The role of welfare regimes on socioeconomic inequalities in edentulism: a cross-national analysis of 40 countries

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Summary

Background We aim to evaluate the association between welfare regimes and edentulism (total tooth loss) and to investigate whether welfare regimes modify the magnitude of socioeconomic inequalities in edentulism.

Methods The Lancet Commission on Oral Health gathered and analysed nationally representative available data from 40 high, middle- and low-income countries, collected between 2007 and 2018. The study included 117,397 individuals 20 years or older. The outcome was edentulism, defined as the absence of all natural teeth. We categorised countries into seven welfare regimes, which served as both the primary exposure and an effect modifier. Individual-level variables included sex, age and a composite measure of socioeconomic position: "wealth" measured in quintiles. Inverse probability of treatment weight and multilevel logistic regression were employed to estimate the odds of being edentulous, and cross–level interaction terms between wealth and country factors.

Findings Individuals at the lowest wealth quintile had the highest prevalence of edentulism in all regimes. The highest age-sex standardised prevalence was found in Eastern European countries (8.4%, 95% Confidence Interval: 7.6–9.3), followed by Corporative (8.1%, 95% CI: 7.0–9.3), while the lowest was among the Insecurity regime (0.8%, 95% CI: 0.4–1.5), followed by the Scandinavian regime (4.7%, 95% CI: 3.5–6.1). Liberal countries presented the highest magnitude of absolute and relative inequalities, where the lowest quintile had OR = 20.6 (95% CI: 15.3–27.8) times higher likelihood of being edentulous and 17.3 percentage points (pp) higher prevalence. Low-income countries in the Insecurity regime presented the lowest level of inequality. Among high- and upper-middle income countries, the Scandinavian regime had the lowest absolute inequalities (5.5 pp difference between highest and lowest quintiles). The Informal Security regime had the lowest relative differences between the highest and lowest quintiles (OR = 2.20, 95% CI: 1.06–4.59).

Interpretation Our findings indicate that some welfare regime policies may enhance oral health while decreasing socioeconomic inequalities. Higher prevalence and inequalities among industrialised countries may reflect higher levels of oral health hazards.

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Keywords: Socioeconomic inequalities; Dental care; Oral health; Multilevel analysis; Public policy

Research in context

Evidence before this study

We searched the Scopus database in addition to the reference list of identified studies. The search strategy included the following words: ("Oral health" OR "dental caries" OR edentul* OR dent* OR DMFT OR "tooth loss" OR "missing teeth") AND (multilevel OR cross-country OR cross-national OR context* OR ecologic*) AND ("welfare provision" OR "welfare state" OR "welfare regime" OR "welfare typology" OR "social policy" OR "public policy") and we retrieved 136 studies published without year and language constraints until November 26, 2025. Ten key-studies were selected for full-text reading and from their reference list, other 14 papers were included. Overall, seven studies investigated welfare regimes, although five were from the same dataset (Eurobarometer 72.3), two included information about coverage of public/social policies and five about government expenditures. All studies were cross-sectional with national or cross-national representative samples. Although most studies showed better oral health outcomes among social-democratic (Scandinavian) countries, the magnitude of inequalities across welfare regimes showed wide variation and the reasons for them are still unclear. Furthermore, only one study included low- and middle-income countries (LMIC).

Added value of this study

The Lancet Commission on Oral Health gathered available data from nationally representative epidemiologic surveys of 40 countries and 117 397 individuals, the largest study so far on the subject. We also included country-level covariables to enhance comparability. By including several LMICs, two additional welfare categories have been considered based on previous studies. The new categories were the Informal Security and the Insecurity regimes, both representing countries with large informal labour markets in which individuals primarily rely on either family and non-governmental institutions or none, respectively. Results showed a high degree of collinearity between welfare regimes and high-income countries. The lowest prevalence of edentulism and the lowest level of socioeconomic inequality were found in the Insecurity regime (Low-Income Countries) followed by Scandinavian countries. In contrast, the highest prevalence was found in Eastern European and Informal Security regimes. Liberal countries presented the highest level of inequalities both in absolute or relative terms.

Implications of all the available evidence

Findings point out that, despite economic development being related to a higher prevalence of edentulism, social protection in universal Scandinavian countries was associated with a lower burden of edentulism and socioeconomic inequities in absolute terms. Welfare regimes may reflect broad, long-term social policies that impact both prevalence and socioeconomic inequalities. Specific policy factors at the contextual level that affect oral health must be assessed to see their impact on inequalities.

Introduction

Oral diseases are a global health concern as they have a very high prevalence and severe consequences for individuals at a high cost for the whole society, such as severe pain, impaired food intake, loss of work and schooldays, impact on quality of life and other issues.[1–3] There are over 3.5 billion individuals affected by oral diseases, mainly dental caries and periodontal diseases. Their prevalence has increased 3.2% in middle-income countries in the last 30 years, 0.1% in low and 2.2% in high-income countries.[4] Prevalence of complete tooth loss–edentulism–reaches 30% of world population at age 75 and seems to be stable since 1990.[5] Edentulism is the result of cumulative harmful effects over the life course reflecting the individual and structural socio-economic determinants of health and the dominant curative dental care model.[3,6] Tooth loss shares a series of modifiable risk factors with other non-communicable diseases,[7] the root causes are structural, based on social, political and commercial determinants. Therefore, they cannot be tackled solely with dental interventions, but adopting the common risk factor approach can also benefit other health conditions. This work, as part of the Lancet Commission on Oral Health, sought to investigate the role of social and welfare policies, key factors in political epidemiology.

The effects of social and welfare policies on population health have attracted interest in the recent decades.[8–11] Sustainable economic growth can improve living conditions, but it is not sufficient to promote equitable population health on its own, an issue addressed by welfare policies. They are defined as the state's role in critical structural determinants of society, such as protection from unemployment, education, healthcare, housing, poor relief, social insