, 23.37) | 29.82 (25.74, 34.26) | 22.03 (19.16, 25.19) |
| Manual workers | 21.34 (18.79, 24.14) | 24.70 (20.47, 29.47) | 20.21 (18.10, 22.50) | 34.43 (31.41, 37.58) | 26.76 (24.23, 29.45) |
| Subjective social status | | | | | |
| Highest rank | 13.44 (10.59, 16.90) | 21.73 (15.73, 29.21) | 15.77 (12.49, 19.73) | 32.35 (25.45, 40.12) | 24.39 (19.15, 30.52) |
| Second highest rank | 16.63 (14.51, 18.99) | 21.62 (18.20, 25.49) | 16.88 (15.00, 18.95) | 28.16 (25.49, 30.99) | 22.21 (19.50, 25.18) |
| Second lowest rank | 24.90 (21.57, 28.55) | 24.15 (19.90, 28.97) | 21.62 (19.45, 23.95) | 34.15 (31.21, 37.22) | 27.90 (25.34, 30.62) |
| Lowest rank | 38.57 (30.17, 47.70) | 29.61 (17.96, 44.71) | 28.74 (23.20, 35.01) | 44.72 (35.89, 53.90) | 34.73 (29.07, 40.86) |

**Association between oral impacts and SEP using prevalence ratios**

Results of the multivariable regression models investigating the relationship between oral impacts and SEP are given in Table 6.6. These models were fitted to obtain PRs adjusting for age, gender and marital status. With few exceptions, results were in the expected direction with stronger PRs among adults in lower levels of SEP than among those in higher levels. However, only some of these estimates were statistically significant. When welfare regimes were compared, the Scandinavian showed more consistent significant associations between oral impacts and SEP. Specific results by each SEP indicator are presented below.

There were significant associations between oral impacts and education in the Scandinavian and Anglo-Saxon regimes. In those two regimes, associations took the shape of a gradient and tests for trend in PRs were significant. For the other three regimes, PRs by education were not significant. With respect to associations with occupational social class, significant PRs were found for the two categories of occupation in the Scandinavian regime and for manual workers in the Southern. In addition to being significant, associations in the Scandinavian regime were of larger magnitude with a PR of 1.57 (95%CI: 1.21, 2.05) for adults in intermediate occupations and 1.78 (95%CI: 1.42, 2.24) for those in manual occupations. Tests for trend also suggested that in the Scandinavian and Southern regimes the proportion of adults reporting oral impacts increased at each lower occupational level once age, gender and marital status were taken into account. Findings by SSS showed that adults in the Scandinavian and Bismarckian regimes who placed themselves in the two lowest SSS ranks had higher PRs than their counterparts in the highest rank. All PRs in the other three regimes were not significant. Similar to results for occupation, stronger associations were identified in the Scandinavian regime.

*Sensitivity analysis*

The associations between oral impacts and measures of SEP were also explored using ORs, and they were higher than the respective PRs. The direction of the associations was the same and the significance levels were identical with the only

exception of the value for the lowest SSS rank in the Southern regime which showed a significant OR but a borderline not significant PR (Table A2.3 in Appendix 2).

Table 6.6 - Regression analysis of the association between oral impacts and SEP measures by welfare state regime

| Socioeconomic position | Welfare state regime | | | | |
|---|---|---|---|---|---|
| | Scandinavian | Anglo-Saxon | Bismarckian | Southern | Eastern |
| | Prevalence ratio (95% CI) | | | | |
| Education<br>(Age when stop full-time education) | | | | | |
| 20 years and older (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 16 - 19 years | 1.46 (1.20, 1.79) | 1.42 (1.04, 1.93) | 1.03 (0.87, 1.21) | 1.07 (0.89, 1.29) | 1.06 (0.88, 1.27) |
| Up to 15 years | 1.56 (1.22, 2.00) | 1.83 (1.28, 2.62) | 1.20 (0.98, 1.47) | 1.21 (1.00, 1.46) | 1.21 (0.97, 1.52) |
| *p*-value for trend | <0.001 | 0.001 | 0.108 | 0.045 | 0.116 |
| Occupational class | | | | | |
| Managers and professionals (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Intermediate | 1.57 (1.21, 2.05) | 1.03 (0.71, 1.48) | 1.11 (0.89, 1.37) | 1.23 (0.96, 1.59) | 0.82 (0.66, 1.04) |
| Manual workers | 1.78 (1.42, 2.24) | 1.34 (0.98, 1.84) | 1.13 (0.93, 1.37) | 1.38 (1.09, 1.74) | 1.03 (0.84, 1.25) |
| *p*-value for trend | <0.001 | 0.052 | 0.225 | 0.005 | 0.357 |
| Subjective social status | | | | | |
| Highest rank (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Second highest rank | 1.28 (0.99, 1.65) | 1.07 (0.75, 1.53) | 1.07 (0.82, 1.38) | 0.87 (0.68, 1.12) | 0.85 (0.64, 1.14) |
| Second lowest rank | 1.91 (1.46, 2.50) | 1.15 (0.80, 1.67) | 1.35 (1.05, 1.74) | 1.05 (0.82, 1.34) | 1.08 (0.82, 1.42) |
| Lowest rank | 2.91 (2.04, 4.15) | 1.09 (0.55, 2.15) | 1.82 (1.34, 2.48) | 1.34 (0.99, 1.81) | 1.29 (0.96, 1.74) |
| *p*-value for trend | <0.001 | 0.463 | <0.001 | 0.003 | 0.002 |

## 6.5 Relative and absolute inequalities using the RII and SII

In this section, the magnitude of socioeconomic inequalities in oral impacts is compared across welfare regimes using the RII and SII. For these analyses, there were no convergence issues with the log-binomial regression models to estimate the indices. Therefore, results presented here were obtained using generalised linear models specifying a binomial family distribution, with the log link function for RII and with the identity link function for SII (see Chapter 4, section 4.3.3). These log-binomial regression models were adjusted for age (as a categorical variable of ten-year intervals), gender and marital status (as categorical variable with 3 levels). The RII and SII can be interpreted as the effect on oral impacts of moving from the lowest to the highest socioeconomic group. The absolute effect is shown by the SII, while the relative effect is shown by the RII. Significant estimates correspond to values larger than zero of SII and larger than one of RII. For both indices, higher values indicate larger magnitude of inequalities.

The results of relative and absolute inequalities in oral impacts as measured by the RII and SII are presented in Table 6.7. Even though some estimates were not significant, RIIs were larger than one, and SIIs were larger than zero in all welfare regimes, indicating that oral impacts tended to be more frequently experienced by adults in lower levels of education, occupation and SSS. These findings, however, did not show a very consistent pattern across welfare regimes in terms of significance. The only regime with significant relative and absolute inequalities by all SEP measures was the Scandinavian.

Findings for relative inequalities (RII) showed non-significant interaction effects between the SEP scores and welfare regimes. Although the Scandinavian and Anglo-Saxon regimes showed larger estimates by education, and the Scandinavian regime also exhibited larger RIIs by occupation and SSS, the interaction effects indicated that there was not enough evidence to claim significant differences in those inequalities across welfare regimes. The general picture shown by RIIs was

consistent with findings of prevalence ratios where the Scandinavian regime displayed stronger and significant associations.

Results for absolute inequalities (SII) indicated that there was a significant difference between welfare regimes for education, but not for SSS and occupation. The Anglo-Saxon regime had the largest SII with an estimate of 18.68 (95% CI: 8.87, 28.50) followed by the Scandinavian (14.86 95% CI: 7.94, 21.78), while the Bismarckian and Eastern regimes exhibited non-significant estimates (3.69 95%CI: -1.95, 9.33) and (6.84 95%CI: -0.93, 14.62) respectively. Although SIIs were not significantly different by welfare regimes for occupation and SSS, larger absolute inequalities in these two SEP indicators were observed in the Scandinavian regime. Lower SIIs were found in the Bismarckian regime for occupation and in the Anglo-Saxon for SSS (Table 6.7).

Table 6.7 - Relative and absolute inequalities in oral impacts by welfare regime

| | Socioeconomic position measure | | |
|---|---|---|---|
| | Education | Occupational class | Subjective social status |
| **Relative inequalities** | RII (95% CI) | RII (95% CI) | RII (95% CI) |
| Scandinavian | 2.23 (1.57, 3.18)** | 2.31 (1.64, 3.25)** | 2.96 (2.10, 4.17)** |
| Anglo-Saxon | 2.22 (1.38, 3.58)** | 1.64 (0.99, 2.71) | 1.17 (0.75, 1.80) |
| Bismarckian | 1.27 (0.95, 1.69) | 1.20 (0.90, 1.59) | 1.91 (1.45, 2.51)** |
| Southern | 1.30 (0.98, 1.73) | 1.50 (1.13, 1.99)** | 1.47 (1.15, 1.88)** |
| Eastern | 1.25 (0.94, 1.67) | 1.20 (0.90, 1.59) | 1.57 (1.21, 2.04)** |
| *p*-value[a] | 0.073 | 0.682 | 0.856 |
| **Absolute inequalities** | SII (95% CI) | SII (95% CI) | SII (95% CI) |
| Scandinavian | 14.86 (7.94, 21.78)** | 15.19 (9.49, 20.88)** | 17.10 (11.76, 22.45)** |
| Anglo-Saxon | 18.68 (8.87, 28.50)** | 11.34 (1.22, 21.47)* | 4.21 (-5.51, 13.93) |
| Bismarckian | 3.69 (-1.95, 9.33) | 3.38 (-2.16, 8.92) | 11.86 (7.03, 16.70)** |
| Southern | 8.99 (1.11, 16.88)* | 10.69 (2.50, 18.88)* | 10.82 (3.74, 17.90)** |
| Eastern | 6.84 (-0.93, 14.62) | 3.77 (-3.66, 11.19) | 11.24 (4.61, 17.88)** |
| *p*-value[a] | 0.013 | 0.703 | 0.471 |

* p<0.05, **p<0.01

RII: Relative Index of Inequality, SII: Slope Index of Inequality

[a] *p*-value of the interaction between each SEP score and welfare regime

When tests for gender interaction were carried out, occupational inequalities were shown to differ by gender, both in relative and absolute terms. There were higher RIIs and SIIs among men in all regimes (Table 6.8). In fact, estimates of RII and SII in the Anglo-Saxon, Bismarckian and Southern regimes were significant for men, but not for women. In addition, and resembling results in the unstratified analysis, no significant difference across regimes was revealed in both genders.

Table 6.8 - Relative and absolute occupational inequalities in oral impacts by welfare regime and gender

| | Women | Men |
|---|---|---|
| **Relative inequalities** | RII (95% CI) | RII (95% CI) |
| Scandinavian | 1.87 (1.19, 2.94)** | 2.78 (1.65, 4.68)** |
| Anglo-Saxon | 1.21 (0.64, 2.29) | 2.39 (1.07, 5.36)* |
| Bismarckian | 0.97 (0.67, 1.40) | 1.58 (1.02, 2.45)* |
| Southern | 1.33 (0.87, 2.05) | 1.60 (1.10, 2.35)* |
| Eastern | 1.11 (0.78, 1.57) | 1.43 (0.86, 2.37) |
| *p*-value[a] | 0.597 | 0.314 |
| | | |
| **Absolute inequalities** | SII (95% CI) | SII (95% CI) |
| Scandinavian | 13.71 (5.12, 22.29)** | 15.46 (7.88, 23.03)** |
| Anglo-Saxon | 6.45 (-9.38, 22.28) | 13.51 (0.14, 26.89)* |
| Bismarckian | -2.43 (-11.25, 6.39) | 7.17 (0.15, 14.18)* |
| Southern | 7.26 (-5.14, 19.67) | 13.24 (2.47, 24.02)* |
| Eastern | 2.44 (-7.80, 12.68) | 4.65 (-5.18, 14.47) |
| *p*-value[a] | 0.378 | 0.921 |

* p<0.05, **p<0.01
RII: Relative Index of Inequality, SII: Slope Index of Inequality
[a] *p*-value of the interaction between each SEP score and welfare regime

*Sensitivity analysis*

As previously mentioned in Chapter 4, section 4.3.5, when the RII and SII were estimated with log-binomial regression models, a sensitivity analysis was carried out to test the robustness of the results. Values of RII and SII presented in this section were compared with estimates obtained from robust Poisson and linear regression models respectively. In general, results were robust to the alternative specification

of the models and very similar figures were obtained (Tables A3.1 and A3.2 in Appendix 3). Just two estimates of RII that were barely non-significant with log-binomial models were borderline significant when estimated with robust Poisson models. These estimates were the RIIs for education in the Southern regime and for occupation in the Anglo-Saxon.

## 6.6 Summary of main findings

- In this analysis, the age-standardized prevalence of oral impacts (any oral impact experienced 'often' or 'from time to time' in the last 12 months) was between 18.5% in the Scandinavian regime and 31.7% in the Southern. The Southern regime displayed a significantly higher prevalence rate compared to the other four welfare regimes. Conversely, oral impacts were less prevalent in the Scandinavian and Bismarckian regimes. Prevalence rates of oral impacts were higher among women in all welfare regimes.
- When prevalence rates were estimated by SEP levels, in general, adults in lower levels of education, occupation and SSS tended to report more oral impacts. However, there was no consistent pattern and graded shapes appeared together with U-shape and J-shape patterns. Subjects in the lowest socioeconomic levels tended to fare better in the Bismarckian regime (lower prevalence of oral impacts), and to fare worse in the Southern (higher prevalence) compared to their counterparts in other welfare regimes.
- After adjusting for age, gender and marital status, associations between oral impacts and all SEP dimensions of interest were in the expected direction with higher PRs among those in lower SEP levels. These PRs were, however, only significant in certain cases. Most notably, the Scandinavian regime showed more significant PRs than any other welfare regime.
- Estimates of the relative and slope indices of inequality showed that inequalities in oral impacts were not consistently significant across SEP measures and welfare regimes. However, all RII and SII were in the expected direction (RII above one and SII above zero) suggesting that oral impacts tended to be higher among adults in lower SEP levels.

- The comparison of relative and absolute inequalities across welfare regimes revealed that the Scandinavian was the only regime with significant RIIs and SIIs by all SEP indicators. In addition, there was evidence of larger absolute inequalities by education in the Anglo-Saxon and Scandinavian regimes.
- Results of tests for interaction by gender revealed that occupational inequalities in oral impacts were higher among men in all welfare regimes. This holds true for absolute and relative inequalities.

# Chapter 7 - Influence of welfare state regimes on the variation in oral health: a multilevel analysis

## 7.1 Introduction

This chapter describes the results of analyses performed using a multilevel approach. These analyses addressed objective 2 of the thesis: to assess the influence of welfare state regime (a country-level characteristic) on the variation in oral health between European countries. The analyses also explored how the oral health of people with different SEP level was influenced by living in five different welfare state regimes. In these analyses, data followed a two-level hierarchy with individuals (level-1) nested within countries (level-2). In this chapter, data from the Eurobarometer survey were used. The analytical sample was limited to individuals aged 20 years and over who were interviewed in one of the 21 countries classified in five welfare regimes using the Ferrera's typology and the additional Eastern regime. For each oral health outcome, only adults with complete data on the outcome and all covariates were included in the models (complete-case analyses). The final analytical sample was 16,314 for the two outcomes based on number of teeth and 16,525 for oral impacts (see Chapter 4, section 4.4).

The three oral health outcomes analysed in Chapters 5 and 6, were considered in this multilevel modelling strategy. Therefore, three dichotomous indicators of oral health were used: not having a functional dentition (less than 20 natural teeth), edentulousness (no natural teeth), and impacts of oral conditions on daily life (prevalence of experiencing any oral impact either 'often' or 'from time to time').

The individual-level explanatory variables 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, a binary variable with men as reference category; and 3) Marital status, categorized as married/cohabiting (reference category), single and divorced/separated/widowed.

Meanwhile, the socioeconomic variables were: 1) Education, measured as age when completed full-time education and categorized consistently with previous analyses into three groups: 20 years and older; 16 - 19 years; and up to 15 years; and 2) Occupational social class: defined according to the UK three-category NS-SEC (managerial and professional, intermediate, and routine-manual).

The country-level explanatory variables were the five welfare state regimes (Scandinavian, Anglo-Saxon, Bismarckian, Southern and Eastern) introduced as binary variables with the Scandinavian regime as the reference category. Additionally, GDP per capita (at purchasing power parity) and GDP annual growth rate (%) were included as country-level variables in the last model to account for country differences in economic growth and development. Data on GDP per capita and GDP growth rate were derived from the EU statistics and measured as five-year averages (2005-2009) (376, 377).

For each study outcome, five multilevel logistic regression models were fitted as explained previously in the Methods section (Chapter 4, section 4.3.4). To recap, the first model was a null or empty model; the second model included individual-level variables only; the third one involved individual-level and welfare regime variables; the fourth model included all individual- and country-level variables; and finally, models 5a and 5b included individual- and country-level variables and cross-level interaction terms. Results of these models are presented in this chapter in separate sections according to the outcome measure used. Before those sections, findings of the sensitivity analysis, which compared different estimation procedures to fit the empty model, are briefly presented below.

*Sensitivity analysis – different estimation procedures for the empty model*

As the first step in the analysis, diverse estimation procedures suggested for multilevel models with binary outcomes were used to fit the empty model in order to test the sensitivity of analysis to different methods. Although estimates did not change substantially according to the various procedures (Appendix 4, Tables A4.1

to A4.3), results agree with previous studies showing that the marginal quasi-likelihood (MQL) procedure tends to underestimate the values of parameters. i.e., estimates are smaller than those obtained from the other methods (380, 381). Results presented in this chapter are based on the Markov chain Monte Carlo (MCMC) estimation, which is the preferred method to fit multilevel models with binary outcomes because it does not use approximations when estimating binary response models and therefore, estimates are considered less biased (33, 328, 381, 382).

## 7.2 No functional dentition

**Variation between countries**

The results of the multilevel logistic regression models 1 to 4 for the outcome of no functional dentition are presented in Table 7.1. The empty model (Model 1) provided a baseline estimate of the country-level variance in no functional dentition and showed that there was significant variation across countries. Specifically, the country-level variance was 0.29 with a standard error of 0.11. This estimate gives a proportional variance of 8.07, which means that about 8.07% of the variation in no functional dentition was attributable to differences between countries. Previous multilevel analyses on different health outcomes with individual nested within countries have shown similar proportional variation at the country-level (33, 177, 217). In this analysis, most of the variation in no functional dentition was at level 1, which is the usual finding in hierarchies with individuals at level 1 (378). The estimate of the median odds ratio (MOR) was 1.67 which can be interpreted as an increase by almost 70% in the odds of not having functional dentition that a person would have if moving from one country with lower odds of this outcome to a country with higher odds of this outcome.

**Individual-level characteristics**

Adding individual-level variables to the model (Model 2) showed that no functional dentition was significantly associated with being a man, older, being divorced, widowed or single (compared to being married), having lower education level and

belonging to lower social classes. Moreover, the ORs for education and occupational social class showed a pattern of social gradients with higher odds of no functional dentition at each lower SEP level. Largest odds of no functional dentition were observed among those who stopped full-time education at 15 years or less (OR=2.26, 95%CI: 1.96-2.58) and among those in the routine/manual social class (OR=2.10, 95%CI: 1.86-2.37). The inclusion of individual-level variables caused a reduction of the Deviance Information Criterion (DIC) score from 19889 to 13090 indicating that the fit of the model improved substantially. In this Model 2, the country-level variance was 0.57 which in proportional terms indicates that 15% of the total variation in no functional dentition was attributable to differences between countries after adjusting for individual-level characteristics. As age was centred at the sample mean of 51 years, 0.57 was the country-level variance at age=51.

Compared to Model 1 (empty model), Model 2 showed an increase in the country-level variance (from 0.29 to 0.57). This change needs to be interpreted considering the features of multilevel logistic regression models. Since multilevel models for binary outcomes 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 variance that is at level 2 (380). The increase in country-level variance in Model 2 indicates that adjustment for demographic and socioeconomic characteristics at individual level did not explain differences between countries. To determine which specific adjustment resulted in increase of country-level variance, a step-wise addition of each covariate was conducted, starting from the empty model. When individual characteristics were added to the model one at the time, country-level variation increased largely due to the inclusion of age.

**Welfare state regimes**

When welfare regime variables were included in the model (Model 3), results showed that all regimes had larger odds of no functional dentition compared to the Scandinavian regime (Table 7.1). Remarkably, adults from Eastern countries had

almost seven times higher odds of no functional dentition than those living in Scandinavian countries (OR=6.94, 95%CI: 3.62-12.67). The other welfare regimes showed associations in the same direction, although the magnitude was not as large. Compared to adults in Scandinavian countries, those in Bismarckian, Anglo-Saxon and Southern countries had between three and two times higher odds of no functional dentition. Although in the expected direction, the association between the Anglo-Saxon regime and the outcome was marginally insignificant.

The country-level variance was reduced from 0.57 in model 2 to 0.16 in Model 3. This reduction indicates that welfare regimes explained a significant proportion (around 72%) of the variation in no functional dentition among countries. As a consequence of the reduction in country-level variance, the proportional variance at country level decreased from 14.67% to 4.53%, and the MOR was reduced from 2.05 to 1.46. These changes confirm that variations in no functional dentition between countries were substantially explained by welfare regime typology. Adding welfare regime variables to the model slightly improved the fit of the model. In turn, the associations between individual-level variables and functional dentition observed in Model 2 remained almost identical after the addition of welfare regime variables in Model 3.

As discussed previously, GDP per capita and GDP annual growth rate were included as covariates in Model 4 since they were considered to potentially confound the primary association of interest between welfare regimes and oral health measures. After adjusting for the economic development variables, the association between no functional dentition and the Bismarckian and Eastern regimes became stronger, while the respective association for the Anglo-Saxon and Southern regimes became slightly weaker. For the Anglo-Saxon regime the association changed from marginally insignificant to borderline significant while the opposite occurred for the Southern regime. All welfare regimes, except the Southern, showed higher odds of no functional dentition compared to the Scandinavian regime, indicating that the general effect of welfare regimes initially exhibited in Model 3 was not explained by differences in economic development. Additionally, adding the two economic

variables did not explain the country-level variance observed in Model 3, and actually caused the fit of the model to decline slightly (according to the DIC score). Both, GDP per capita and GDP annual growth rate were unrelated to the outcome in Model 4. Associations between the outcome and individual-level characteristics did not change from those in Models 2 and 3. Finally, the MOR in Model 4 was still larger than one, showing that there was some residual heterogeneity across countries which could be due to unobserved or unmeasured individual characteristics and to country-level factors not adjusted for in the model.

Table 7.1 - Two-level random intercept model for no functional dentition with predictor variables (16,314 individuals nested within 21 countries)

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | | OR (95% CI) | | |
| **Individual-level variables** | | | | |
| Sex | | | | |
| Men | | 1.00 | 1.00 | 1.00 |
| Women | | 0.91* (0.83-0.99) | 0.91* (0.83-0.99) | 0.91* (0.83-0.99) |
| Age (centred on 51) | | 1.11** (1.10-1.11) | 1.11** (1.10-1.11) | 1.11** (1.10-1.11) |
| Marital status | | | | |
| Married/cohabiting | | 1.00 | 1.00 | 1.00 |
| Divorced/separated/widowed | | 1.32** (1.18-1.47) | 1.31** (1.18-1.46) | 1.31** (1.18-1.46) |
| Single | | 1.25* (1.08-1.44) | 1.25* (1.08-1.45) | 1.25* (1.08-1.44) |
| Education (Age when stop full-time education) | | | | |
| 20 years and older | | 1.00 | 1.00 | 1.00 |
| 16 - 19 years | | 1.38** (1.23-1.54) | 1.37** (1.21-1.53) | 1.37** (1.22-1.54) |
| Up to 15 years | | 2.26** (1.96-2.58) | 2.25** (1.96-2.59) | 2.26** (1.96-2.59) |
| Occupational social class | | | | |
| Managerial and professional | | 1.00 | 1.00 | 1.00 |
| Intermediate | | 1.47** (1.29-1.67) | 1.47** (1.29-1.68) | 1.47** (1.28-1.68) |
| Routine and manual | | 2.10** (1.86-2.37) | 2.11** (1.87-2.38) | 2.11** (1.87-2.38) |
| **Country-level variables** | | | | |
| Welfare state regime | | | | |
| Scandinavian | | | 1.00 | 1.00 |
| Bismarckian | | | 2.76** (1.49-4.83) | 2.81* (1.38-4.82) |
| Anglo-Saxon | | | 2.28 (0.99-4.80) | 2.27* (1.03-4.79) |
| Southern | | | 2.03* (1.01-4.10) | 1.93 (0.98-3.41) |
| Eastern | | | 6.94** (3.62-12.67) | 7.16** (2.88-16.25) |
| Mean GDPpc (2005-2009) | | | | 1.00 (0.99-1.01) |
| Mean growth GDP (2005-2009) | | | | 0.98 (0.78-1.15) |
| Country-level variance (SE) | 0.289 (0.107) | 0.566 (0.203) | 0.156 (0.067) | 0.186 (0.088) |
| % of total variance (partition) | | | | |
| Individual level (%) | 91.93 | 85.33 | 95.47 | 94.66 |
| Country level (%) | 8.07 | 14.67 | 4.53 | 5.34 |
| % change in country-level var | - | 95.85 | -72.44 | 19.23 |
| MOR (95% CrI) | 1.67 (1.44-2.04) | 2.05 (1.68-2.68) | 1.46 (1.29-1.73) | 1.51 (1.30-1.85) |
| DIC | 19889.21 | 13089.87 | 13089.51 | 13089.82 |

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

**Interaction effects between SEP and welfare state regimes**

Tables 7.2 and 7.3 present the results of models with cross-level interactions between SEP measures and welfare regimes for the outcome of no functional dentition. The first model (Model 5a) shows the results of fitting interaction terms between participants' level of education and different welfare regimes while adjusting for all individual- and country-level variables. Findings of this model indicated that participants in any educational level from the Bismarckian, Anglo-Saxon, Southern and Eastern regimes had significantly higher odds of no functional dentition compared to those in the highest educational level in the Scandinavian regime. Moreover, within the Scandinavian regime, the likelihood of no functional dentition increased at each lower educational level. Clear educational gradients were also found in all welfare regimes with the exception of the Southern, where the associations were significant but less clearly linear and graded (Table 7.2). Findings also suggest that it was most detrimental (in terms of no functional dentition) to live in the Eastern regime, irrespective of people's level of education. Specifically, at each educational category, the odds ratios were higher for individuals living in the Eastern regime compared to individuals in the highest educational category living in the Scandinavian regime.

Similar to results for education, a general pattern of social gradients was found for occupational social class (Table 7.3). Although the association for the managerial/professional category in the Anglo-Saxon regime showed magnitude and direction matching with the general picture, it was marginally non-significant. In addition, at each occupational level, higher odds ratios were observed for the Eastern welfare regime followed by the Bismarckian. Findings of Model 5b also indicated that adults belonging to any occupational social class were better off in terms of no functional dentition in the Scandinavian regime than in other welfare state regime.

Table 7.2 - Two-level random intercept model for no functional dentition with interaction effects between education and welfare state regime (16,314 individuals nested within 21 countries)

| | **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 | |

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

Table 7.3 - Two-level random intercept model for no functional dentition with interaction effects between occupation and welfare state regime (16,314 individuals nested within 21 countries)

| | **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 | |

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

## 7.3 Edentulousness

**Variation between countries**

Results of multilevel analyses (Models 1 to 4) for the outcome of edentulousness are presented in Table 7.4. The empty model showed that roughly 7% of the variance in this outcome was due to differences between countries, rather than differences between individuals. The estimate of the country-level variance was 0.24 with a standard error of 0.10 which gives evidence of a significant variation in edentulousness across countries. Similarly to findings for no functional dentition, a larger proportion of the variation in edentulousness was found at level 1, which is very common in multilevel analyses with individuals as level 1 units (378). The MOR in the empty model (Model 1) was 1.59, indicating that, overall, a person's odds of not having natural teeth varied by country. Thus, if a person moved to another country with a higher probability of edentulousness, their odds of edentulousness would increase by 60%.

**Individual-level characteristics**

The model with individual-level variables only (Model 2) showed that edentulousness was significantly associated with age, marital status, education and occupation. Regarding demographic characteristics, older participants and those divorced or widowed were more likely to be edentulous compared to their younger and married counterparts. The associations by education and occupational social class were in the expected direction. Those who stopped full-time education at 15 years or less had double the odds of edentulousness than those who stopped full-time education at 20 years or more. Likewise, participants in the routine/manual social class were two times more likely to have no natural teeth compared to their counterparts in the managerial/professional category. Furthermore, the associations by SEP showed a pattern of social gradients with higher odds of edentulousness at each lower educational and occupational level. Adding the demographic and socioeconomic individual-level variables significantly improved the fit of the model with a reduction of the DIC score of almost 3,000. The country-

level variance in this Model 2 was 0.34 which gives a proportional variance of 9.3, indicating that 9.3% of the total variation in edentulousness was attributable to differences between countries after adjusting for individual-level characteristics.

Similar to findings for no functional dentition, although more modest in magnitude, adding individual-level variables caused the country-level variance to increase. In this case, the variance at country level increased by 41% (from 0.24 to 0.34). As discussed previously, this change is not uncommon in multilevel models for binary outcomes. The increase of the level 2 variance is related to the fact that in multilevel models for binary outcomes the level 1 variance cannot change, it is fixed at 3.29 when using a logit function or at 1 when using a probit function (380). Therefore, the addition of level-1 variables to the model cannot have an effect on the variance at level 1 but just on variance at level 2. In this analysis, the increase in the variance at country level means that accounting for demographic and socioeconomic variables at individual level did not explain differences in edentulousness between countries. To assess the effect of each individual covariate on the country-level variance, variables were added to the empty model one at a time and the largest increase in country-level variation was observed when age was included in the model.

**Welfare state regimes**

Adding the welfare regime typology to the model (Model 3), showed that associations between edentulousness and welfare regimes were in the expected direction, although not all of them were statistically significant. Participants from Eastern European (OR=2.99, 95%CI: 1.44-5.30) and Bismarckian (OR=2.27, 95%CI: 1.10-4.16) regimes had higher odds of being edentulous compared to those from the Scandinavian regime. For the Anglo-Saxon regime, a similar but non-significant association was found. Finally, the odds ratio for the Southern regime was the lowest in size and not statistically significant.

Compared to Model 2 (individual-level variables only), Model 3 showed that adjustment for welfare state regimes reduced the country-level variance from 0.34

to 0.22. In other words, welfare regimes explained 34% of the variation in edentulousness across countries observed in Model 2. After adjusting for welfare regimes, the proportion of country-level variance that remained unexplained was reduced to 6.4% (from 9.3% in model 2). Similarly, the MOR decreased from 1.74 in model 2 to 1.57 in Model 3, confirming that differences in welfare regimes explained some of the variance in edentulousness between countries. Results in Model 3 revealed that including the welfare regime variables did not affect the direction or size of the associations between edentulousness and individual-level variables.

In Model 4, with GDP per capita and GDP annual growth rate included as covariates, all the associations between edentulousness and welfare regimes were non-significant. This finding indicates that the significant associations initially observed in Model 3 for the Bismarckian and Eastern regimes were explained by differences in economic development. There was an increase in the size of association for Anglo-Saxon and Southern regimes, but they remained non-significant. Adjustment for the two economic variables also caused the variance at country level to increase slightly, indicating that these economic characteristics did not explain the country-level variance in edentulousness. Model 4 also showed no association between the economic development variables and the individual odds of edentulousness. The MOR in Model 4 was still larger than one, showing that the residual heterogeneity across countries existed, and the variables considered in the analysis did not fully explained the overall country-level variation in edentulousness.

Table 7.4 - Two-level random intercept model for edentulousness with predictor variables (16,314 individuals nested within 21 countries)

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | | OR (95% CI) | | |
| **Individual-level variables** | | | | |
| Sex | | | | |
| Men | | 1.00 | 1.00 | 1.00 |
| Women | | 0.97 (0.84-1.10) | 0.96 (0.84-1.10) | 0.96 (0.84-1.10) |
| Age (centred on 51) | | 1.11** (1.10-1.12) | 1.11** (1.10-1.12) | 1.11** (1.10-1.12) |
| Marital status | | | | |
| Married/cohabiting | | 1.00 | 1.00 | 1.00 |
| Divorced/separated/widowed | | 1.39** (1.20-1.61) | 1.39** (1.20-1.60) | 1.39** (1.20-1.59) |
| Single | | 1.05 (0.83-1.30) | 1.05 (0.83-1.31) | 1.06 (0.83-1.32) |
| Education (Age when stop full-time education) | | | | |
| 20 years and older | | 1.00 | 1.00 | 1.00 |
| 16 - 19 years | | 1.67** (1.37-2.03) | 1.64** (1.34-2.01) | 1.64** (1.34-1.99) |
| Up to 15 years | | 2.25** (1.82-2.75) | 2.24** (1.82-2.76) | 2.25** (1.83-2.74) |
| Occupational social class | | | | |
| Managerial and professional | | 1.00 | 1.00 | 1.00 |
| Intermediate | | 1.50** (1.20-1.86) | 1.50** (1.20-1.85) | 1.50** (1.19-1.85) |
| Routine and manual | | 2.28** (1.87-2.78) | 2.28** (1.87-2.78) | 2.28** (1.87-2.75) |
| **Country-level variables** | | | | |
| Welfare state regime | | | | |
| Scandinavian | | | 1.00 | 1.00 |
| Bismarckian | | | 2.27* (1.10-4.16) | 2.39 (0.90-5.68) |
| Anglo-Saxon | | | 2.21 (0.80-4.80) | 2.44 (0.77-6.83) |
| Southern | | | 1.34 (0.59-2.60) | 1.47 (0.52-3.96) |
| Eastern | | | 2.99** (1.44-5.30) | 2.69 (0.65-9.46) |
| Mean GDPpc (2005-2009) | | | | 1.00 (0.99-1.01) |
| Mean growth GDP (2005-2009) | | | | 1.13 (0.90-1.43) |
| Country level variance (SE) | 0.239 (0.095) | 0.337 (0.131) | 0.224 (0.101) | 0.263 (0.148) |
| % of total variance (partition) | | | | |
| Individual level (%) | 93.23 | 90.71 | 93.62 | 92.60 |
| Country level (%) | 6.77 | 9.29 | 6.38 | 7.40 |
| % change in country-level var | - | 41.00 | -33.53 | 17.41 |
| MOR (95% CrI) | 1.59 (1.38-1.93) | 1.74 (1.47-2.18) | 1.57 (1.34-1.94) | 1.63 (1.35-2.15) |
| DIC | 10042.93 | 7052.90 | 7052.60 | 7052.97 |

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

**Interaction effects between SEP and welfare state regimes**

Table 7.5 shows cross-level interaction analyses between welfare regime and education for edentulousness. Adults in the lowest educational level in all welfare regimes had significantly higher odds of edentulousness than those in the highest educational level in the Scandinavian regime. Although estimates for the medium and high educational level were in the expected direction, not all of them were statistically significant. In particular, odds ratios were non-significant for the Anglo-Saxon and Southern regimes in medium and high educational levels, and for the Bismarckian regime in high educational level. Among adults with high educational level, just those in the Eastern regime were significantly more likely to be edentulous than those in the reference category. Clear and significant educational gradients were found in the Scandinavian and Eastern welfare regimes.

Regarding interactions between occupation and welfare regimes, people in routine/manual occupations in all regimes were significantly more likely to be edentulous than those in managerial/professional occupations in the Scandinavian regime (Table 7.6). On the other hand, those in intermediate occupations in the Southern and Scandinavian regimes and those in the highest occupational level in the Southern and Anglo-Saxon showed non-significantly higher ORs as compared to the reference category. Although adults in managerial/professional occupations in the Anglo-Saxon regime did not have significantly higher odds of edentulousness, the results suggest that it is most detrimental (in terms of edentulousness) to live in the Anglo-Saxon than in any other regime for those in intermediate or manual occupations.

Table 7.5 - Two-level random intercept model for edentulousness with interaction effects between education and welfare state regime (16,314 individuals nested within 21 countries)

| | **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 | 1.76* (1.07-2.74) | 2.39** (1.56-3.56) |
| Bismarckian | 2.06 (0.67-5.31) | 3.92* (1.33-10.30) | 4.87* (1.66-12.65) |
| Anglo-Saxon | 1.15 (0.25-3.37) | 2.92 (0.88-7.50) | 5.94* (1.87-14.94) |
| Southern | 1.41 (0.34-3.92) | 1.45 (0.48-3.59) | 3.40* (1.32-7.90) |
| Eastern | 3.44* (1.02-10.34) | 4.57* (1.41-13.54) | 5.08* (1.53-15.06) |
| Country level variance (SE) | | 0.248 (0.118) | |
| % of total variance (partition) | | | |
| Individual level (%) | | 93.00 | |
| Country level (%) | | 7.00 | |

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

Table 7.6 - Two-level random intercept model for edentulousness with interaction effects between occupation and welfare state regime (16,314 individuals nested within 21 countries)

| | **Model 5b** | | |
|---|---|---|---|
| | Occupational social class | | |
| | Managerial and professional | Intermediate | Routine and manual |
| | OR (95% CI) | | |
| Welfare state regime | | | |
| Scandinavian | 1.00 | 1.82 (0.88-3.34) | 3.96** (2.30-6.51) |
| Bismarckian | 2.58* (1.03-5.33) | 4.70** (1.91-9.70) | 7.05** (2.91-14.36) |
| Anglo-Saxon | 1.56 (0.42-3.98) | 4.92* (1.46-12.04) | 7.12** (2.18-16.84) |
| Southern | 2.86 (0.83-6.90) | 2.22 (0.72-5.04) | 3.79* (1.37-8.18) |
| Eastern | 4.57* (1.14-11.07) | 4.51* (1.14-10.72) | 6.14* (1.57-14.44) |
| Country level variance (SE) | | 0.242 (0.123) | |
| % of total variance (partition) | | | |
| Individual level (%) | | 93.14 | |
| Country level (%) | | 6.86 | |

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

## 7.4 Oral impacts on daily life

### Variation between countries

There was a significant variation in oral impacts on daily life across countries (Table 7.7). Specifically, the country-level variance in Model 1 was 0.11 with a standard error of 0.04 which is evidence that the between-country variation was non-zero. In this empty model, 3% of the total variance in oral impacts was at the country level. The estimate of the MOR confirms that there was significant variation between countries in the probability of reporting oral impacts on daily life. However, compared to the other oral health outcomes analysed, oral impacts on daily life varied considerably less between European countries than functional dentition and edentulousness. This suggests that the variation of people's oral impacts is mainly caused by individual factors, as 97% of the total variation is located at the individual level.

### Individual-level characteristics

Estimates of the relationships between oral impacts and individual-level variables in Model 2 showed that women, older participants, and those in the lowest educational and occupational levels were more likely to report oral impacts on daily life. Specifically, those who stopped full-time education at 15 years or less had 20% higher odds of the outcome (OR=1.21, 95%CI: 1.07-1.36) than to those who stopped at 20 years or more. In turn, those in the routine/manual occupational social class were almost 40% more likely to report impacts than those in managerial or professional occupations (OR=1.37, 95%CI: 1.23-1.52). For oral impacts, the magnitude of the associations by SEP was smaller than for the oral health outcomes based on number of natural teeth (no functional dentition and edentulousness). Regarding the variation of oral impacts, results of Model 2 showed that 3% of the total variation in this oral health outcome was attributable to differences between countries after adjusting for individual-level characteristics. When individual-level variables were included (Model 2), the fit of the model improved (according to the

DIC score), but the country-level variance remained almost the same. This suggests that demographic and socioeconomic characteristics at the individual level did not explain the variance in oral impacts at the country level.

**Welfare state regimes**

Results of Model 3, which includes the welfare regime variables, showed that participants from the Scandinavian regime fared significantly better compared to those in the Bismarckian, Southern and Eastern regimes. Although the association between the Anglo-Saxon regime and the outcome was in the expected direction, there was no significant difference between the Anglo-Saxon and the reference category. The largest effect was observed for the Southern and Eastern regimes where the odds of reporting oral impacts was around two times larger than in the Scandinavian (OR=2.05 95%CI: 1.41-2.96 and OR=1.84 95%CI: 1.28-2.57 respectively). The association for the Bismarckian regime was also in the expected direction with an increase of almost 50% in the odds of reporting oral impacts (OR=1.45, 95%CI: 1.02-2.02) compared with the Scandinavian. Except for the Southern regime, the associations between welfare regimes and oral impacts were weaker than those observed for the other two oral health outcomes.

The inclusion of welfare regime variables resulted in a reduction of the country-level variance from 0.11 in Model 2 to 0.06 in Model 3. This decrease suggests that the welfare regime type helps to explain the variation in oral impacts on daily life between countries. Due to the decline in the country-level variance, the proportional variation at country level reduced from 3.3% to 1.8% and the MOR changed from 1.37 to 1.26. When the welfare regime variables were included, the fit of the model improved just marginally. With regard to associations between individual-level variables and oral impacts, their size and direction remained almost identical after the addition of welfare regime variables in Model 3.

Model 4 controls for all individual- and country-level variables simultaneously in a single multilevel logistic regression. Adding GDP per capita and GDP annual growth to the model resulted in an increase in the magnitude of the associations between

oral impacts and the Southern and Eastern regimes. On the other hand, the association with the Bismarckian regime declined and became non-significant. These results suggest that the significant associations initially observed in Model 3 for the Southern and Eastern regimes were not explained by economic development characteristics while the opposite is true for the Bismarckian regime. Adjusting for the economic development variables caused a slight increase in the country-level variance which means that GDP per capita and GDP annual growth rate did not explain the variation at the country level observed in Model 3. Consistent with findings for no functional dentition and edentulousness, the two economic variables did not show a significant association with the odds of reporting oral impacts (Model 4). The direction and magnitude of associations between oral impacts and individual-level variables did not change from those observed in Models 2 and 3. Finally, the MOR in Model 4 was still larger than one, meaning that there was some residual heterogeneity in oral impacts across countries which could be due to unobserved or unmeasured individual characteristics and to country-level factors not adjusted for in the model.

Table 7.7 - Two-level random intercept model for oral impacts on daily life with predictor variables (16,525 individuals nested within 21 countries)

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | | OR (95% CI) | | |
| **Individual-level variables** | | | | |
| Sex | | | | |
| Men | | 1.00 | 1.00 | 1.00 |
| Women | | 1.22** (1.13-1.31) | 1.22** (1.13-1.31) | 1.22** (1.13-1.31) |
| Age (centred on 51) | | 1.01** (1.01-1.02) | 1.01** (1.01-1.02) | 1.02** (1.01-1.02) |
| Marital status | | | | |
| Married/cohabiting | | 1.00 | 1.00 | 1.00 |
| Divorced/separated/widowed | | 1.10 (0.99-1.21) | 1.10* (1.00-1.21) | 1.10 (0.99-1.21) |
| Single | | 0.98 (0.87-1.09) | 0.98 (0.87-1.10) | 0.98 (0.88-1.10) |
| Education (Age when stop full-time education) | | | | |
| 20 years and older | | 1.00 | 1.00 | 1.00 |
| 16 - 19 years | | 1.10 (0.97-1.18) | 1.06 (0.96-1.16) | 1.06 (0.96-1.16) |
| Up to 15 years | | 1.21* (1.07-1.36) | 1.20* (1.06-1.35) | 1.19* (1.05-1.34) |
| Occupational social class | | | | |
| Managerial and professional | | 1.00 | 1.00 | 1.00 |
| Intermediate | | 1.12 (0.99-1.25) | 1.11 (0.99-1.24) | 1.11 (0.99-1.25) |
| Routine and manual | | 1.37** (1.23-1.52) | 1.37** (1.23-1.52) | 1.37** (1.23-1.53) |
| **Country-level variables** | | | | |
| Welfare state regime | | | | |
| Scandinavian | | | 1.00 | 1.00 |
| Bismarckian | | | 1.45* (1.02-2.02) | 1.41 (0.96-1.99) |
| Anglo-Saxon | | | 1.11 (0.68-1.69) | 1.12 (0.68-1.73) |
| Southern | | | 2.05** (1.41-2.96) | 2.14** (1.36-3.13) |
| Eastern | | | 1.84** (1.28-2.57) | 2.27* (1.24-3.84) |
| Mean GDPpc (2005-2009) | | | | 1.00 (1.00-1.01) |
| Mean growth GDP (2005-2009) | | | | 0.96 (0.86-1.08) |
| Country level variance (SE) | 0.108 (0.041) | 0.111 (0.042) | 0.060 (0.027) | 0.066 (0.033) |
| % of total variance (partition) | | | | |
| Individual level (%) | 96.83 | 96.74 | 98.20 | 98.03 |
| Country level (%) | 3.17 | 3.26 | 1.80 | 1.97 |
| % change in country-level var | - | 2.78 | -45.95 | 10.0 |
| MOR (95% CrI) | 1.37 (1.25-1.55) | 1.37 (1.25-1.56) | 1.26 (1.17-1.41) | 1.28 (1.17-1.45) |
| DIC | 17827.32 | 17492.16 | 17491.66 | 17492.02 |

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

**Interaction effects between SEP and welfare state regimes**

For the outcome of oral impacts on daily life, Table 7.8 shows results of Model 5a which includes cross-level interactions between education and welfare regimes while adjusting for all individual- and country-level variables. The findings revealed that adults in high and intermediate educational levels were more likely to report oral impacts in all welfare regimes, apart from the Anglo-Saxon one, when compared with high educated individuals in the Scandinavian regime. Within the Scandinavian regime, those in the lowest educational level showed a non-significant difference in the odds of oral impacts when compared with their counterparts in the highest educational category. Results of this Model 5a moreover showed larger odds ratios for the Southern and Eastern regime at all educational levels.

Results of fitting interaction terms between occupation and welfare regimes were similar to findings from the previous model in that, although estimates for the Anglo-Saxon regime were in the expected direction, none of them was statistically significant (Table 7.9). That was, however, the only exception to a general picture of significant odds ratios for all welfare regimes at each occupational level. Clear and significant occupational gradients were found in the Bismarckian, Southern and Scandinavian welfare regimes, where the likelihood of reporting oral impacts compared to the reference category, increased at each lower occupational level. In the Eastern regime, even though the associations were significant, they were less clearly linear and graded. Similar to findings for cross-level interaction analyses between regime type and education, higher odds of oral impacts on daily life were observed for those in Southern and Eastern countries at all occupational levels.

Table 7.8 - Two-level random intercept model for oral impacts with interaction effects between education and welfare state regime (16,525 individuals nested within 21 countries)

| | **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 | 1.46* (1.14-1.85) | 1.19 (0.87-1.57) |
| Bismarckian | 1.73* (1.08-2.55) | 1.62* (1.01-2.37) | 1.65* (1.01-2.46) |
| Anglo-Saxon | 1.09 (0.61-1.78) | 1.35 (0.80-2.13) | 1.40 (0.82-2.23) |
| Southern | 2.22* (1.36-3.44) | 2.29** (1.45-3.49) | 3.15** (2.00-4.77) |
| Eastern | 2.43* (1.35-4.09) | 2.50** (1.39-4.14) | 2.98** (1.64-5.07) |
| Country level variance (SE) | | 0.066 (0.031) | |
| % of total variance (partition) | | | |
| Individual level (%) | | 98.04 | |
| Country level (%) | | 1.96 | |

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

Table 7.9 - Two-level random intercept model for oral impacts with interaction effects between occupation and welfare state regime. (16,525 individuals nested within 21 countries)

| | **Model 5b** | | |
|---|---|---|---|
| | Occupational social class | | |
| | Managerial and professional | Intermediate | Routine and manual |
| | OR (95% CI) | | |
| Welfare state regime | | | |
| Scandinavian | 1.00 | 1.72** (1.27-2.29) | 1.76** (1.35-2.27) |
| Bismarckian | 1.83* (1.12-2.81) | 1.99* (1.22-3.04) | 2.34* (1.45-3.56) |
| Anglo-Saxon | 1.40 (0.76-2.37) | 1.76 (0.96-2.97) | 1.76 (0.99-2.90) |
| Southern | 2.51** (1.49-4.08) | 2.91** (1.80-4.64) | 3.83** (2.39-6.08) |
| Eastern | 3.08** (1.65-5.33) | 2.74** (1.48-4.77) | 3.80** (2.05-6.58) |
| Country level variance (SE) | | 0.067 (0.032) | |
| % of total variance (partition) | | | |
| Individual level (%) | | 98.00 | |
| Country level (%) | | 2.00 | |

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

## 7.5 Summary of main findings

- Using a multilevel approach, this analysis revealed that country-level characteristics accounted for up to 8 per cent of the variation in oral health outcomes. This proportional variation was similar for the two outcomes based on number of natural teeth while considerably lower for oral health related impacts on daily life.
- Findings on individual-level characteristics showed that being older and belonging to the lowest educational and occupational levels were consistently related to worse oral health. Analysis of SEP measures showed a generalized pattern of social gradients, with stronger associations for no functional dentition and edentulousness, whereas weaker and not always significant estimates were found for oral impacts on daily life.
- The analyses consistently showed that adults in the Eastern regime were more likely to have poor oral health than their counterparts in the Scandinavian regime. However, overall results did not show a clear regime-specific pattern.
- Associations between oral health and welfare regimes were stronger for no functional dentition. After adjustment for individual- and country-level characteristics, the Bismarckian, Anglo-Saxon and Eastern regimes had higher odds of having no functional dentition compared to the Scandinavian regime.
- For all three oral health outcomes, the variation at country-level reduced significantly when welfare regimes variables were introduced into the models. This indicates that grouping countries into welfare regimes contributes to explaining some of the variation in oral health among European countries.
- A larger proportion of the country-level variation was explained by welfare state regimes when the outcome was no functional dentition, compared to the other two outcomes analysed.
- Analyses of cross-level interaction terms suggested that adults in any occupational or educational level were better off in terms of no functional dentition in the Scandinavian regime than in other welfare regime. In addition, adults in the lowest educational and occupational categories in all welfare

regimes had higher odds of edentulousness than those in the reference group. In turn, participants at any SEP level in the Bismarckian, Southern and Eastern regimes were more likely to report oral impacts than those in the highest SEP level in the Scandinavian regime. Finally, the Eastern regime showed higher odds of poor oral health in all socioeconomic groups compared to the Scandinavian.

# Chapter 8 - Educational inequalities in oral health: a comparison of England and the United States

## 8.1 Introduction

In this chapter, educational inequalities in oral health are compared between two countries, England and the United States which are both in the Anglo-Saxon welfare state regime, but whose health care systems differ considerably. This comparison addresses objective 4 of the thesis. The analysis used data from the Adult Dental Health Survey (ADHS) 2009 for England, and the National Health and Nutrition Examination Survey (NHANES) 2005-2008 for the US. These two surveys were selected as they were nationally representative, were conducted during similar time periods, and had some comparable measures of oral health and SEP. Details of the surveys are given in the Methods chapter (Chapter 4, sections 4.1.2 and 4.1.3). For analyses in this chapter, the analytical sample in each country consisted of adults aged 25 years and over with complete data on the study variables. The final sample sizes were 8,719 in England and 9,786 in the US. When analysing clinical data, only dentate participants in the US were considered so that the sample was comparable with the English sample of adults with clinical information.

In England and the US, educational inequalities were examined for three measures of oral health using an analytical strategy similar to the one followed for analyses in Chapters 5 and 6. The three oral health measures were number of missing teeth, self-rated oral health (less than good) and oral impacts on daily life (any impact experienced 'fairly often' or 'very often' in the last 12 months). Inequalities in those outcomes were assessed by education, measured as educational attainment and categorized in three levels (see Chapter 4, section 4.2.2.2). Data were analysed in three main steps. First, population oral health was assessed in the two countries using age-standardized estimates of the mean number of missing teeth and prevalence rates of self-rated oral health and oral impacts. These estimates were

age standardized by the direct method, using the OECD 2009 age distribution as the standard. Second, the potential association between education and oral health was gauged by comparing age-standardized estimates across educational levels and by fitting multivariable regression models. Robust Poisson models were fitted for the binary outcomes of self-rated oral health and oral impacts to obtain prevalence ratios (PR), and a Poisson model was fitted for the count outcome of number of missing teeth to obtain incidence rate ratios (IRR). Third, relative and absolute inequalities were measured with the RII and the SII. For analyses presented in this chapter, as certain convergence issues occurred with log-binomial models, RII and SII were estimated using robust Poisson and linear regression models respectively. All regression models were adjusted for age, gender, marital status and ethnicity. In addition, all analyses took into account the complex sampling design variables and survey weights available in the two surveys to obtain population-based estimates.

## 8.2 Descriptive statistics

Table 8.1 presents descriptive characteristics of the study variables in analytical samples by country. The weighted percentage of demographic characteristics showed a fairly similar distribution by age groups in the two countries. Some minor differences appeared, however, with England showing a slightly higher percentage of adults aged 65 years and over, and the US a larger percentage in the group of 45-54 year olds. The distribution by gender was identical in the two countries (52% women and 48% men). Data on marital status showed that being married or cohabitee was more common among American than English adults, while the opposite was true for being single. With respect to ethnicity, the American sample included a larger proportion of Non-White population with 29% of adults in that category, whereas that proportion in England was 12%. Finally, the distribution of participants by categories of education was very similar in the two countries, with 27% of adults in the high level, around 54% in the intermediate and 19% in the low level (Table 8.1).

Table 8.1 - Baseline characteristics of the study samples by country (Adults aged ≥25 years)

| Characteristics | Weighted percentage (%) | |
|---|---|---|
| | England (n= 8,719) | US (n=9,786) |
| Age | | |
| 25 - 34 | 18.97 | 19.99 |
| 35 - 44 | 21.67 | 22.33 |
| 45 - 54 | 19.14 | 23.70 |
| 55 - 64 | 17.07 | 15.46 |
| ≥ 65 | 23.16 | 18.51 |
| Gender | | |
| Men | 48.05 | 47.95 |
| Women | 51.95 | 52.05 |
| Marital status | | |
| Married/living with partner | 57.35 | 68.02 |
| Single (never married) | 21.09 | 11.49 |
| Separated/divorced | 12.40 | 13.64 |
| Widowed | 9.16 | 6.86 |
| Ethnicity | | |
| White (non-Hispanic) | 88.47 | 71.26 |
| Non-White | 11.54 | 28.74 |
| Educational attainment | | |
| High (college degree or above) | 26.45 | 27.33 |
| Medium (high school or more but not college degree) | 54.63 | 53.69 |
| Low (no qualifications - below high school) | 18.91 | 18.98 |

## 8.3 Population oral health in England and the US

The three measures of oral health used in this analysis were first compared between the two countries using age-standardized estimates. Mean number of missing teeth and prevalence rates of self-rated oral health and oral impacts are shown for each country in Table 8.2. The mean number of missing teeth was significantly lower in England (6.97 SE=0.09) than in the US (7.31 SE=0.15). Prevalence rates of self-rated oral health were almost identical in the two countries

with 31% of adults classifying their oral health as less than good. In turn, prevalence of reported oral impacts was slightly higher in England, although not significantly different from the prevalence rate in the US.

Findings by gender indicated that women in the two countries had a marginally higher mean number of missing teeth compared to men. Although there were no significant differences by gender in prevalence rates of less than good self-rated oral health, the prevalence tended to be larger among men. On the other hand, and in line with findings from Chapter 6, the prevalence rates of oral impacts tended to be higher among women. In terms of the comparison between the two countries, estimates by gender mirrored those of the pooled sample. The observed significant difference between England and the US in number of missing teeth was also seen among both male and female, while for the other two oral health measures differences between the two countries were not significant (Table 8.2).

Table 8.2 - Age-standardized mean or prevalence of oral health measures in England and the US

| | **England** | | **US** | |
|---|---|---|---|---|
| | Mean or Prevalence | SE or 95% CI | Mean or Prevalence | SE or 95% CI |
| **Total** | | | | |
| Number of missing teeth | 6.97 | 0.09 | 7.31 | 0.15 |
| Self-rated oral health | 30.84 | 29.50, 32.18 | 31.37 | 29.81, 32.93 |
| Oral impacts | 15.07 | 14.05, 16.08 | 13.46 | 12.39, 14.52 |
| **Women** | | | | |
| Number of missing teeth | 7.09 | 0.11 | 7.44 | 0.17 |
| Self-rated oral health | 28.67 | 26.99, 30.35 | 30.14 | 28.29, 31.99 |
| Oral impacts | 17.15 | 15.77, 18.52 | 15.70 | 13.89, 17.50 |
| **Men** | | | | |
| Number of missing teeth | 6.85 | 0.13 | 7.20 | 0.18 |
| Self-rated oral health | 33.12 | 31.37, 34.88 | 32.67 | 30.61, 34.74 |
| Oral impacts | 12.89 | 11.68, 14.09 | 11.07 | 10.03, 12.10 |

## 8.4 Relationship between oral health and education

The potential association between education and the three measures of oral health was evaluated by comparing age-standardized estimates across educational levels and by fitting multivariable regression models. Results of those analyses are presented in this section.

**Oral health by levels of educational attainment**

Age-standardized measures of oral health by levels of education showed a consistent pattern of gradients in the two countries (Table 8.3). Namely, participants at each consecutively lower level of educational attainment had more missing teeth, rated their oral health as less than good more frequently, and experienced more oral impacts. These educational gradients appeared steeper in the US than in England, particularly for self-rated oral health. For that outcome, in the US, the prevalence among adults with no formal education was almost 20 percentage points higher than among those with a high school level, and 37 percentage points higher than among those with a college degree.

When adults belonging to the same educational level were compared between countries, results revealed a mixed picture (Table 8.3). Those in the lowest educational level tended to be better off in terms of oral health in England. The largest difference was for self-rated oral health, with an age-standardized prevalence rate of 37.39 (95%CI: 33.77, 41.02) in England vs. 52.13 (95%CI: 49.33, 54.94) in the US. However, the difference between the two countries was not significant for oral impacts. Adults in the intermediate level of education had a lower number of missing teeth in England, a lower prevalence of oral impacts in the US, while self-rated oral health showed similar prevalence in the two countries. Subjects in the highest level of education tended to have better oral health in the US, although estimates were only significantly different for the outcome of less than good self-rated oral health (prevalence rate of 15.49 (95%CI: 13.61, 17.38) in the US vs. 24.53 (95%CI: 22.41, 26.65) in England).

Table 8.3 - Age-standardized estimates of oral health by education in England and the US

| Educational level | England | US |
|---|---|---|
| | Mean (SE) or Prevalence (95% CI) | |
| | Number of missing teeth [a] | |
| High | 5.70 (0.16) | 5.56 (0.14) |
| Medium | 7.06 (0.12) | 7.51 (0.17) |
| Low | 8.19 (0.23) | 9.58 (0.25) |
| | Self-rated oral health [b] | |
| High | 24.53 (22.41, 26.65) | 15.49 (13.61, 17.38) |
| Medium | 32.01 (30.38, 33.64) | 32.51 (30.85, 34.18) |
| Low | 37.39 (33.77, 41.02) | 52.13 (49.33, 54.94) |
| | Oral impacts [b] | |
| High | 10.31 (8.87, 11.76) | 8.01 (6.61, 9.41) |
| Medium | 16.40 (15.15, 17.64) | 13.62 (12.14, 15.09) |
| Low | 20.94 (17.68, 24.19) | 21.15 (19.23, 23.07) |

[a] Estimates reported are Mean (SE).
[b] Estimates reported are Prevalence rates (95% CI).

**Association between oral health and education using PR and IRR**

Table 8.4 shows results of the models fitted to assess the association between oral health and education while adjusting for age, gender, marital status and ethnicity. These models were fitted to obtain IRRs for the count outcome of number of missing teeth and PRs for the dichotomous outcomes of self-rated oral health and oral impacts. Findings showed that all associations were significant in both England and the US. These associations were also in the expected direction whereby adults in lower educational levels had higher PR or IRR than those in the highest level of education. For example, the mean number of missing teeth among adults with no educational qualifications was 49% higher than among those with a degree level in England, and 67% higher in the US. PRs for oral impacts suggested that, in the two countries, the probability of having experienced any oral impact in the last 12 months was significantly higher among subjects in low and medium educational levels compared to the reference category. Furthermore, findings for self-rated oral

health indicated associations of significantly larger magnitude in the US with a PR of 2.14 (95%CI: 1.85, 2.48) for adults in intermediate educational level and 2.97 (95%CI: 2.58, 3.42) for those with no qualifications (Table 8.4).

In the two countries, the pattern exhibited by these findings was of generalized educational gradients with a higher probability of negative oral health outcomes at each successive lower educational level. These gradients tended to steeper in the US, most notably for self-rated oral health (Figure 8.1).

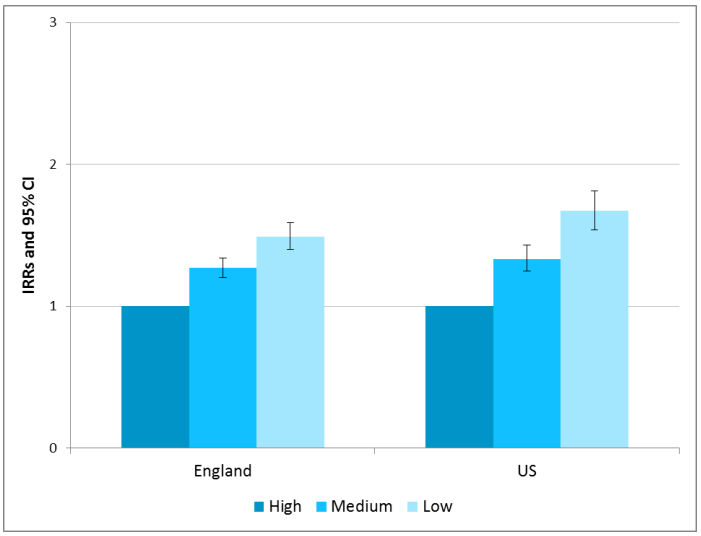
Table 8.4 - Regression analysis of the association between oral health and education in England and the US

| Oral health outcome and educational level | **England** | **US** |
|---|---|---|
| | PR or IRR (95% CI) | |
| Number of missing teeth [a] | | |
| High (Ref) | 1.00 | 1.00 |
| Medium | 1.27 (1.20, 1.34) | 1.33 (1.25, 1.43) |
| Low | 1.49 (1.40, 1.59) | 1.67 (1.54, 1.81) |
| *p*-value for trend | <0.001 | <0.001 |
| Self-rated oral health [b] | | |
| High (Ref) | 1.00 | 1.00 |
| Medium | 1.35 (1.22, 1.50) | 2.14 (1.85, 2.48) |
| Low | 1.59 (1.42, 1.78) | 2.97 (2.58, 3.42) |
| *p*-value for trend | <0.001 | <0.001 |
| Oral impacts [b] | | |
| High (Ref) | 1.00 | 1.00 |
| Medium | 1.72 (1.48, 2.00) | 1.75 (1.44, 2.12) |
| Low | 2.06 (1.68, 2.52) | 2.58 (2.04, 3.27) |
| *p*-value for trend | <0.001 | <0.001 |

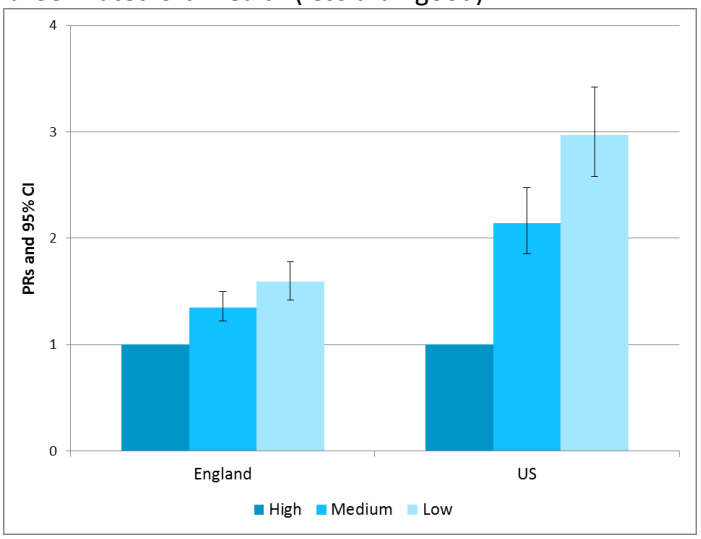
[a] Estimates reported are incidence rate ratios (IRRs).
[b] Estimates reported are prevalence ratios (PRs).

Figure 8.1 - Regression analysis of the association between oral health and educational level in England and the US

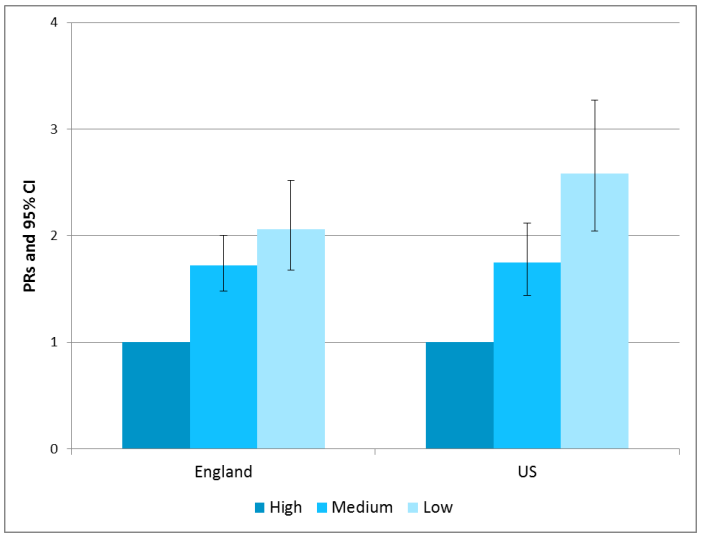
a. Number of missing teeth




b. Self-rated oral health (less than good)




c. Oral impacts



*Sensitivity analysis*

Consistent with sensitivity analyses performed in Chapters 5 and 6, values of PRs presented in this chapter for the binary outcomes of self-rated oral health and oral impacts were compared to the respective ORs. As expected, OR estimates were larger in magnitude compared to PRs. That was the case for the two outcomes in both countries (Table A2.4 in Appendix 2). Both estimates (PR and OR) showed significant associations that were in the same direction.

## 8.5 Relative and absolute inequalities using the RII and SII

In this section, educational inequalities in oral health are compared between England and the US using the RII and SII. For these analyses, as few models did not converge when using log-binomial regression, the indices were estimated with robust Poisson regression models for RII and linear regression models for SII. To keep consistency with adjustments employed in the previous section, models to estimate RII and SII also included as covariates age, gender, marital status and ethnicity. Details about the indices are given in Chapter 4. The RII and SII measure relative and absolute inequalities respectively and values larger than one of RII and larger than zero of SII are considered significant. For both indices, higher estimates indicate larger magnitude of inequalities.

The results of relative educational inequalities, measured by the RII are presented in Table 8.5 and Figure 8.2. All values of RII and their 95%CIs were larger than one, indicating significant relative inequalities in the three oral health outcomes both in England and the US. These results also signified that missing teeth, less than good oral health and oral impacts were more frequent among adults in lower levels of education in the two countries.

Relative educational inequalities in oral health tended to be higher in the US compared to England. The difference in the magnitude of relative inequalities between the two countries was particularly large and significant for self-rated oral

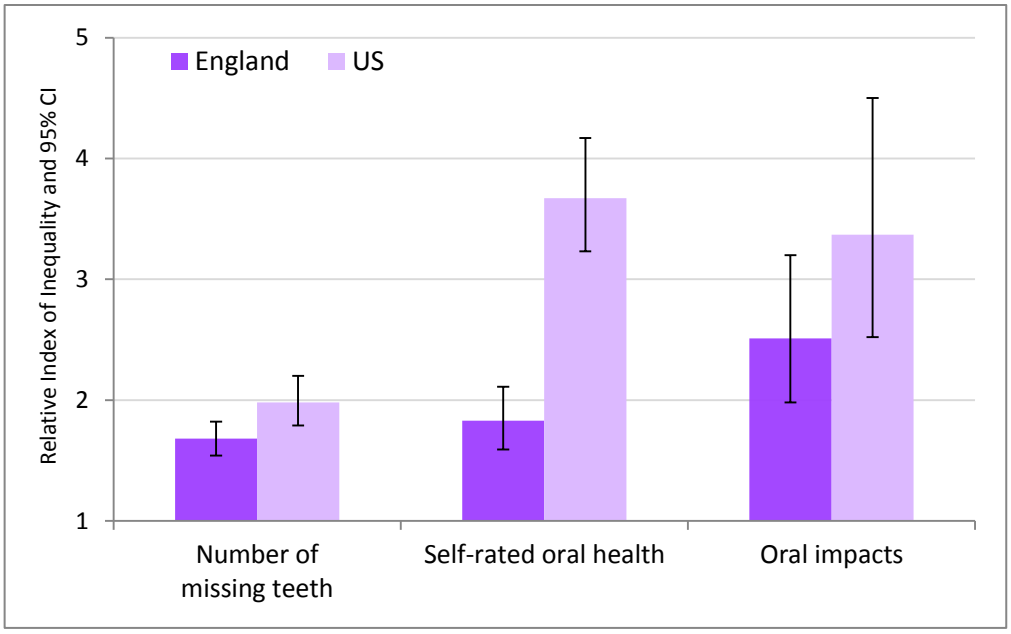
health (Figure 8.2). For that outcome, RII was 3.67 (95%CI: 3.23, 4.17) in the US compared to 1.83 (95%CI: 1.59, 2.11) in England. This finding is consistent with results of prevalence ratios which revealed that associations between education and self-rated oral health were significantly stronger in the US.

Table 8.5 - Relative educational inequalities in oral health measures, England and the US

| | England | US |
|---|---|---|
| | RII (95% CI) | RII (95% CI) |
| Number of missing teeth | 1.68 (1.54, 1.82)** | 1.98 (1.79, 2.20)** |
| Self-rated oral health | 1.83 (1.59, 2.11)** | 3.67 (3.23, 4.17)** |
| Oral impacts | 2.51 (1.98, 3.20)** | 3.37 (2.52, 4.50)** |

RII: Relative Index of Inequality
*p<0.05, **p<0.01

Figure 8.2 - Relative educational inequalities in oral health, England and the US




Results for absolute inequalities, measured by the SII, are presented in Table 8.6. As the SII is influenced by the prevalence (or mean) of the oral health outcome, prevalence rates of self-rated oral health and oral impacts, and the mean number of

missing teeth are presented together with SIIs in Table 8.6. Estimates of SII were consistently larger than zero, suggesting significant educational inequalities in absolute terms in both countries. For example, in the US the SII for missing teeth was 5.00 (95%CI: 4.14, 5.86) and represents the adjusted difference in number of missing teeth between the two extremes of the educational hierarchy. The size of the SII for the same outcome in England was 3.66 (95%CI: 3.05, 4.28).

In common with findings for relative inequalities, results of SII showed that absolute educational inequalities in oral health were consistently higher in the US compared to England. Moreover, the most clear and significant difference between the two countries was for self-rated oral health. For this measure of oral health, the SII in the US was 42.55 (95%CI: 38.14, 46.96) while it was 18.43 (95%CI: 14.01, 22.85) in England. This finding is in agreement with the observed pattern of age-standardized prevalence rates by educational level where the gradient in self-rated oral health was markedly steeper in the US.

Table 8.6 - Absolute educational inequalities in oral health measures, England and the US

| | Mean (SE) or prevalence (95% CI) | SII (95% CI) |
|---|---|---|
| Number of missing teeth | | |
| England | 6.97 (0.09) | 3.66 (3.05, 4.28)** |
| US | 7.31 (0.15) | 5.00 (4.14, 5.86)** |
| Self-rated oral health | | |
| England | 30.84 (29.50, 32.18) | 18.43 (14.01, 22.85)** |
| US | 31.37 (29.81, 32.93) | 42.55 (38.14, 46.96)** |
| Oral impacts | | |
| England | 15.07 (14.05, 16.08) | 13.51 (10.08, 16.95)** |
| US | 13.46 (12.39, 14.52) | 16.72 (12.90, 20.54)** |

SII: Slope Index of Inequality

*p<0.05, **p<0.01 for SII

Estimates of RII and SII stratified by gender indicated that the differences in the magnitude of inequalities between England and the US tended to be more pronounced among women for the two subjective measures, and slightly more pronounced among men for the clinical measure, number of missing teeth. Gender-stratified findings mirrored those from the pooled sample in that significantly higher RIIs and SIIs in the US compared to England were observed for the outcome of self-rated oral health (Tables 8.7 and 8.8).

Table 8.7 - Relative educational inequalities in oral health by gender, England and the US

| | England | US |
|---|---|---|
| | RII (95% CI) | RII (95% CI) |
| **Female** | | |
| Number of missing teeth | 1.66 (1.50, 1.84)** | 1.90 (1.71, 2.10)** |
| Self-rated oral health | 1.74 (1.41, 2.16)** | 3.71 (3.19, 4.32)** |
| Oral impacts | 2.29 (1.66, 3.16)** | 3.42 (2.43, 4.81)** |
| **Male** | | |
| Number of missing teeth | 1.72 (1.53, 1.93)** | 2.10 (1.82, 2.42)** |
| Self-rated oral health | 1.92 (1.53, 2.41)** | 3.63 (3.10, 4.27)** |
| Oral impacts | 2.89 (1.95, 4.27)** | 3.33 (2.08, 5.33)** |

RII: Relative Index of Inequality. *p<0.05, **p<0.01

Table 8.8 - Absolute educational inequalities in oral health by gender, England and the US

| | England | US |
|---|---|---|
| | SII (95% CI) | SII (95% CI) |
| **Female** | | |
| Number of missing teeth | 3.64 (2.88, 4.40)** | 4.78 (3.92, 5.64)** |
| Self-rated oral health | 15.74 (9.67, 21.81)** | 41.44 (36.01, 46.87)** |
| Oral impacts | 13.79 (8.66, 18.91)** | 20.00 (13.71, 26.29)** |
| **Male** | | |
| Number of missing teeth | 3.79 (2.90, 4.67)** | 5.32 (4.13, 6.52)** |
| Self-rated oral health | 21.23 (13.74, 28.72)** | 43.81 (38.10, 49.51)** |
| Oral impacts | 13.43 (8.51, 18.34)** | 13.75 (8.54, 18.95)** |

SII: Slope Index of Inequality. *p<0.05, **p<0.01

Relative and absolute educational inequalities in oral health were also estimated by age groups. These analyses revealed that, although inequalities in number of missing teeth were not significantly different between the two countries in the unstratified analysis, there was a significant difference for the group of older adults (≥65 years) with larger inequalities in the US (Figure 8.3). This finding held for inequalities in absolute (SII) and relative (RII) terms (Tables 8.9 and 8.10). Another interesting result of the analysis stratified by age groups was seen for self-rated oral health. For this outcome, the significantly larger inequalities in the US observed for the pooled sample mainly reflected the high level of educational inequalities among younger people (Figure 8.4). For adults aged 45 years and over, although inequalities were consistently larger in the US, they were less pronounced and not significantly different from those in England. Finally, for reported oral impacts, the magnitude of inequalities did not differ significantly between England and the US in all age groups (Figure 8.5). The stratified results suggested that inequalities were similar between the two countries or even slightly larger in England for adults aged 45-64 years (Tables 8.9 and 8.10).

Figure 8.3 - Relative educational inequalities in number of missing teeth by age groups, England and the US

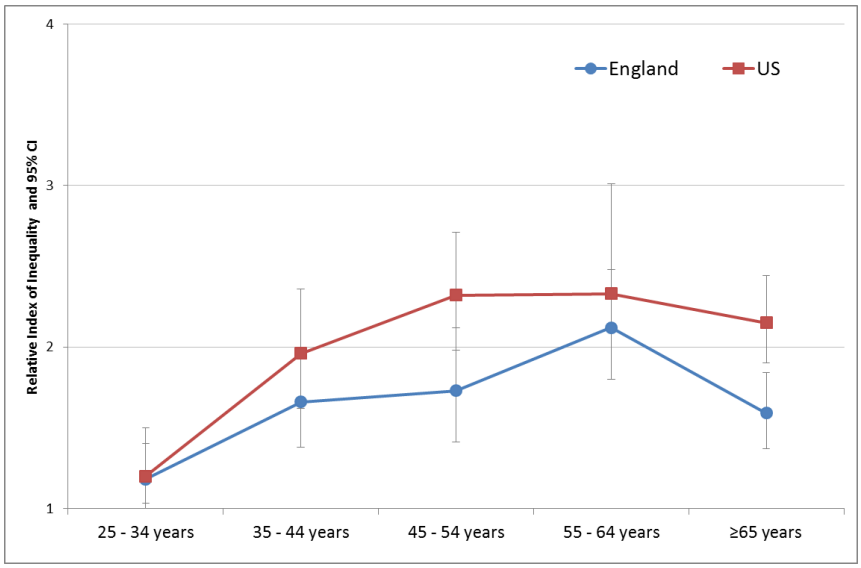


Figure 8.4 - Relative educational inequalities in self-rated oral health by age groups, England and the US

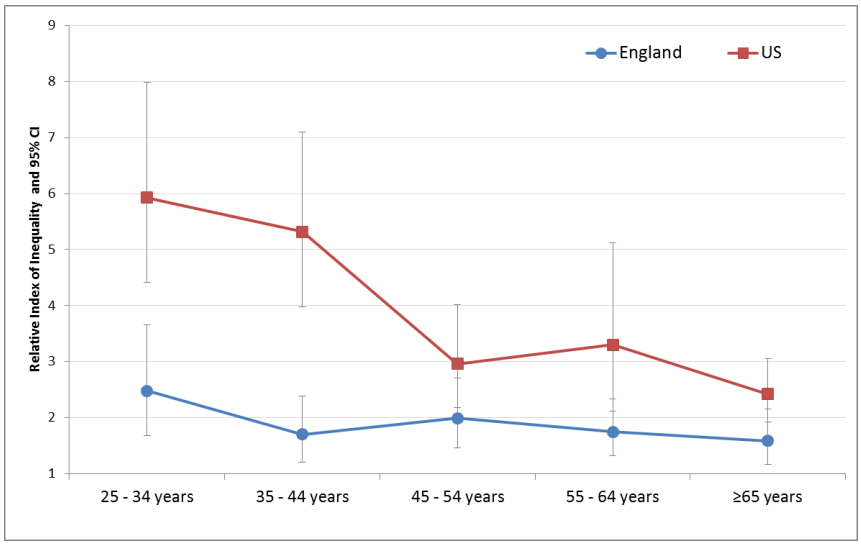
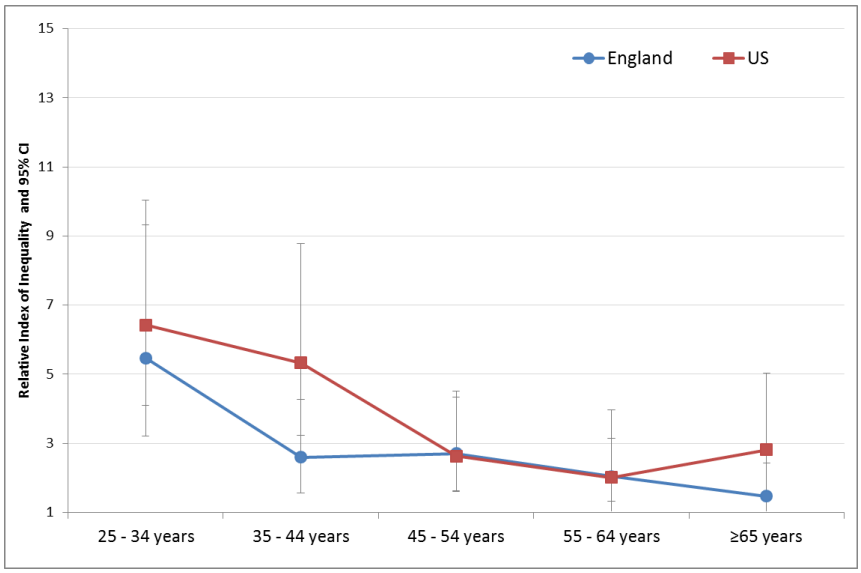



Figure 8.5 - Relative educational inequalities in oral impacts by age groups, England and the US




*Sensitivity analysis*

As there were differences in ethnic composition between England and the US, a sensitivity analysis was conducted restricting both analytical samples to the White population. The main regression analyses presented in this chapter were carried out using the alternative samples and results were not sensitive to this specification (see Tables A5.1 to A5.3 in Appendix 5). Therefore, the different ethnic composition

did not explain larger inequalities in the US found in this analysis. In fact, inequalities in missing teeth became significantly higher in the US compared to England when only the White population was considered.

Table 8.9 - Relative educational inequalities in oral health by age group, England and the US

| Age groups | Number of missing teeth | | Self-rated oral health | | Oral impacts | |
|---|---|---|---|---|---|---|
| | England | US | England | US | England | US |
| | RII (95% CI) | | | | | |
| 25 - 34 years | 1.18 (0.92, 1.50) | 1.20 (1.03, 1.40)* | 2.48 (1.68, 3.66)** | 5.93 (4.41, 7.99)** | 5.47 (3.21, 9.33)** | 6.42 (4.10, 10.05)** |
| 35 - 44 years | 1.66 (1.38, 2.00)** | 1.96 (1.62, 2.36)** | 1.70 (1.21, 2.39)** | 5.32 (3.98, 7.10)** | 2.60 (1.57, 4.28)** | 5.33 (3.24, 8.78)** |
| 45 - 54 years | 1.73 (1.41, 2.12)** | 2.32 (1.98, 2.71)** | 1.99 (1.46, 2.71)** | 2.96 (2.18, 4.02)** | 2.70 (1.62, 4.50)** | 2.63 (1.60, 4.34)** |
| 55 - 64 years | 2.12 (1.80, 2.48)** | 2.33 (1.80, 3.01)** | 1.75 (1.32, 2.33)** | 3.30 (2.12, 5.12)** | 2.04 (1.32, 3.15)** | 2.01 (1.02, 3.96)* |
| ≥65 years | 1.59 (1.37, 1.84)** | 2.15 (1.90, 2.44)** | 1.59 (1.17, 2.16)** | 2.42 (1.92, 3.05)** | 1.47 (0.90, 2.42) | 2.81 (1.58, 5.03)** |

RII: Relative Index of Inequality. *p<0.05, **p<0.01

Table 8.10 - Absolute educational inequalities in oral health by age group, England and the US

| Age groups | Number of missing teeth | | Self-rated oral health | | Reporting ≥1 oral impact | |
|---|---|---|---|---|---|---|
| | England | US | England | US | England | US |
| | SII (95% CI) | | | | | |
| 25 - 34 years | 0.49 (-0.27, 1.26) | 0.72 (0.09, 1.36)* | 26.57 (14.87, 38.27)** | 52.50 (43.63, 60.46)** | 26.18 (18.09, 34.27)** | 22.10 (16.87, 27.33)** |
| 35 - 44 years | 2.17 (1.32, 3.02)** | 3.50 (2.39, 4.61)** | 15.51 (5.34, 25.68)** | 52.27 (42.68, 61.85)** | 14.34 (7.02, 21.65)** | 24.67 (17.86, 31.49)** |
| 45 - 54 years | 3.22 (1.99, 4.45)** | 5.81 (4.59, 7.03)** | 23.84 (12.90, 34.78)** | 40.94 (29.54, 52.35)** | 16.03 (7.96, 24.11)** | 14.69 (6.72, 22.65)** |
| 55 - 64 years | 6.45 (5.03, 7.87)** | 8.02 (5.53, 10.51)** | 18.45 (9.31, 27.59)** | 40.80 (26.95, 54.66)** | 12.06 (4.76, 19.36)** | 10.41 (0.64, 20.19)* |
| ≥65 years | 5.79 (4.01, 7.57)** | 9.08 (7.77, 10.38)** | 12.68 (4.65, 20.72)** | 27.44 (19.83, 35.04)** | 4.51 (-1.25, 10.27) | 12.07 (4.99, 19.15)** |

SII: Slope Index of Inequality. *p<0.05, **p<0.01

## 8.6 Summary of main findings

- The comparison of age-standardized oral health indicators between England and the US showed that the mean number of missing teeth was significantly lower in England (6.97, SE=0.09) compared to the US (7.31 SE=0.15). Prevalence rates of the other two oral health measures were not significantly different between countries. Less than good perceived oral health was as prevalent in England (30.8%) as it was in the US (31.4%), while oral impacts were marginally, but not significantly, more prevalent in England (15.1%) than in the US (13.46%).
- When age-standardized measures of oral health were estimated by levels of educational attainment, results revealed a consistent pattern of educational gradients in the two countries. Specifically, adults at each lower level of education had more missing teeth, rated more frequently their oral health as less than good, and reported experiencing more oral impacts. These gradients in oral health by educational attainment were steeper in the US than in England, particularly for the self-rated oral health measure.
- After adjusting for age, gender, ethnicity and marital status, there were strong and significant associations between oral health and education in the two countries. These associations were in the expected direction with higher PRs and IRRs among those in lower educational levels. In the two countries, the pattern exhibited by these adjusted estimates confirmed the existence of educational gradients with a higher probability of negative oral health outcomes at each consecutive lower educational level. These gradients tended to be steeper in the US, particularly for self-rated oral health.
- Significant relative (RII) and absolute (SII) educational inequalities were found in the two countries for all oral health measures. These inequalities were consistently higher in the US compared to England, and significantly different among the two countries for self-rated oral health. For that oral health measure, RII was 3.67 (95%CI: 3.23, 4.17) in the US and 1.83 (95%CI: 1.59, 2.11) in England. SII values were in 42.55 (95%CI: 38.14, 46.96) in the US and 18.43 (95%CI: 14.01, 22.85) in England.

- Results of the indices of inequality by gender revealed that differences between England and the US in the magnitude of inequalities tended to be more pronounced in women for the two subjective measures of oral health, while slightly more pronounced in men for number of missing teeth. This held true for absolute and relative inequalities.
- RII and SII stratified by age groups showed that inequalities in number of missing teeth were significantly larger in the US only in the group of adults aged 65 years and over. Among subjects aged 25-44 years the inequalities in self-rated oral health were markedly higher in the US and significantly different from those in England.

# Chapter 9 - Discussion

The main aim of this thesis was to examine the relationship between socioeconomic inequalities in oral health and certain welfare state regimes in Europe and the US. The overall working hypothesis was that different types of welfare state have the potential to affect both oral health and oral health inequalities. In line with that, it was hypothesised that lower levels of socioeconomic position (SEP) would be associated with poorer oral health outcomes, and that the magnitude of inequalities would differ across welfare regimes.

Although levels of oral health across welfare regimes were consistent with the hypothesis of better population oral health in the welfare regime with more generous, redistributive and universal welfare policies, the results relating to socioeconomic inequalities in oral health were not clear cut. Contrary to expectations, the findings did not support the hypothesis of lower inequalities in the Scandinavian regime. In fact, there was evidence of some larger inequalities in the Scandinavian regime compared to other welfare regimes. The comparison of the magnitude of relative inequalities (RII) and absolute inequalities (SII) across welfare regimes indicated some significant differences. Educational inequalities in no functional dentition and occupational inequalities in edentulousness were both larger, in relative terms, in the Scandinavian regime. In addition, together with the Anglo-Saxon regime, the Scandinavian displayed larger absolute educational inequalities in oral impacts. Other significant differences between welfare regimes revealed that the Southern regime had larger SII by SSS in no functional dentition and edentulousness, and larger RII by education in edentulousness. Also, larger absolute occupational inequalities in no functional dentition were identified in the Eastern regime. Finally, when significant gender interactions were found, inequalities were larger among women for the two outcomes based on number of teeth, while the opposite was true for inequalities in oral impacts.

Table 9.1 gives an overview of the main findings on the comparison of population oral health and oral health inequalities across welfare state regimes.

Table 9.1 - Summary of findings - oral health and oral health inequalities in welfare regimes

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="3">Oral health outcome</td></tr>
<tr><td>No functional dentition</td><td>Edentulousness</td><td>Oral impacts</td></tr>
<tr><td colspan="2" rowspan="2">Age-standardized prevalence rates (population oral health)</td><td colspan="2" rowspan="2">Lowest in the Scandinavian</td><td>Lowest in the Scandinavian and Bismarckian</td></tr>
<tr><td>Highest in the Southern</td></tr>
<tr><td rowspan="3">Pattern of prevalence rates by SEP levels</td><td>Education</td><td rowspan="2">Social gradients</td><td rowspan="2">Social gradients</td><td rowspan="3">Social gradients, U-shapes, J-shapes</td></tr>
<tr><td>Occupation</td></tr>
<tr><td>SSS</td><td>Social gradients, U-shapes, J-shapes</td></tr>
<tr><td rowspan="3">Associations SEP-oral health (PRs)</td><td>Education</td><td colspan="2" rowspan="2">PRs mostly on the expected direction and few non-significant</td><td rowspan="3">PRs mostly on the expected direction with more than half being non-significant</td></tr>
<tr><td>Occupation</td></tr>
<tr><td>SSS</td><td>PRs mostly on the expected direction with more than half being non-significant</td><td>Almost all PRs were non-significant</td></tr>
<tr><td rowspan="3">Relative inequalities (RII)</td><td rowspan="2">Education</td><td>Larger in the Scandinavian</td><td>Larger in the Southern</td><td rowspan="2"></td></tr>
<tr><td>Lower in the Southern</td><td>Lower in the Eastern</td></tr>
<tr><td rowspan="2">Occupation</td><td rowspan="2"></td><td>Larger in the Scandinavian</td><td rowspan="2"></td></tr>
<tr><td>Lower in the Eastern</td></tr>
<tr><td>SSS</td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">Absolute inequalities (SII)</td><td rowspan="2">Education</td><td rowspan="2"></td><td rowspan="2"></td><td>Larger in the Anglo-Saxon and Scandinavian</td></tr>
<tr><td>NS in the Bismarckian and Eastern</td></tr>
<tr><td rowspan="2">Occupation</td><td>Larger in the Eastern</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Lower in the Bismarckian</td></tr>
<tr><td rowspan="2">SSS</td><td>Larger in the Southern</td><td>Larger in the Southern</td><td rowspan="2"></td></tr>
<tr><td>NS in the Anglo-Saxon Low in Bismarckian</td><td>NS in the Anglo-Saxon and Eastern</td></tr>
</table>

Empty cells indicate that there was no evidence of significant differences in RII or SII across welfare regimes.

In addition to these findings by welfare state regimes, the last analysis of this thesis explored oral health and patterns of inequalities in England and the US. Results were consistent with the hypothesis of lower inequalities in England compared to the US. Moreover, the comparison of oral health status between the two countries showed that the number of missing teeth was significantly lower in England.

The abovementioned and other main findings of the thesis are summarized and discussed in the light of the existing literature in the following sub-sections. In addition, this chapter discusses strengths and limitations, and implications for policies and future research.

## 9.1 Oral health inequalities across welfare state regimes

In general, findings of the analysis were consistent with the expected association between lower levels of SEP and poorer oral health outcomes in all the European welfare state regimes. There were, however, certain differences in results according to the outcome measure, SEP indicator and welfare regime. Higher prevalence rates of no functional dentition were observed at each consecutive lower level of education, occupation and subjective social status in all welfare regimes analysed. Social gradients were also found in edentulousness for education and occupation, but not for SSS. The only exception to educational gradients in edentulousness was in the Southern regime, where a J-shaped pattern appeared. Also, adults in lower SEP tended to experience more impacts, although prevalence rates by SEP exhibited a combination of social gradients, U-shaped and J-shaped patterns. In summary, prevalence rates by SEP revealed generalized social gradients in no functional dentition, educational and occupational gradients in edentulousness, and mixed patterns in oral impacts.

When prevalence rates only for adults in the lowest socioeconomic levels were compared between regimes, those in the Scandinavian regime tended to fare better for the two outcomes based on number of teeth, while those in the Bismarckian fared better for oral impacts. In the same socioeconomic categories, those in the

Eastern regime fared worse in edentulousness and number of natural teeth and those in the Southern regime fared worse for oral impacts.

After adjusting for age, gender and marital status, the associations between SEP and oral health were generally in the expected direction with higher PRs among those in lower SEP levels. For example, prevalence ratios (PRs) of no functional dentition for manual workers compared to managers and professionals, were 2.23 (95%CI: 1.78-2.79) in the Scandinavian regime, 1.35 (95%CI: 1.13-1.60) in the Bismarckian, 1.99 (95%CI: 1.44-2.76) in the Anglo-Saxon, 1.79 (95%CI: 1.25-2.56) in the Southern, and 1.60 (95%CI: 1.35-1.90) in the Eastern (Chapter 5, Table 5.8). However, certain associations between SEP and oral health were not consistently significant, in particular, when SSS was used as the SEP measure. For example, PRs of edentulousness by SSS were only significant in the two lowest SSS ranks in the Scandinavian regime (Chapter 5, Table 5.9).

All estimates of the relative and slope indices of inequality were in the expected direction, suggesting that negative oral outcomes tended to be more common among adults in disadvantaged socioeconomic circumstances. Estimates of RII and SII were, however, not always significant. Different patterns of significance appeared according to the outcome, SEP indicator and nature of the inequalities (absolute and relative). There were consistent significant educational and occupational inequalities in no functional dentition and edentulousness in all welfare regimes, in both relative and absolute terms. Estimates of the RII and SII were less consistently significant by SSS with non-significant estimates in the Anglo-Saxon regime for the two oral health outcomes, and in the Eastern regime for edentulousness (Chapter 5, Tables 5.10 and 5.11). Results of inequalities in oral impacts were more mixed and showed a larger number of non-significant RII and SII. The only welfare regime that exhibited significant relative and absolute inequalities in oral impacts by all SEP indicators was the Scandinavian (Chapter 6, Table 6.7).

The comparison on the magnitude of inequalities across welfare regimes indicated some significant differences that were summarized at the beginning of this chapter. Overall, the comparison showed a complex picture with different welfare regimes showing larger and lower inequalities for particular combinations of outcome, SEP indicator and type of the inequalities (absolute or relative).

Results of this study are in line with literature reviews on the topic showing that: 1) contrary to expectations from the welfare state theory, socioeconomic inequalities in health are not systematically lower in the Scandinavian (social democratic) countries when compared to other welfare states, and 2) there is not a consistent pattern of health inequalities across welfare state regimes (28, 37, 150, 154). In particular, largest relative educational inequalities in the Scandinavian regime, found in this thesis for no functional dentition, have also been reported in previous analyses in relation to general health. A comparison of 11 European countries revealed higher levels of relative inequalities in self-reported morbidity by education level in Sweden, Denmark and Norway compared to Spain, Switzerland, the Netherlands, Germany, Finland, Great Britain, France, and Italy (81). Another study of the same group of countries reported that Norway and Sweden had larger RIIs for perceived general health by levels of educational attainment (80). Additionally, larger relative educational inequalities in self-rated general health were found by Eikemo et al. (164) in the Scandinavian regime compared to the Eastern and Anglo-Saxon welfare types. Eikemo and collaborators also observed the largest relative educational inequalities in the Southern regime, in agreement with findings of this study on edentulousness.

On the other hand, results of this thesis showing larger relative educational inequalities in the Scandinavian regime disagree with findings from some studies. For example, Borrell et al., (95) compared 13 European countries grouped according to the Navarro and Shi typology and observed lowest relative educational inequalities in the Scandinavian/Social democratic regime for men's self-reported health. Also, two studies based on SHARE data noticed either non-significant or lowest inequalities in Scandinavian countries (180, 181). Finally, educational

inequalities in 'sickness', defined as non-employment in people with long standing illness, were lower among working age women in the Scandinavian regime compared to their counterparts in the Bismarckian, Anglo-Saxon, Eastern and Southern regimes (182).

Results for oral impacts and also those for absolute inequalities in no functional dentition are consistent with previous analyses on general health measures by suggesting lower educational inequalities in Bismarckian countries. In a comparison of 23 European countries based on data from the European Social Survey, Eikemo et al., (164) reported lower educational inequalities in long standing illness and self-assessed general health in the Bismarckian regime. In another analysis using the same health outcomes, Bambra et al., (172) found that the Bismarckian and Southern welfare regimes exhibited smaller inequalities by educational level when compared to the Scandinavian and the Anglo-Saxon regimes. A third recent analysis of European welfare regimes confirmed the findings of smaller educational inequalities in self-rated health in the Bismarckian regime (178). Among adults aged 50-74 years, self-perceived health was also more equally distributed by educational level in Bismarckian countries in a comparison of welfare regimes based on the Navarro and Shi typology (34). Although not using a welfare regimes approach, another two studies also showed lower educational inequalities in Bismarckian countries. A comparison of 22 European countries revealed smaller inequalities in self-rated health in Bismarckian and Southern European countries (39), while a study of 11 European countries found a tendency of lower absolute and relative educational inequalities in self-assessed health in Bismarckian countries (184).

In the only previous study on oral health, Sanders et al., (195) analysed relative income inequalities in OHRQoL in four welfare state regimes, represented each by one country. The authors used the score of the Oral Health Impact Profile (OHIP-14) questionnaire as outcome measure and observed lower inequalities in Germany and higher in Australia, with the UK and Finland holding intermediate positions. A direct comparison of their findings with those of this thesis is not straightforward given the differences in oral health measures, SEP indicators and the welfare state

typology used. Nevertheless, in general, there is agreement between the two studies regarding which welfare regimes had the lowest and largest inequalities in oral impacts. Findings also agree in two important aspects. First, both revealed that the magnitude of certain socioeconomic inequalities in oral health differs across welfare state regimes, and second, results of the two studies failed to support the hypothesis of smaller inequalities in Scandinavian countries, as Sanders et al., did not find the smallest income inequalities in Finland when compared to Australia, Germany and the UK.

The lack of consistently lower health inequalities in Scandinavian welfare states is the subject of a lively academic debate in what has been called a 'public health paradox' by Mackenbach (394) or a 'public health puzzle' by Bambra (206). In her main paper on this topic, Bambra examined six theories on health inequalities; materialist, psychosocial, life-course, cultural/behavioural, health selection and artefact, and their potential insights to explain the puzzle (206). Using some of these theories, she identified certain characteristics of Scandinavian regimes that could contribute to explain their health inequalities: 1) the higher socioeconomic inequalities in smoking, which could be related to 'intervention generated inequalities' where universal health promotion interventions are taken up mostly by those in higher SEP; 2) the exclusion of certain population groups, mostly immigrants, from the full benefits of welfare policies; 3) the potential larger effect of relative deprivation, since Scandinavian welfare states create high expectations of upward social mobility among those in lower SEP, and those expectations are frequently not met; and 4) the persistence of inequalities in some material resources such as access to health services. Bambra concluded, however, that these theoretical explanations and the theories on health inequalities in general, have limitations to fully explain the unexpected higher inequalities in Scandinavian countries.

Following a very similar approach, Mackenbach (394) reviewed nine theories on health inequalities. Based on some of them, he hypothesised that certain characteristics of the most generous welfare states could help to explain the

paradox: 1) larger inter-generational social mobility with greater scope for health selection; and 2) health increasingly determined by consumption behaviours. Regarding the first hypothesis, it is argued that the greater social mobility in Scandinavian countries (given their strong merit-based system) results in a more relevant role of personal characteristics, like personality factors and cognitive ability, to access higher socioeconomic positions. As these personal characteristics are also related to health, via health-related behaviours for example, certain personality and cognitive features that elevated some people to higher SEP also led them to achieving better health, then explaining the larger inequalities. The second hypothesis states that disease patterns in advanced welfare states have been increasingly determined by consumption behaviours. Consequently, the very unequal socioeconomic distribution of those behaviours plays a key role in explaining health inequalities. It is argued that in those advanced welfare states, extensive welfare benefits such as cash benefits could, paradoxically, have contributed to widen health inequalities by making more available certain health-damaging goods such as alcohol and tobacco to those in lower SEP (395). In addition, it is said that non-material resources related to behaviours, such as cultural capital, have been traditionally 'untouched' by the welfare state provision.

Some of the aforementioned explanations for why Scandinavian countries do not consistently show the smallest health inequalities help to explain results of this thesis. One of the arguments is that levels of stress and frustration linked to being relatively deprived are higher in Scandinavian welfare states given the expectations of upward social mobility among those in lower socioeconomic position (37, 205). These higher levels of stress and frustration could affect self-perceived health and other stress-related outcomes. This explanation may be relevant to the outcome of oral impacts as it is more influenced by perceptions than the self-reported number of natural teeth, a historical measure of oral health. However, as chronic stress levels are linked to periodontal disease (396, 397), which in turn could result in tooth loss, the potential role of this mechanism in explaining inequalities in no functional dentition and edentulousness in the Scandinavian regime cannot be ruled out. Future research should explore if other psychosocial factors related to

oral health such as self-esteem and sense of coherence (234, 236, 310) are higher among those in lower SEP in Scandinavian countries.

Another suggested explanation is concerned with the large socioeconomic inequalities in health-related behaviours, particularly smoking, in Scandinavian countries (39, 206). This is a credible mechanism for certain findings in this thesis given the strong association between smoking and oral health (398). Further analyses should determine if socioeconomic differences in other behaviours related to oral health are also larger in Scandinavian countries. In addition to psychosocial and behavioural factors, the increasing immigration to Scandinavian states could help to explain the oral health inequalities found in this thesis. Immigrants have restricted access to certain welfare benefits, are more likely to experience social exclusion, unemployment, discrimination, poor acculturation, and have higher poor self-rated health (164, 399). Further research including analyses of particular sub-groups and/or considering indicators on immigration status could help to clarify this argument for oral health. Finally, it has been argued that certain universal policies could eventually improve population health but not change health inequalities since all groups in the socioeconomic spectrum benefit from them (41, 156). This argument would also go some way to explaining why results reported in this thesis showed consistently better oral health but not lower oral health inequalities in the Scandinavian regime, which is characterized by a universal provision of welfare benefits.

In addition to the abovementioned mechanisms, larger educational inequalities in the Scandinavian regime for the outcomes of no functional dentition and oral impacts could indicate that other explanations need to be considered. One explanation is that the small group of individuals with low educational level in Scandinavian countries appears to form a particular cluster, with a greater concentration of poor health than in other countries, thus increasing educational health inequalities (95). Moreover, compared to other European countries, the Scandinavian have shown a higher proportion of unskilled workers among their men with lowest level of education (95). It has also been suggested that the

comparatively better access to financial resources among persons at lower educational levels in Scandinavian states might have increased their health compromising behavioural patterns (180).

Despite the fact that the Scandinavian regime did not show the lowest inequalities in oral health, it is worth considering a view of welfare states put forward by Bambra (206) that might allow interpretation of the results in this thesis to be more consistent with the welfare regime theory. That view is that the role of the welfare state is not only to create overall general equality, but also, improve the situation of those at the bottom of the socioeconomic hierarchy (206). According to that view, the results of this thesis suggest that Scandinavian and Bismarckian welfare regimes performed well as adults in the lowest socioeconomic groups in the Scandinavian countries tended to have lower prevalence rates of no functional dentition and edentulousness than those in the lowest socioeconomic groups in the other European welfare regimes. For the outcome of oral impacts, those in the lowest socioeconomic levels were better off in the Bismarckian regime. This comparison also suggested that the Eastern and Southern regimes were the least successful in protecting the oral health of their most deprived adult populations.

In addition to differences by regimes, results of the analyses in this thesis suggest that welfare states might play a different role on the magnitude of inequalities according to the oral health measure used. In particular, findings indicate that inequalities in oral impacts could be less sensitive to welfare regimes compared to inequalities in the other oral health indicators. Since oral impacts on daily life is a subjective measure that captures different aspects of oral health than those related to number of teeth, certain results of this outcome will be discussed separately.

Inequalities in oral impacts were significantly different across welfare regimes in absolute but not in relative terms, and only for education of the three SEP measures studied. In an earlier similar analysis on oral impacts, Sanders et al., reported significant differences in relative inequalities by income quartiles (195). Since different SEP indicators capture diverse dimensions of people's socioeconomic

circumstances, results of the present analysis suggest that welfare state arrangements could influence the relationship between oral impacts and a person's knowledge-related resources. This could be partially due to the fact that education is closely related to health expectations and perceptions, probably through its relationships with cognitive function, health literacy, access and use of health services and interaction with health care providers (66). Moreover, education significantly affects occupation and income, and is considered a good proxy of life time SEP since it is usually achieved early in life (66, 79). Considering those two arguments, education could be an important socioeconomic determinant of oral impacts (347, 400), and this relationship might vary across different characteristics of the welfare provision.

In agreement with the only previous study on oral impacts across welfare regimes (195), this thesis showed lower inequalities in the Bismarckian regime and larger in the Anglo-Saxon. This finding of higher inequalities in the Anglo-Saxon regime seems consistent with welfare state theory. In Anglo-Saxon countries, the comparatively modest welfare benefits and the more substantial role of the market in welfare provision would contribute to maintain the association between socioeconomic position and access to resources that are relevant for oral health.

In the context of this discussion, it is also worth mentioning other factors that are potentially related to the study results. These factors are concerned with a measurement issue, the importance of oral health services, and changes in welfare policies. First, the higher relative inequalities in the Scandinavian regime could partially reflect a numerical artefact. When the prevalence rate of a given health outcome is low, relative inequalities tend to be larger (303, 401) and in this analysis, the Scandinavian regime showed the lowest prevalence rates in all studied outcomes. This issue could also go some way to explain the small relative inequalities observed in the Eastern regime. Large prevalence rates of the oral health outcomes, particularly those based on number of teeth, were found in the Eastern regime even in the highest socioeconomic groups. Therefore, when relative inequalities are assessed, these tend to be lower since the starting point of

comparison is quite high. Absolute health inequalities are less likely to be influenced by the overall level of the outcome and in line with this idea, findings of this study did not show consistent lower absolute inequalities in Scandinavian countries. Second, the outcomes of edentulousness and no functional dentition are based on number of natural teeth, a cumulative measure of oral health that is greatly affected by dental care services and specific interventions. Therefore, considerations regarding differential access to oral health services, diverse approaches in those services and other specific oral health interventions are important in their own right, not only as part of a broader welfare state regime. They could have partly contributed to the observed results. Finally, individuals included in analyses could have experienced changes in oral health policies and broader social welfare policies during their life-course. This is especially relevant in the case in the Eastern European regime where countries experienced a rapid and abrupt transformation from Communist to Capitalist systems.

Other changes in the social welfare policies in Europe, particularly in the last three decades, have led to questions about the welfare state regimes. For example, reforms to social policies and the increasing socioeconomic inequalities in Scandinavian countries (402) have generated discussions on the persistence of an ideal social democratic welfare state, and the extent to which those countries still differ from the Bismarckian states (393). Additionally, it has been argued that changes in social policies implemented in Germany since the late 1990s have made the country today closer to a liberal welfare state than to a Bismarckian (403). These and other arguments concerned with the limitations of the welfare regimes approach are relevant discussion points of this project. They will be presented in the following subsection where findings from the multilevel analysis are discussed.

## 9.2 Welfare state regimes and the variation in oral health: a multilevel analysis

The objective of this analysis was to assess the influence of welfare state regime (a country-level characteristic) on the variation in oral health between European

countries using a multilevel approach. It was hypothesised that welfare regimes would contribute to explaining some of the observed variation in oral health.

Results of the multilevel analysis revealed that about 8% of the variation in no functional dentition was attributable to differences between countries. This proportional variation at the country-level was 7% for edentulousness and 3% for oral impacts. The remaining 92%, 93% and 97% of the total variation in each outcome was related to individual-level factors. Adding individual-level variables to the models showed that being older and belonging to the lowest educational and occupational levels were consistently related to worse oral health outcomes. Moreover, clear educational and occupational gradients were found with stronger associations for no functional dentition and edentulousness, while estimates were weaker and not always significant for oral impacts on daily life. For example, for the medium and low educational levels estimates were OR=1.67 (95%CI: 1.37-2.03) and OR=2.25 (95%CI: 1.82-2.75) for edentulousness, and OR=1.10 (95%CI: 0.97-1.18) and OR=1.21 (95%CI: 1.07-1.36) for oral impacts (Chapter 7, sections 7.3 and 7.4).

Consistent with the hypothesis of this analysis, the variation at country-level reduced significantly when the welfare regimes variables were introduced into models of all oral health outcomes. This indicates that clustering countries in welfare state regimes contributed to explaining some of the variation in oral health among European countries. From the three outcomes analysed, no functional dentition was the one that exhibited a larger proportion of the country-level variation explained by welfare regimes. Specifically, the inclusion of the welfare regimes variables in models already adjusted for individual-level characteristics, reduced the country-level variance from 0.57 to 0.16 for no functional dentition, from 0.34 to 0.22 for edentulousness, and from 0.11 to 0.06 for oral impacts. In proportional terms this indicates that the country-level variance was reduced by about 72%, 34% and 45% respectively (Chapter 7, Tables 7.1, 7.4 and 7.7). This suggests that not having a functional dentition is the oral health indicator most sensitive to differences in political arrangements related to the welfare provision.

In the final step of this analysis, cross-level interaction terms between SEP and welfare regimes were included in the models with the highest SEP group in the Scandinavian welfare regime as reference category. Results of these cross-level interactions showed that at any educational and occupational level, participants had lower odds of no functional dentition in the Scandinavian regime than in other welfare regimes. Other findings revealed that adults in the lowest educational and occupational categories in all welfare regimes had higher odds of edentulousness than those in the reference group. In turn, participants at any SEP level in the Bismarckian, Southern and Eastern regimes were more likely to report oral impacts than those in the highest SEP level in the Scandinavian regime.

This study showed that country-level characteristics accounted for up to 8 per cent of the variation in oral health measures. Previous analyses on general health outcomes using a multilevel approach with individuals nested in countries have shown similar proportional variations at the country-level (33, 177, 215, 217, 218). In those studies, individual characteristics account for most of the variation in health, while country-level characteristics account for about 10% of that variation. For example, an analysis of 65,065 adults in 21 European countries found that around 90% of the variation in self-perceived general health was at the individual-level, whereas almost 10% was attributable to differences between countries (33). That study also explored the role of regions within countries using a multilevel model with three levels. However, findings indicated a non-significant variation across regions. In similar analyses, country-level characteristics have accounted for 7% of the variation in self-rated health (177, 215), 8.5% to 10% of the variation in depressive episodes or symptoms (197, 217), 6% to 15% of the variation in disability (218) and 4% of the variation in two or more health complaints (177). In this analysis, the proportional variation at the country-level was similar for the two outcomes based on number of natural teeth (7% and 8%) while considerably lower for oral impacts (3%). This would suggest that oral impacts on daily life are less sensitive to contextual characteristics and more related to individual features.

Results of this analysis provide support for the hypothesis that welfare state regimes contribute to explaining the variation in oral health across countries. About 72% of the country-level variation in no functional dentition, 34% in edentulousness and 45% in oral impacts was explained by the type of welfare regime. Evidence from earlier analyses on general health also indicates that welfare state regimes play an important role in explaining some variation in health across countries (33, 168, 177, 215, 217, 218). For example, using data from 23 European countries and the five welfare regimes according to the Ferrara typology and the additional Easter regime, Leveque et al., (197) found that welfare regimes accounted for 73% of the variation in depressive symptoms across countries. In a study using the same welfare regime classification, Eikemo et al., (33) showed that welfare regimes accounted for 48% of the national-level variation in self-perceived health among European countries. In addition, Foubert et al., (215), 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. This role of the welfare regimes in explaining health variation across countries has also been observed in studies of adolescent and child health outcomes. In a study of adolescents from 32 high income countries, Richter et al., (177) 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 (168).

In the current study, the two-level hierarchical models also showed certain significant associations between welfare regimes and oral health. Results of the odds ratios indicated that, after controlling for individual socio-demographic characteristics and country economic development, adults in the Eastern regime were more likely to lack a functional dentition and experience oral impacts than their counterparts in the Scandinavian regime. In addition, the associations were stronger for the outcome of no functional dentition where the Anglo-Saxon, Bismarckian, and Eastern regimes displayed significantly higher odds of a negative

outcome compared to the Scandinavian regime. Some of the associations between welfare regimes and oral health changed after including the economic variables in the models. These changes were not always in the same direction. Some ORs decreased, suggesting that some of the relationships initially observed could be attributable to national factors of economic growth and development. Other ORs, however, showed an increase indicating that the potential confounding effect of the economic characteristics had resulted in an underestimation of the association between welfare regimes and oral health.

Although findings of the multilevel analysis highlight the potential influence of welfare state regimes on oral health, disadvantages of the welfare regime approach are worth discussing in the context of this thesis. The main limitations are related to the homogeneity assumed within each regime and the changes in social welfare policies observed during the last decades. The first, and perhaps most important, limitation is concerned with the variations that exist in programmes and policies between countries within the same welfare state regime (28, 151, 206). Authors have maintained that more specific characteristics of welfare state institutions and policies become diluted in the higher level of aggregation of the welfare types. Specifically, it has been argued that policies of unemployment, education, sickness insurance, pensions and family are not always all formulated following the same principles within each regime, or even sometimes within the same country (156). The welfare regime approach is then criticized for not taking into account cross-national variations in different social policy areas (169, 404). Therefore, as typologies obscure relevant variations, they limit to a certain extent the possibility to assess more specific pathways and mechanisms linking welfare state characteristics and health (217). 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 (197). 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) (217).

The second limitation of the welfare regime approach 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 (405-407). The argument is then that these reforms have made the welfare state types less differentiated now than they were in the past. For example, reforms to various European health care systems implemented since the 1980s aimed at cost containment and the introduction of more competition and privatisation among healthcare providers, resulted in convergence across systems, particularly in the financing aspect (405, 407). Further, reforms in labour market policies (including unemployment benefits) applied in Germany since the late 1990s have generated controversy regarding the 'conservative/Bismarckian' nature of the German welfare state (403). In addition, the increasing socioeconomic inequalities in Scandinavian countries and recent changes in their social policies have brought into question the extent to which they still represent the ideal social democratic welfare state (393, 402).

Despite the above-mentioned disadvantages of the welfare regime approach, there are reasons to consider it a valid alternative in the study of political determinants of health and health inequalities. Cross-national comparisons of specific areas of the welfare provision (e.g., health care, labour market and family) have identified clusters of countries which tend to mirror welfare regimes (163, 169). Moreover, besides analyses on principles and institutional design of different social policies, the clusters of welfare regimes also appear when assessing social 'outcomes' such as income inequality and poverty (174, 402). These analyses have however exhibited the existence of hybrid cases of countries lying between different regimes and ideal prototypes. For example, the United States is considered the ideal-type of the liberal/Anglo–Saxon regime, Germany of the Bismarckian/conservative and Sweden of the Scandinavian/social-democratic (350). Despite existent variations,

one might think that expectations of the regime theory are still met in the sense that countries seem to follow certain patterns and tend to cluster along different dimensions of the welfare state (402). It is then argued that the regimes maintain their value as ways to identify commonalities between, and within, different welfare states (163). Therefore, their use appears to remain a useful way to study the potential influence of the general principles behind welfare policies. This seems to be a reasonable starting point when very little is known about the political determinants of a certain health outcome.

## 9.3 Oral health across welfare state regimes

Results of the comparison of oral health across welfare regimes based on prevalence rates were consistent with the hypothesis of better population oral health in the welfare regime with more generous, redistributive and universal welfare policies. The Scandinavian welfare regime showed better oral health than the other regimes. Poorer outcomes were observed in the Eastern and Southern regimes. The Scandinavian regime showed better performance in all outcomes analysed, with consistently lower age-standardized prevalence rates: 7.1% for edentulousness, 20.9% for no functional dentition, and 18.5% for oral impacts. In contrast, the Eastern welfare regime exhibited the highest prevalence rates of edentulousness (23%) and no functional dentition (64.1%), and the Southern the highest prevalence of oral impacts (31.7%). Findings also indicated that the prevalence rates of edentulousness and no functional dentition did not differ significantly among the Bismarckian, Anglo-Saxon and Southern regimes. For oral impacts, in addition to the Scandinavian, lower prevalence was also observed in the Bismarckian regime.

As there are no studies aimed at comparing oral health between welfare regimes, results of this analysis are mainly discussed in relation to the existing literature on general health. Overall, findings summarized above are in agreement with a group of previous analyses showing that the Scandinavian (social democratic) welfare state regime has a protective effect on health (21, 26, 33, 35, 168, 170, 178, 197,

199, 207-211, 216). In those studies, Scandinavian countries have exhibited lowest infant mortality rates (21, 26, 35, 168, 170, 207-211), higher life expectancy (199, 209) and lower rates of poor self-rated health (33, 178, 216) and depression (197). Those findings for general health have been related to the universal and more generous welfare provision that characterizes the Scandinavian regime, and the cumulative effect of its strong redistributive social security system (21, 26, 168, 170). Furthermore, the better health outcomes in Scandinavian countries could be associated with characteristics of their health policies. They explicitly aimed to address the social determinants of health (408) and have universal health care services with a high degree of decommodification (169). Here, the health care decommodification refers to how much a person's access to health services depends on his/her market position and the role of the private sector in a country's health care system (169, 409). In a comparison of 18 OECD countries, Bambra (169) applied those concepts and found that Scandinavian countries, particularly Finland, Norway and Sweden ranked above others in terms of level of health care decommodification. Namely, in those countries people relied less on their labour market position to access health services, and there was lower participation of the private sector in the health care provision. In addition to these characteristics of the welfare provision and health policies, it has been suggested that more gender equality and stronger social cohesion and social trust in Scandinavian societies could help to explain their better population health outcomes (33, 47, 410-412).

In this study, population oral health was found to be consistently better in the Scandinavian regime, then suggesting that the mechanisms connecting the broad social determinants and general health are also important to oral health. Moreover, since both edentulousness and no functional dentition are cumulative measures of lifetime oral health (52, 328, 329), it could be argued that the observed effects of the Scandinavian welfare regime on oral health may operate through diverse pathways over the life course. Furthermore, as the two measures based on number of teeth are historical indicators of oral health, they could reflect some potential benefits on population oral health of the 'golden age' of the Scandinavian welfare regimes (1950s to early 1970s) (172). On the other hand, the outcome of oral

impacts is considered a contemporary measure and, therefore, could be affected by more recent conditions of these welfare states.

This study also showed poorer oral health outcomes in the Eastern and Southern welfare regimes, in line with a number of previous studies on general health (33, 178, 197, 213, 216, 217, 413). In particular, this analysis showed significantly higher prevalence rates of edentulousness and no functional dentition in the Eastern welfare regime. Comparatively poorer levels of population health in the Eastern countries have also been reported in additional studies (164, 170, 171, 176, 177, 209, 212-215). In analyses on health differences across welfare state regimes, the Eastern regime has exhibited worse self-rated health (164, 171, 176, 212-215), lowest life expectancy (170, 199, 209), and highest levels of long standing illness (164, 171) and depression (197). These findings would suggest that the large-scale political and social changes experienced in Eastern European countries could have affected negatively the population's oral health in a similar way that affected general health outcomes. However, additional studies using longitudinal data from Eastern countries are required to confirm this hypothesis.

It is important to mention that cultural differences may account for some of the variation in oral health between welfare regimes observed in this thesis. Particularly for oral impacts on daily life, cultural factors might play a role in explaining why the highest prevalence was found in the Southern welfare regime. Some authors have suggested that higher levels of health complaints identified among Southern Europeans could be linked to cultural issues such as greater expression of emotions when compared to other Europeans (36, 177). As reporting oral impacts is strongly related to people's perceptions and expectations, it is possible that certain cultural features made individuals from Southern Europe more likely to notice and express the ways in which oral health affect their normal life. A previous analysis aimed at comparing oral impacts in adults aged 65 years and over in Greece and Britain, revealed cultural effects in the perceptions of impacts of oral diseases on quality of life (414). Cultural factors seem to be less likely to play a role in explaining the observed differences in the other two oral health measures as they are based on

the number of natural teeth. However, it is still possible that some of the variation in these outcomes reflects certain cultural differences in the value placed on retaining one's own teeth. There is some evidence of cross-cultural variation in the utility values assigned to tooth loss/retention in populations in New Zealand, Iran and the UK (415, 416). These differences could affect people's decisions regarding their oral health practices and use of dental services. Furthermore, differences in loss of natural teeth could also be partially attributed to diverse approaches in dental care practice.

Certain differences in oral health across welfare regimes observed in this comparison are in agreement with the general picture showed by the multilevel analysis discussed in the previous section. A tendency of better oral health outcomes in the Scandinavian regime compared to other regimes (particularly the Eastern), and higher oral impacts in the Southern and Eastern regimes are common findings in the two analyses. Results, however, do not show exactly the same welfare regime pattern due to differences in what the analyses measured. While the analysis discussed in this section is based on comparisons of age-standardized prevalence rates across welfare regimes (performed as the first stage in analyses of inequalities), in the multilevel study the OR for each regime is an estimate obtained from a hierarchical model adjusting for age, gender, marital status, education, occupation and economic development.

## 9.4 Educational inequalities in oral health: a comparison of England and the US

In this thesis, after examining welfare state regimes, one of the objectives was to compare two Anglo-Saxon welfare states with different approaches in their health care system: England and the US. Health care is one of the most important areas of social provision and has shown important variability within the liberal/Anglo-Saxon welfare regime (409). In addition, the health system is part of the social policies with the potential to ameliorate the relationship between socioeconomic stratification and health (29). International comparisons have shown that

characteristics of the health care systems are related to health and health inequalities. For example, Kunitz and Pesis-Katz (38) compared the US to Canada and found that racial/ethnic differences in life expectancy and avoidable mortality were explained, to a certain extent, by the lack of a universal health care system in the US. In this section, findings on the comparison on oral health and oral health inequalities between England and the US are discussed.

Educational inequalities in number of missing teeth, self-rated oral health and oral impacts on daily life were compared between England and the US. The two countries displayed significant relative and absolute educational inequalities in all outcomes analysed. These inequalities were consistently higher in the US than in England, in line with the hypothesis of this analysis.

As the first step of analysis, population oral health was assessed in the two countries using age-standardized estimates (means and prevalence rates). The comparison on oral health across the two countries showed that the mean number of missing teeth was significantly higher in the US (7.31 SE=0.15) than in England (6.97 SE=0.09). This difference, although statistically significant, should be looked with caution as it was only of 0.34 teeth. Hence, its importance from a clinical or public health perspective is limited. For the other two outcomes, prevalence rates were not significantly different between the two countries. Less than good oral health was reported by 30.8% of adults in England and 31.4% of adults in the US. In turn, prevalence rates of oral impacts were 15.1% in England and 13.5% in the US (Chapter 8, Table 8.2).

A consistent pattern of gradients was observed in the two countries with adults at each consecutive lower educational level having more missing teeth, rating more frequently their oral health as less than good, and experiencing more oral impacts. These educational gradients appeared steeper in the US compared to England, especially for self-rated oral health. For that outcome, prevalence rates in the US were 52.1% among adults with no achieved level of formal education, 32.5% in those with at least a high school level and 15.5% in participants with a college

degree. In England, these estimates were 37.4%, 32% and 24.5% respectively (Chapter 8, Table 8.3).

After adjusting for age, gender, marital status and ethnicity, the associations between education and oral health in the two countries were all significant and in the expected direction with higher PRs and IRRs among those in lower educational levels. For example, the mean number of missing teeth among adults with no educational qualifications was 67% higher than among those with a degree level in the US, and 50% higher in England (IRR of 1.67 (95%CI: 1.54, 1.81) in the US and 1.49 (95%CI: 1.40, 1.59) in England). Prevalence ratios for the other two oral health measures showed that people in medium and low educational levels were more likely to report both oral impacts and less than good oral health compared to the reference category. In the two countries, the pattern exhibited by the IRRs and PRs confirmed the existence of educational gradients in all oral health outcomes. These gradients tended to steeper in the US, particularly for self-rated oral health.

In the two countries there was evidence of significant relative (RII) and absolute (SII) educational inequalities in all oral health measures. The comparison on the magnitude of the relative and slope indices of inequality indicated some differences which support the hypothesis of higher inequalities in the US. The difference among the two countries in the magnitude of inequalities was particularly strong and significant for the outcome of self-rated oral health. For that oral health measure, RII was 3.67 (95%CI: 3.23, 4.17) in the US and 1.83 (95%CI: 1.59, 2.11) in England. In turn, SII values were in 42.55 (95%CI: 38.14, 46.96) in the US and 18.43 (95%CI: 14.01, 22.85) in England (Table 8.5 and Figure 8.2).

A comparison of findings of this analysis with similar studies is difficult since no previous research has specifically aimed to assess differences in population oral health and patterns of inequalities between England and the US. Two descriptive cross-national studies on oral health status have included the US and UK, but they did not evaluate differences between the two countries. The first of these analyses intended to compare oral health of adults in Australia with that of adults in

Germany, the UK and US (417). The ranking of countries presented in the study showed that the US had better overall oral health than the UK in terms of percentage with at least one decayed tooth, percentage of edentate, mean number of missing teeth and percentage with periodontal disease. However, these results need to be viewed with caution since statistical analyses were only performed for the Australian data and were carried out to obtain estimates comparable to those already reported from the other three surveys. Therefore, comparability between the German, American and UK data was not always possible, and in fact, was not the objective of the study. The second analysis was a similar descriptive study aimed to assess the level of oral health in the state of New South Wales, Australia with national epidemiological data from the US and UK (418). Again, larger estimates in the UK compared to the US were found for edentulousness, number of missing teeth and percentage with decayed teeth. However, final conclusions about differences between UK and US cannot be drawn from this analysis as it suffers from the same limitations mentioned for the first study.

The existing literature on general health comparing levels of inequalities between England and the US has revealed a mixed picture. Some studies have shown steeper gradients (larger health inequalities) in the US (230, 231), while others did not find significant differences across the two countries (13, 232). Findings of this analysis are in general agreement with the former. When those studies comparing health inequalities have also included information on general health status, or when comparisons of health across the two countries have been performed (419, 420), they consistently showed poorer outcomes in the US, in agreement with results obtained in this study for number of missing of teeth.

Differences between England and the US in certain aspects related to oral health should be considered as potential explanations for the observed results. First, some findings showing larger inequalities in the US may stem from the different ethnic composition in the two countries. It has been established that individuals of certain ethnic minorities tend to exhibit poorer oral health outcomes than the majority white population (55, 421, 422). Since the US have a higher proportion of non-white

population than England (for example, in the national samples analysed in this study the proportion of non-white population was 28.8% in the US and 11.5% in England), this difference in ethnic composition could play a role in explaining cross-national variations in oral health inequalities found in this analysis. However, findings of the sensitivity analysis revealed that restricting the analytical samples to the White population did not affect the conclusions drawn on the comparison between the two countries (Tables A5.1 to A5.3 in Appendix 5).

Differences in behavioural risk factors related to oral health, such as sugars consumption and smoking rates, could also help to explain findings of this study. Examining the role of these risk factors was out of the scope of this study and also constrained by data availability and comparability. However, it is likely that behaviours played only a modest role in explaining the England-US differences. Previous analyses assessing health and health inequalities have demonstrated that behaviours accounted only for a small fraction, if at all, of the cross-national variations in health and levels of inequality between these countries (230, 232). Furthermore, in the US, studies have found that the role of health-related behaviours as explanation of inequalities in both general and oral health is marginal (305, 423). Further analyses focused on oral health related behaviours would shed light on the role that they might play in explaining differences between England and the US.

Features of the dental health care systems may also have contributed to the disparities across the two countries. In the US, access to dental services is mainly through private insurance as very few public programmes include dental services for adults (226-228). In addition, dental care professionals are also mainly located in private settings. In contrast to this largely private provision of services in the US, in England the National Health Service (NHS) remains the main provider of care. This suggests that access to dental services would have a stronger relationship with SEP in the US than in England. Additionally, if the approach to dental services mirrors that of general health, one would expect a higher primary care orientation and focus on prevention in the English dental health care system. These differences in

levels of access, provision of treatment services and preventive care may have influenced findings of this analysis. Further comparative research needs to examine more closely the organisation and characteristics of the dental health systems in each country.

Larger inequalities in the US, particularly significant for self-rated oral health, could be related to potential differences in the proportion of edentate adults between the two countries. Studies have shown that inequalities in subjective oral health tend to be very low among edentate adults (59, 424). This has been related to the small variation in oral health among those without natural teeth, and the adaptation of expectations and perceptions that gradually follows the fact of becoming edentulous (59). In this study, additional analyses of the two subjective outcomes were conducted restricting the analytical samples to dentate participants. Findings showed that, as expected, educational inequalities in self-rated oral health and oral impacts were larger among dentate, in both the US and England. The conclusions on the comparison of inequalities between the two countries were not sensitive to this alternative sample specification (Tables A6.1 and A6.2 in Appendix 6).

Differences in the economic benefits of formal education between the US and England could also partly explain the larger educational inequalities in oral health found in the US. It has been established that in the US, educational attainment has a stronger relationship with income and employment security than in other high income countries, including the UK (224, 425). Comparative analyses have revealed that the income penalty for not finishing high school and the returns for getting a college degree are both higher in the US compared to the UK (224). This would mean that access to material resources that are important for oral health, such as dental care and a healthy diet, could be more linked to educational attainment in the US than in England. Other mechanisms through which education may influence oral health, could also differ between the US and England. Examining whether pathways related to psychosocial resources or behavioural factors operate differently in the two countries is an important topic for further research.

Finally, wider differences in social and welfare policies exist between the two countries with England having a more comprehensive range of 'social safety net' policies which could contribute to lessen oral health inequalities compared to the US. On the other hand, similarities related to the general approach to the welfare provision, relatively high level of income inequality and less labour market regulation could explain the fact that not all differences in oral health or level of inequality were significant between the two countries.

## 9.5 Strengths and limitations of the thesis

This section discusses strengths and limitations of the analyses. It focuses first on the studies about welfare state regimes and then, on the study about England and the US.

### 9.5.1 Analyses of welfare state regimes

One of the strengths of this thesis is that it is the first to analyse the potential relationship between welfare regimes and oral health and patterns of inequalities in a wide range of European countries using appropriate statistical methods. Also, it benefits from the use of a variety of oral health measures, socioeconomic indicators and the estimation of both relative and absolute inequalities. In doing so, the analysis makes a contribution to the limited literature about political factors as macro-level determinants of oral health and oral health inequalities.

Other advantages are related to characteristics of the data and analytical approach. The analyses were based on the same data source for all countries and this strengthens the comparability and precision since the surveys used the same time lag and methodology in every country. Further, the oral health indicators included in the studies represent different dimensions of oral health. Measures based on number of teeth are considered indicators of life-time oral health status since they capture the cumulative effect of determinants of health, past disease and treatment experience (52, 328, 329, 426, 427). On the other hand, oral impacts on

daily life aim to assess the functional, psychological and social effects of clinical oral health (338, 339). Finally, this project used robust analytical tools previously recommended for cross-national comparisons on health and inequalities (e.g., RII, SII and multilevel analysis).

Limitations of the analyses on welfare state regimes should be noted. First, the sample sizes of countries with different populations were similar, which could affect representativeness of the data in certain countries. However, analyses took into account the population size weighting factor that was designed to correct for this issue so, every country was represented according to its population size (see Chapter 4, section 4.1.1). In addition, the post-stratification sample weighting that accounts for non-response was used in the analyses therefore potentially addressing concerns in relation to representativeness of the samples and generalizability of the findings. Second, it is important to recognize that surveys of this kind, which are conducted across several different countries, are subject to variable measurement error that may affect the results. Third, information on Switzerland (Bismarckian regime) and Norway (Scandinavian regime) was not available in the survey. Although including information from those two countries might have slightly changed certain estimates, it seems unlikely that it would have considerably altered the general findings.

Fourth, the measures of oral health employed in these analyses have certain limitations. All outcomes were self-reported, which some argue, may be less appropriate for international comparisons as they may reflect differences in health perceptions and national cultural backgrounds (357, 358). Despite this limitation, subjective measures have been considered suitable for cross-national analyses (175, 428) and their use is supported by the high correlations they have with clinical indicators of morbidity and mortality (429-431). In oral health, self-reported indicators have also shown significant associations with diverse clinical conditions and are considered valid measures of oral health (51, 59, 234, 432, 433). In addition, subjective indicators are the only way to assess oral impacts on quality of life, and it seems plausible to assume that number of natural teeth is less sensitive to cultural

variations than other self-reported measures. Moreover, data were collected from the same survey, using identical questions and in the same time lag across all countries. Another limitation related to the oral health measures was the lack of data regarding causes of tooth loss. However, as the causes of tooth loss are usually linked to caries and periodontal disease, it is reasonable to consider the outcomes based on number of teeth as indicators of cumulative disease. Analysis of these outcomes would have been also improved by the inclusion of data about need or use of prostheses. Finally, the measure of oral impacts used in the survey was not a validated measure. This may have affected comparability across countries and could partly account for certain differences observed between results of oral impacts and those for the other two outcomes (no functional dentition and edentulousness). Nonetheless, items on oral impacts from validated measures, for example those related to difficulty eating, were included in this survey. Moreover, this project included an assessment of the reliability of the oral impacts scale used in the survey and results showed very good estimates with a total Cronbach's alpha of 0.893, and Cronbach's alpha by welfare state regimes ranging from 0.824 to 0.919 (see Chapter 4, section 4.2.1.1).

Fifth, the SEP indicators used in the analyses could have limitations for cross-national comparisons of health inequalities. Even though age when completing full time education is considered a proxy of years of schooling, 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. However, measures of education on a continuous scale have also benefits for international comparisons because they are less influenced by cross-country differences in the distribution of general educational levels (180). There are also limitations in the use of occupation for cross-national studies, as the same occupational level could lead to dissimilar access to health related resources (material and immaterial) in different countries. Nevertheless, the three occupational categories used in the analyses came from the UK National Statistics Socio-Economic Classification scheme (NS-SEC), a classification designed to capture well-differentiated conditions of occupations and employment relations in modern societies (97, 434). Fitting

occupations into this NS-SEC 3-categories resulted in the exclusion of certain participants from analyses by occupation (students, unemployed, homemakers, and subjects who never did any paid job) (see Chapter 4, section 4.2.1.2). Although this could have introduced certain level of systematic bias, the advantages of using SII and RII counterbalance the potential limitation. With respect to subjective social status, the limitation of its use in comparative international research is mainly related to the fact that, being a subjective measure, it could be more susceptible to reflect cultural variations across countries. SSS was used, however, as it is thought to be a marker of life-time socioeconomic position and a good predictor of health (103, 104, 106).

Sixth, in addition to limitations linked to the use of specific SEP measures, a general issue relevant in this thesis is concerned with the different composition of socioeconomic groups across welfare states. Dibben and Popham have argued that social welfare policies can affect the composition of socio-economic groups within countries then introducing complexity in cross-national comparisons of health inequalities (435). They state that in more meritocratic societies (like the Scandinavian), personal abilities are more linked to the achievement of higher SEP, while in less meritocratic societies those abilities would be more equally distributed across SEP levels. They suggested that the limitation of poor comparability between socioeconomic groups across welfare regimes affects all studies that estimate the magnitude of inequalities within regimes and then compare it across regimes, the method more frequently used. These issues are framed within an intense ongoing debate about the relationship between levels of social mobility and the magnitude of health inequalities (436-439). As future work is required to clarify these matters, further studies could analyse, for example, the potential independent association between personal abilities and oral health, over and above SEP (both current and in early-life), and assess whether this relationship varies under different political contexts.

Seventh, it should be noted that there is no consensus in the social policy literature about an 'ideal' welfare regime classification and there is an active debate around

the criteria to group countries in welfare regimes and the accuracy of different typologies. The typology by Maurizio Ferrera was selected because it has been recognized as one of the most accurate classifications (164, 165, 173), has exhibited high within-regime homogeneity and between-regime heterogeneity (93), and various analyses have used it to examine variations in population health and health inequalities (33, 159, 164, 171, 172, 175-178) (see Chapter 2, section 2.2.1.2). Furthermore, the Eastern welfare regime complements this typology by including countries which have experienced profound political and social changes in their welfare state since the early '90s.

Finally, other methodological considerations are also worth mentioning. Although analyses of this project were not intended to establish causal relationships, but rather to identify associations, the cross-sectional nature of the dataset implies that results on inequalities are prone to questions about health selection. Additionally, in multilevel models testing the association between oral health and welfare regimes, other attributes of countries, apart from GDP per capita and GDP growth rate, were not included. According to the conceptual model of this thesis, national-level factors like level of income inequality were part of the pathway between welfare regimes and oral health and therefore, were not considered as potential confounders of associations tested in the multilevel models. However, these associations could have been partly attributed to other country-level factors not measured in the analysis. As a final methodological remark, it was not always possible to derive RII and SII using log-binomial regression models due to non-convergence issues. As a result, in certain analyses robust Poisson and linear regression models were used instead. It seems nevertheless a matter of little concern since in cases when convergence was achieved with log-binomial regression, estimates were compared to those obtained from the alternative methods of robust Poisson and linear regression, and results were very similar.

### 9.5.2 Comparison between England and the US

This analysis is the first analytical study aimed to compare levels of oral health and oral health inequalities between England and the US. The comparison has various strengths as was based on nationally representative surveys that were conducted during similar time periods, with clinical and subjective indicators representing different dimensions of oral health, and a fairly comparable measure of SEP. The analysis also included adjustments for relevant covariates and assessed both relative and absolute inequalities. The study was further strengthened by the addition of some sensitivity analyses carried out to test the robustness of findings.

This analysis has also certain limitations. First, the study was limited to one clinical measure of oral health status, number of missing teeth. Although this is a relevant measure of lifetime oral health status, past disease and treatment experience (426, 427), it would have been desirable to have other more current clinical measures such as decayed teeth and periodontal disease. These indicators were not included in the analysis due to limitations in comparability of clinical data between NHANES 2005-2008 and ADHS 2009. For example, while the two surveys assessed decayed teeth, they used different diagnostic criteria and ways to derive the variable(s) available in the datasets, then making the comparability between the measures quite difficult to justify.

Second, the subjective measures used in this study have also certain disadvantages. As previously discussed in limitations of the welfare regimes analyses, subjective measures are sensitive to cultural differences in health perceptions and expectations. This issue needs to be kept in mind when looking at results of this kind of analyses. However, as discussed earlier, self-reported health outcomes have been considered valid for cross-national comparisons (175, 428) and subjective measures are accepted as valid indicators of oral health (51, 56, 59, 234). In this study, one of the subjective measures analysed was self-rated oral health. Results of this measure could be sensitive to the cut-off point of the oral health scale selected for the dichotomization. Particularly problematic seems to be the category ‘fair’

which might have problems of comparability across the two countries. The categorization used in this study meant to differentiate those participants with a clear positive perception of their oral health from those who do not, and therefore, the 'fair' option was considered less than good oral health. Likewise, classifying 'fair' as less than good health has been a practice in previous analyses in social epidemiology (33, 440). Moreover, a comparison of the relationship between social class and self-rated health using both the dichotomous variable of less than good health, and the original categorical variable showed that results from the binary measure were confirmed by analyses that incorporate the ordered nature of the variable (441).

Third, the assessment of potential pathways to explain the differences between England and the US was restricted by the limited availability of comparable psychosocial, behavioural, and economic data in the surveys. As an example, attempts were made to identify measures of sugar consumption, but the wording of specific questions and the coding of variables available in the datasets make the low level of comparability a real issue. Further studies will need to be undertaken to explore the potential role of different mechanisms in each country.

Finally, using data from the NHANES 2009-10 would have been a good alternative as the information was collected during a closer time period to the ADHS 2009. However, data from that survey was not suitable for this analysis since for that period the NHANES survey did not include questions on oral impacts on daily life and the self-rated oral health information was available only for participants 30 years and over.

## 9.6 Future research

This research has shown that population oral health was better in the Scandinavian welfare regime that is associated with more generous, redistributive and universal welfare policies. However, in line with previous evidence for general health, socioeconomic inequalities in oral health were not lower in that regime. It is

essential, therefore, to understand why and how significantly better oral health status goes together with intermediate or even larger inequalities in those welfare states. Future research should then explore the mechanisms leading to oral health inequalities in different welfare regimes. Assessing the potential role of material, behavioural, psychosocial and social relational factors, and how they operate under diverse political contexts would shed light on this area of political determinants of oral health inequalities. Similar analyses of mechanisms of inequalities could be conducted to better understand differences observed between England and the US.

Analyses of welfare regimes in this thesis were limited to the adult population and did not explore differences across all age groups. It has been stated that children, adolescents and adults in different age groups have had diverse welfare state experiences, what has been called 'welfare regime life courses' (172). Assessing the relationship between oral health inequalities and welfare regimes at different moments of the life course, ideally using longitudinal data, would also help to gain further understanding on this area. In addition, the study of specific subpopulation groups such as immigrants would allow testing some of the hypothesised explanations for findings of this project.

Considering the limitations of the welfare regimes approach, future studies could 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 (151, 203, 207), universalism in social protection systems (28, 151, 195), efforts directed to minimize the effects of negative life events (e.g. loss of job, disability) (29, 33, 442), and supportive family policies (151, 443). Likewise, further comparative research should examine characteristics of the dental health systems, alone and in combination with different features of health and social policies. Another research opportunity is the possibility to longitudinally examine variations in oral health and inequalities in societies that have experienced major political and societal changes. This approach has been used, for example, to analyse the mortality crisis in countries of the former Soviet Union and central and

Eastern Europe (444, 445). For oral health, one interesting case study is Brazil, which has experienced during the last two decades important transformations in its social and health policies (including the oral health care system). Certain studies aimed to assess changes in oral health and inequalities using Brazilian data have been conducted recently (see Chapter 2, section 2.3.2).

In analyses of welfare regimes conducted as part of this thesis, the use of objectively measured clinical outcomes was restricted by data availability. In addition, the outcome of oral impacts was from a non-validated scale. In turn, the oral health measures employed in the England-US comparison were subject to limitations as the clinical outcome does not reflect more current oral health status, and the subjective measures are prone to cultural influences and potential measurement bias. It would be, therefore, ideal to conduct similar analyses using data from comparable clinical examinations and validated measures. To enable such extension of analyses, the availability of comparable, quality data is a key issue. The regular inclusion of validated measures of oral health in cross-national health and social surveys would be of considerable benefit to enable such kind of analyses in the future.

Finally, this research was restricted to high income countries. Further research could expand the analysis of political factors as determinants of oral health and inequalities to middle and low income countries. As previously mentioned, some studies have been conducted in Brazil, and it might be the case that literature published in other languages would reflect a larger number of analyses in those contexts. The study of political determinants is, nevertheless, a challenging endeavour which requires a large number of research studies providing the better possible evidence from different settings, and using complementary theoretical perspectives and analytical approaches.

## 9.7 Policy implications

The study of determinants of oral health inequalities at different levels enhances our understanding of how those systematic differences are produced and hence, our capacity to appropriately inform national and cross-national strategies. In fact, as tackling inequalities in oral health has increasingly become a goal of governments in different countries, cross-national comparisons can make a relevant contribution to the evidence base that should inform appropriate policy development.

The finding of social gradients in all welfare state regimes, as well as in England and the US, suggests that oral health inequalities should be considered a public health priority. The persistence of these inequalities in advanced, high income societies also suggests that specific strategies have not been completely successful in tackling important determinants, even in the most egalitarian states. One possible reason is that the main focus of most oral health strategies is on individual level factors, such as behaviours. These downstream interventions could even increase inequalities as those in higher SEP may be more likely to take up health promotion information, use new health services available and get more from their interaction with health care providers. Instead, more structural interventions, such as policies on taxation, are more effective in reducing health inequalities, as it has been shown by a systematic review on the kind of non-healthcare interventions that are more likely to increase or reduce health inequalities (446).

Results of this project provide evidence of the good performance of the Scandinavian welfare regime in terms of population oral health. This is so, even in times of policy reforms or the era of 'welfare state retrenchment' across all Europe (168, 447). These findings suggest that universal and generous welfare policies and a strong redistributive social security system would have a positive, cumulative effect on oral health. Moreover, characteristics of their model of oral health care could provide valuable insights for policy development in other countries. The model is characterized by a mixed-funded scheme combining general and local taxation with some patient fees. Delivery of services is mostly focused on the

population aged less than 18 years for whom use is free of charge and individual recalls are made. For younger children, specific preventive interventions including those directed to the parents are mainly delivered by dental hygienists. Adults in turn, receive a subsidy to access basic dental treatment in private services. There is also an established 'cap' or protection for high cost treatments. However, reforms implemented since the 1990s, particularly in Sweden, have decreased the value of both subsidy for regular treatment and high cost protection. In fact, a report revealed that one in five Swedish did not seek dental services despite perceived need, with the main reason being that people do not think they can afford it (448). Lack of access despite perceived need was common among immigrants, single adults with children, and people in lower occupational and income levels. Putting that evidence and results of this project together, it seems that the model of oral health care has contributed to improve oral health of the majority but also plays a role in explaining the relatively large inequalities in Scandinavian countries. A previous analysis explored this issue by using data from the Swedish National Survey of Public health (54). Authors concluded that a combination of socioeconomic disadvantage and refraining from seeking required dental treatment resulted in the highest odds of poor self-rated oral health and periodontal disease. According to their results, more than 60% of the socioeconomic differences in self-rated oral health were explained by inequity in access to oral health care (54). In addition, a recent study conducted in the Swedish county of Västmanland found that not using dental care services for financial reasons was strongly associated with poor self-rated oral health, and was more common among the unemployed, those born outside Scandinavian countries, single mothers, and those with no cash margin (access to 15,000 SEK within a week, if needed) (449). This evidence would indicate that reducing public subsidy to dental services and increasing patient fees are likely to affect the more socioeconomically vulnerable, and has a negative effect on inequalities.

## 9.8 Conclusions

Analyses presented in this thesis suggest that political factors have significant relationships with oral health and inequalities.

1. There were significant differences in adults' oral health across European welfare regimes suggesting that features of the Scandinavian countries, such as the universalism and generosity of their welfare provision, are linked to better oral health outcomes.
2. Socioeconomic inequalities in oral health exist in all European welfare state regimes, frequently taking the shape of social gradients. However, contrary to expectations from the welfare state theory, these inequalities are not smaller in the Scandinavian regime.
3. Results of the comparison of inequalities across welfare state regimes showed a mixed picture and did not reveal a consistent pattern of oral health inequalities across regimes.
4. Using a multilevel approach, results showed that welfare state regimes contributed to explain the variation in oral health among European countries. This 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.
5. Significant associations between welfare regimes and oral health were also found in these hierarchical models and showed that adults in the Eastern regime were more likely to lack a functional dentition and experience oral impacts than their counterparts in the Scandinavian regime.
6. The comparison between England and the US indicated some significant differences in oral health status and magnitude of inequalities between the two countries. Number of missing teeth was higher in the US, while no significant differences were found in the two subjective outcomes. Both countries displayed significant relative and absolute educational inequalities in all outcomes analysed, and these inequalities were consistently higher in the US than in England.

7. Further studies are needed to explain the findings and gain further understanding on the potential mechanisms linking welfare provision and other political factors with oral health and patterns of inequalities.

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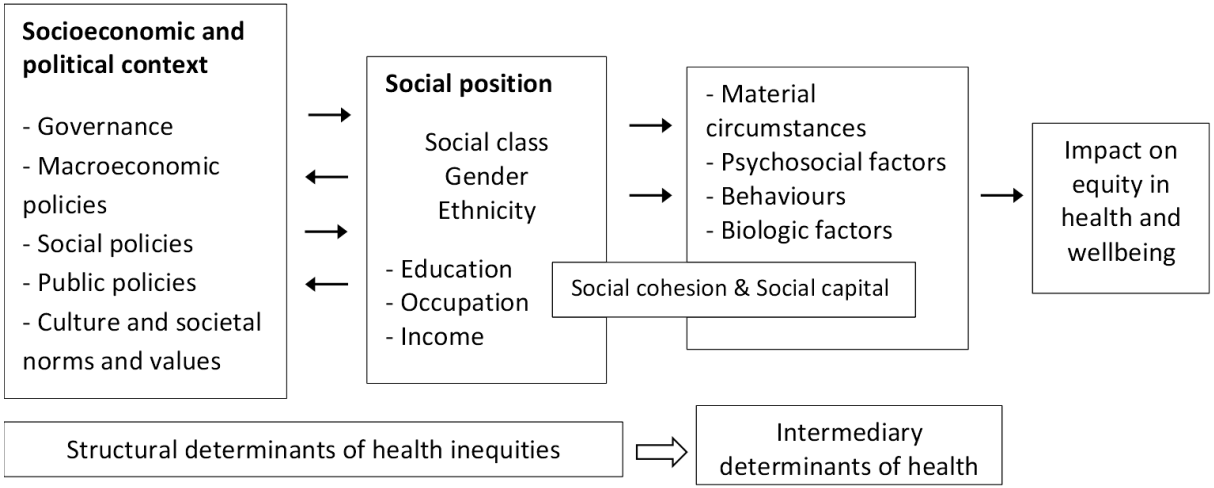
## Appendix 1

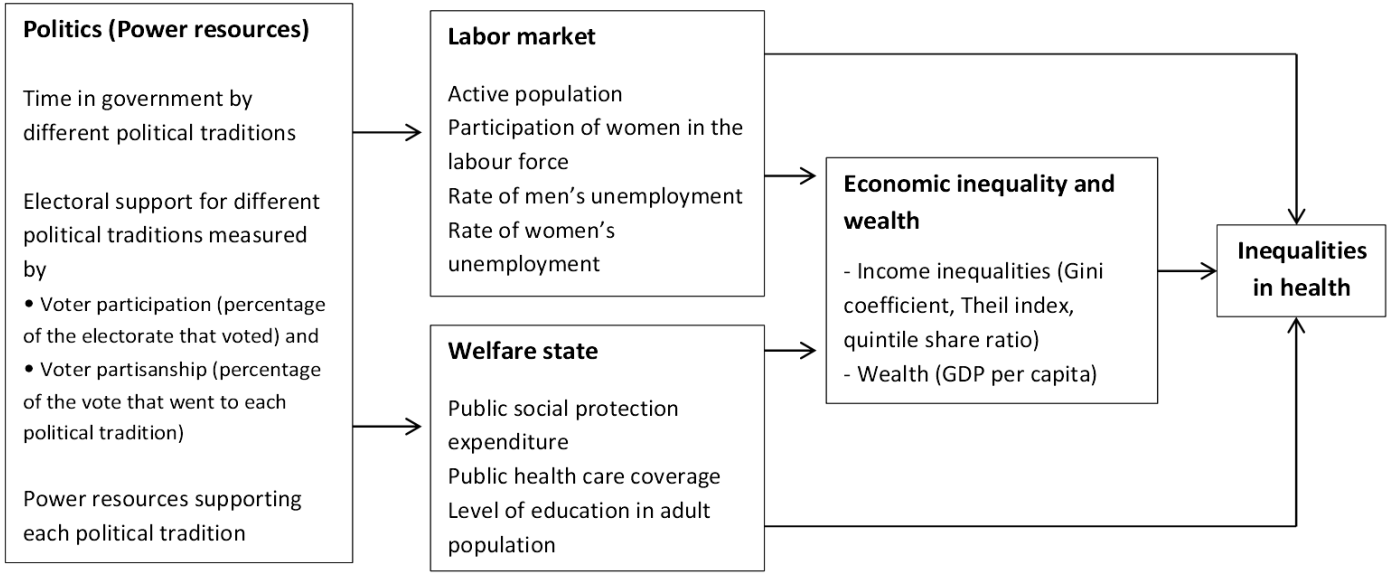
Figures A1.1 and A1.2 show the Social Determinants of Health model from the CSDH (25) and the model by Navarro and colleagues (26, 95), about the relationship between politics and health. The Social Determinants of Health framework (Figure A1.1) suggests that tackling health inequalities requires action on two main levels, the daily living conditions and the structural drivers of these conditions. As a complementary framework to understand the role of political factors, Navarro et al., depict pathways linking power resources to health inequalities (Figure A1.2). In their framework, governing political parties have implemented specific welfare state and labour market policies which result in different levels of income inequality and wealth in turn, influencing health inequalities.

Figure A1.1 - Social Determinants of Health Model




Source: Solar and Irwin, 2007. CSDH conceptual framework (25)

Figure A1.2 - Model by Navarro et al., on the relationship between politics and health




Sources: Navarro et al., 2006 (26) and Borrell et al., 2009 (95)

## Appendix 2

Tables A2.1 - A2.4 show results of logistic regression models used to derive ORs for associations between oral health and SEP. These ORs were compared to PRs in one of the sensitivity analyses of this thesis.

Table A2.1 - Logistic regression analysis of the association between no functional dentition and SEP measures by welfare state regime

| Socioeconomic position | Welfare state regime | | | | |
|---|---|---|---|---|---|
| | Scandinavian | Anglo-Saxon | Bismarckian | Southern | Eastern |
| | Odds ratio (95% CI) | | | | |
| Education (Age when stop full-time education) | | | | | |
| 20 years and older (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 16 - 19 years | 1.52 (1.12, 2.07) | 1.31 (0.74, 2.32) | 1.43 (1.08, 1.89) | 0.97 (0.59, 1.60) | 1.68 (1.19, 2.37) |
| Up to 15 years | 3.62 (2.59, 5.07) | 2.22 (1.25, 3.94) | 2.58 (1.90,3.50) | 1.59 (1.01, 2.51) | 5.23 (3.19, 8.58) |
| *p*-value for trend | <0.001 | 0.003 | <0.001 | 0.005 | <0.001 |
| Occupational class | | | | | |
| Managers and professionals (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Intermediate | 1.42 (0.97, 2.08) | 1.89 (1.03, 2.46) | 1.63 (1.18, 2.26) | 1.68 (0.99, 2.87) | 1.38 (0.92, 2.07) |
| Manual workers | 3.18 (2.34, 4.34) | 3.23 (1.88, 5.55) | 1.64 (1.23, 2.18) | 2.36 (1.45, 3.85) | 3.40 (2.31, 5.01) |
| *p*-value for trend | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 |
| Subjective social status | | | | | |
| Highest rank (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Second highest rank | 1.19 (0.84, 1.68) | 1.41 (0.77, 2.60) | 1.11 (0.78, 1.58) | 1.43 (0.72, 2.83) | 0.95 (0.55, 1.64) |
| Second lowest rank | 2.51 (1.71, 3.68) | 1.41 (0.74, 2.66) | 1.39 (0.97, 1.99) | 2.33 (1.18, 4.59) | 1.48 (0.87, 2.51) |
| Lowest rank | 5.32 (2.64, 10.70) | 3.35 (1.03, 10.87) | 1.72 (1.01, 2.92) | 4.14 (1.78, 9.65) | 2.06 (1.11, 3.85) |
| *p*-value for trend | <0.001 | 0.143 | 0.008 | <0.001 | <0.001 |

Table A2.2 - Logistic regression analysis of the association between edentulousness and SEP measures by welfare state regime

| Socioeconomic position | Welfare state regime | | | | |
|---|---|---|---|---|---|
| | Scandinavian | Anglo-Saxon | Bismarckian | Southern | Eastern |
| | Odds ratio (95% CI) | | | | |
| Education (Age when stop full-time education) | | | | | |
| 20 years and older (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 16 - 19 years | 2.08 (1.31, 3.30) | 1.41 (0.54, 3.30) | 2.28 (1.47, 3.53) | 0.75 (0.24, 2.29) | 1.67 (1.06, 2.62) |
| Up to 15 years | 3.48 (2.26, 5.37) | 4.26 (1.75, 10.35) | 2.87 (1.87, 4.41) | 3.55 (1.32, 9.57) | 1.84 (1.13, 3.00) |
| *p*-value for trend | <0.001 | <0.001 | <0.001 | <0.001 | 0.019 |
| Occupational class | | | | | |
| Managers and professionals (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Intermediate | 1.74 (0.88, 3.44) | 3.18 (1.28, 7.94) | 2.40 (1.51, 3.82) | 1.73 (0.60, 4.96) | 1.01 (0.63, 1.62) |
| Manual workers | 6.18 (3.71, 10.29) | 5.20 (2.39, 11.31) | 3.28 (2.19, 4.93) | 2.77 (1.10, 6.97) | 1.83 (1.22, 2.74) |
| *p*-value for trend | <0.001 | <0.001 | <0.001 | 0.015 | <0.001 |
| Subjective social status | | | | | |
| Highest rank (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Second highest rank | 1.48 (0.84, 2.57) | 0.83 (0.40, 1.68) | 0.90 (0.57, 1.42) | 1.03 (0.39, 2.68) | 0.59 (0.33, 1.06) |
| Second lowest rank | 2.44 (1.37, 4.33) | 0.91 (0.44, 1.88) | 1.09 (0.68, 1.75) | 1.34 (0.51, 3.49) | 0.63 (0.37, 1.09) |
| Lowest rank | 2.70 (1.06, 6.87) | 1.26 (0.29, 5.47) | 1.76 (0.93, 3.32) | 3.10 (0.99, 9.68) | 0.89 (0.49, 1.61) |
| *p*-value for trend | <0.001 | 0.887 | 0.033 | 0.017 | 0.621 |

Table A2.3 - Logistic regression analysis of the association between oral impacts and SEP measures by welfare state regime

| Socioeconomic position | Welfare state regime | | | | |
|---|---|---|---|---|---|
| | Scandinavian | Anglo-Saxon | Bismarckian | Southern | Eastern |
| | Odds ratio (95% CI) | | | | |
| Education (Age when stop full-time education) | | | | | |
| 20 years and older (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 16 - 19 years | 1.61 (1.25, 2.07) | 1.56 (1.05, 2.31) | 1.03 (0.84, 1.27) | 1.10 (0.85, 1.41) | 1.08 (0.85, 1.37) |
| Up to 15 years | 1.75 (1.27, 2.42) | 2.19 (1.37, 3.49) | 1.26 (0.98, 1.63) | 1.32 (1.00, 1.73) | 1.33 (0.97, 1.84) |
| *p*-value for trend | <0.001 | 0.001 | 0.106 | 0.042 | 0.110 |
| Occupational class | | | | | |
| Managers and professionals (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Intermediate | 1.72 (1.25, 2.35) | 1.03 (0.65, 1.63) | 1.14 (0.87, 1.49) | 1.34 (0.95, 1.89) | 0.77 (0.56, 1.05) |
| Manual workers | 2.01 (1.53, 2.64) | 1.46 (0.98, 2.19) | 1.17 (0.92, 1.48) | 1.59 (1.15, 2.19) | 1.04 (0.79, 1.37) |
| *p*-value for trend | <0.001 | 0.051 | 0.221 | 0.004 | 0.347 |
| Subjective social status | | | | | |
| Highest rank (Ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Second highest rank | 1.34 (0.99, 1.80) | 1.09 (0.69, 1.72) | 1.08 (0.79, 1.47) | 0.82 (0.58, 1.17) | 0.81 (0.56, 1.19) |
| Second lowest rank | 2.23 (1.61, 3.08) | 1.20 (0.75, 1.94) | 1.45 (1.07, 1.97) | 1.08 (0.75, 1.53) | 1.11 (0.77, 1.61) |
| Lowest rank | 4.14 (2.48, 6.90) | 1.11 (0.46, 2.70) | 2.16 (1.45, 3.22) | 1.66 (1.01, 2.75) | 1.47 (0.96, 2.25) |
| *p*-value for trend | <0.001 | 0.463 | <0.001 | 0.004 | 0.002 |

Table A2.4 - Logistic regression analysis of the association between oral health measures and education in England and the US

| Oral health outcome and educational level | England | US |
|---|---|---|
| | OR (95% CI) | |
| Self-rated oral health | | |
| High (Ref) | 1.00 | 1.00 |
| Medium | 1.53 (1.33, 1.77) | 2.73 (2.27, 3.29) |
| Low | 1.96 (1.66, 2.31) | 4.93 (4.09, 5.95) |
| *p*-value for trend | <0.001 | <0.001 |
| Oral impacts | | |
| High (Ref) | 1.00 | 1.00 |
| Medium | 1.88 (1.58, 2.23) | 1.87 (1.51, 2.33) |
| Low | 2.34 (1.85, 2.97) | 3.02 (2.30, 3.97) |
| *p*-value for trend | <0.001 | <0.001 |

## Appendix 3

Tables A3.1 and A3.2 show estimates of the RII and SII calculated with robust Poisson and linear regression models. These estimates were compared to those obtained from log-binomial models in one of the sensitivity analyses of this thesis.

Table A3.1 - Relative and absolute inequalities in oral impacts by welfare regime. RII estimated with robust Poisson and SII with a linear regression model

| | Socioeconomic position measure | | |
|---|---|---|---|
| | Education | Occupational class | Subjective social status |
| **Relative inequalities** | RII (95% CI) | RII (95% CI) | RII (95% CI) |
| Scandinavian | 2.23 (1.57, 3.17)** | 2.35 (1.67, 3.31)** | 2.86 (2.05, 4.00)** |
| Anglo-Saxon | 2.24 (1.40, 3.58)** | 1.67 (1.02, 2.75)* | 1.18 (0.77, 1.82) |
| Bismarckian | 1.24 (0.94, 1.66) | 1.19 (0.89, 1.59) | 1.90 (1.45, 2.49)** |
| Southern | 1.33 (1.01, 1.75)* | 1.49 (1.12, 1.99)** | 1.46 (1.15, 1.86)** |
| Eastern | 1.25 (0.94, 1.68) | 1.20 (0.89, 1.60) | 1.57 (1.20, 2.07)** |
| *p*-value[a] | 0.091 | 0.683 | 0.812 |
| **Absolute inequalities** | SII (95% CI) | SII (95% CI) | SII (95% CI) |
| Scandinavian | 15.60 (8.45, 22.74)** | 14.83 (9.08, 20.58)** | 19.50 (13.36, 25.64)** |
| Anglo-Saxon | 17.46 (7.48, 27.44)** | 10.90 (0.48, 21.31)* | 3.85 (-6.00, 13.70) |
| Bismarckian | 4.47 (-1.11, 10.05) | 3.44 (-2.07, 8.96) | 12.36 (7.14, 17.57)** |
| Southern | 8.65 (0.57, 16.73)* | 11.66 (3.50, 19.83)** | 11.60 (4.18, 19.01)** |
| Eastern | 6.11 (-1.35, 13.57) | 4.59 (-2.59, 11.76) | 11.39 (4.68, 18.10)** |
| *p*-value[a] | 0.005 | 0.683 | 0.426 |

* p<0.05, **p<0.01

RII: Relative Index of Inequality, SII: Slope Index of Inequality

[a] *p*-value of the interaction between each SEP score and welfare regime

Table A3.2 - Relative and absolute occupational inequalities in oral impacts by welfare regime and gender. RII estimated with robust Poisson and SII with a linear regression model

| | Women | Men |
|---|---|---|
| **Relative inequalities** | RII (95% CI) | RII (95% CI) |
| Scandinavian | 1.93 (1.22, 3.06)** | 2.79 (1.68, 4.65)** |
| Anglo-Saxon | 1.26 (0.67, 2.34) | 2.33 (1.05, 5.13)* |
| Bismarckian | 0.95 (0.66, 1.38) | 1.58 (1.02, 2.44)* |
| Southern | 1.31 (0.86, 2.01) | 1.62 (1.10, 2.38)* |
| Eastern | 1.11 (0.78, 1.57) | 1.43 (0.86, 2.39) |
| *p*-value[a] | 0.585 | 0.314 |
| | | |
| **Absolute inequalities** | SII (95% CI) | SII (95% CI) |
| Scandinavian | 12.19 (3.90, 20.48)** | 16.51 (8.47, 24.55)** |
| Anglo-Saxon | 5.54 (-9.61, 20.69) | 15.63 (1.41, 29.85)* |
| Bismarckian | -1.18 (-9.61, 7.25) | 7.71 (0.43, 15.00)* |
| Southern | 8.40 (-4.20, 21.01) | 13.68 (3.04, 24.32)* |
| Eastern | 2.95 (-7.38, 13.28) | 7.01 (-3.05, 17.08) |
| *p*-value[a] | 0.355 | 0.777 |

* p<0.05, **p<0.01
RII: Relative Index of Inequality, SII: Slope Index of Inequality
[a] *p*-value of the interaction between each SEP score and welfare regime

## Appendix 4

Tables A4.1 - A4.3 show estimates of the country-level variance were compared when using five different estimation procedures.

Table A4.1 - Two-level variance component model of no functional dentition using different estimation procedures

| Statistics | Estimation procedure | | | | |
|---|---|---|---|---|---|
| | Maximum likelihood | IGLS, PQL2 2nd order PQL | MCMC (priors from PQL2)[a] | IGLS MQL1 1st order MQL | MCMC (priors from MQL1)[b] |
| Intercept (prevalence of the outcome on the logistic scale) | -0.751 | -0.753 | -0.763 | -0.714 | -0.745 |
| **Random intercept variances** | | | | | |
| Individual level | 3.290 | 3.290 | 3.290 | 3.290 | 3.290 |
| Country level (standard error) | 0.247 (0.078) | 0.248 (0.079) | 0.289 (0.107) | 0.237 (0.075) | 0.288 (0.083) |
| **% of total variance (partition)** | | | | | |
| Individual level | 93.03% | 92.99% | 91.93% | 93.27% | 91.95% |
| Country level | 6.97% | 7.01% | 8.07% | 6.73% | 8.05% |
| Number of individuals | **16,314** | **16,314** | **16,314** | **16,314** | **16,314** |
| Number of countries | 21 | 21 | 21 | 21 | 21 |

IGLS: iterative generalised least squares, PQL: penalised quasi-likelihood, MCMC: Markov Chain Monte Carlo, MQL: marginal quasi-likelihood, MOR: median odds ratio. [a] MCMC using the PQL2 estimates from the previous model as starting values for MCMC estimation, [b] MCMC using the MQL1 estimates from the previous model as starting values for MCMC estimation.

Table A4.2 - Two-level variance component model of edentulousness using different estimation procedures

| Statistics | Estimation procedure | | | | |
|---|---|---|---|---|---|
| | Maximum likelihood | IGLS, PQL2 2nd order PQL | MCMC (priors from PQL2)[a] | IGLS MQL1 1st order MQL | MCMC (priors from MQL1)[b] |
| Intercept (prevalence of the outcome on the logistic scale) | -2.336 | -2.339 | -2.336 | -2.260 | -2.340 |
| **Random intercept variances** | | | | | |
| Individual level | 3.290 | 3.290 | 3.290 | 3.290 | 3.290 |
| Country level (standard error) | 0.203 (0.071) | 0.203 (0.068) | 0.239 (0.095) | 0.156 (0.053) | 0.239 (0.095) |
| **% of total variance (partition)** | | | | | |
| Individual level | 94.18% | 94.20% | 93.23% | 95.46% | 93.23% |
| Country level | 5.82% | 5.80% | 6.77% | 4.54% | 6.77% |
| Number of individuals | **16,314** | **16,314** | **16,314** | **16,314** | **16,314** |
| Number of countries | 21 | 21 | 21 | 21 | 21 |

IGLS: iterative generalised least squares, PQL: penalised quasi-likelihood, MCMC: Markov Chain Monte Carlo, MQL: marginal quasi-likelihood, MOR: median odds ratio. [a] MCMC using the PQL2 estimates from the previous model as starting values for MCMC estimation, [b] MCMC using the MQL1 estimates from the previous model as starting values for MCMC estimation.

Table A4.3 - Two-level variance component model of oral impacts on daily life using different estimation procedures

| Statistics | Estimation procedure | | | | |
|---|---|---|---|---|---|
| | Maximum likelihood | IGLS, PQL2 2nd order PQL | MCMC (priors from PQL2)[a] | IGLS MQL1 1st order MQL | MCMC (priors from MQL1)[b] |
| Intercept (prevalence of the outcome on the logistic scale) | -1.176 | -1.177 | -1.176 | -1.152 | -1.173 |
| **Random intercept variances** | | | | | |
| Individual level | 3.290 | 3.290 | 3.290 | 3.290 | 3.290 |
| Country level (standard error) | 0.092 (0.031) | 0.092 (0.031) | 0.108 (0.041) | 0.084 (0.028) | 0.107 (0.040) |
| **% of total variance (partition)** | | | | | |
| Individual level | 97.29% | 97.29% | 96.83% | 97.50% | 96.85% |
| Country level | 2.71% | 2.71% | 3.17% | 2.50% | 3.15% |
| Number of individuals | **16,525** | **16,525** | **16,525** | **16,525** | **16,525** |
| Number of countries | 21 | 21 | 21 | 21 | 21 |

IGLS: iterative generalised least squares, PQL: penalised quasi-likelihood, MCMC: Markov Chain Monte Carlo, MQL: marginal quasi-likelihood, MOR: median odds ratio. [a] MCMC using the PQL2 estimates from the previous model as starting values for MCMC estimation, [b] MCMC using the MQL1 estimates from the previous model as starting values for MCMC estimation.

## Appendix 5

Tables A5.1 - A5.3 show results of the main regression analyses conducted for the England-US comparison, restricting the sample to the White population.

Table A5.1 - Regression analysis of the association between oral health and educational level in England and the US - White population only

| Oral health outcome and educational level | **England** | **US** |
|---|---|---|
| | PR or IRR (95% CI) | |
| Number of missing teeth [a] | | |
| High (Ref) | 1.00 | 1.00 |
| Medium | 1.26 (1.19, 1.33) | 1.40 (1.29, 1.52) |
| Low | 1.52 (1.43, 1.63) | 1.93 (1.76, 2.12) |
| *p*-value for trend | <0.001 | <0.001 |
| Self-rated oral health [b] | | |
| High (Ref) | 1.00 | 1.00 |
| Medium | 1.35 (1.21, 1.52) | 2.34 (1.94, 2.81) |
| Low | 1.60 (1.41, 1.81) | 3.42 (2.84, 4.13) |
| *p*-value for trend | <0.001 | <0.001 |
| Oral impacts [b] | | |
| High (Ref) | 1.00 | 1.00 |
| Medium | 1.69 (1.42, 2.01) | 1.72 (1.38, 2.15) |
| Low | 2.15 (1.74, 2.65) | 2.96 (2.15, 4.07) |
| *p*-value for trend | <0.001 | <0.001 |

[a] Estimates reported are incidence rate ratios (IRRs).
[b] Estimates reported are prevalence ratios (PRs).

Table A5.2 - Relative educational inequalities in oral health measures, England and the US - White population only

| | England | US |
|---|---|---|
| | RII (95% CI) | RII (95% CI) |
| Number of missing teeth | 1.71 (1.57, 1.87)** | 2.32 (2.05, 2.62)** |
| Self-rated oral health | 1.83 (1.57, 2.14)** | 4.64 (3.82, 5.64)** |
| Oral impacts | 2.62 (2.04, 3.37)** | 4.04 (2.67, 6.11)** |

*p<0.05, **p<0.01 RII: Relative Index of Inequality

Table A5.3 - Absolute educational inequalities in oral health measures, England and the US - White population only

| | England | US |
|---|---|---|
| | SII (95% CI) | SII (95% CI) |
| Number of missing teeth | 4.16 (3.49, 4.84)** | 6.05 (4.98, 7.12)** |
| Self-rated oral health | 18.23 (13.49, 22.98)** | 40.23 (34.63, 45.83)** |
| Oral impacts | 13.67 (10.12, 17.21)** | 16.96 (11.88, 22.05)** |

*p<0.05, **p<0.01 SII: Slope Index of Inequality

## Appendix 6

Tables A6.1 and A6.2 show estimates of educational inequalities in self-rated oral health and oral impacts (the two subjective outcomes) England and the US, restricting the sample to dentate participants.

Table A6.1 - Regression analysis of the association between subjective oral health measures and educational level, England and the US - Dentate participants

| Oral health outcome and Educational level | England | US |
|---|---|---|
| | PR (95% CI) | |
| **Self-rated oral health** | | |
| High (Ref) | 1.00 | 1.00 |
| Medium | 1.37 (1.23, 1.52) | 2.13 (1.82, 2.49) |
| Low | 1.63 (1.46, 1.82) | 3.06 (2.64, 3.54) |
| *P* for trend | <0.001 | <0.001 |
| **Oral impacts** | | |
| High (Ref) | 1.00 | 1.00 |
| Medium | 1.72 (1.48, 2.01) | 1.83 (1.50, 2.23) |
| Low | 2.11 (1.72, 2.59) | 2.78 (2.22, 3.49) |
| *P* for trend | <0.001 | <0.001 |

All models are weighted and adjusted for age, gender, ethnicity, and marital status.
Estimates reported are prevalence ratios (PRs).

Table A6.2 - Relative and absolute educational inequalities in self-rated oral health and oral impacts, England and the US - Dentate participants

| | Self-rated oral health | Oral impacts |
|---|---|---|
| **Relative inequalities - RII (95% CI)** | | |
| England | 1.90 (1.65, 2.19) | 2.63 (2.06, 3.36) |
| US | 3.95 (3.44, 4.54) | 3.74 (2.83, 4.95) |
| **Absolute inequalities - SII (95% CI)** | | |
| England | 19.80 (15.29, 24.31) | 14.37 (10.82, 17.93) |
| US | 44.91 (39.80, 50.02) | 17.82 (14.28, 21.37) |

RII: Relative Index of Inequality, SII: Slope Index of Inequality

## Appendix 7

## Publications:

Guarnizo-Herreno CC, Tsakos G, Sheiham A, Watt RG. (2013). Oral health and welfare state regimes: a cross-national analysis of European countries. *European Journal of Oral Sciences*; 121 (3 Pt 1): 169-75.

Guarnizo-Herreno CC, Watt RG, Pikhart H, Sheiham A, Tsakos G. (2013) Socioeconomic inequalities in oral health in different European welfare state regimes. *Journal of Epidemiol and Community Health*; 67(9):728-35.

Guarnizo-Herreno CC, Watt RG, Pikhart H, Sheiham A, Tsakos G. (2014) Inequalities in oral impacts and welfare regimes: analysis of 21 European countries. *Community Dentistry and Oral Epidemiology*; 42(6):517-25.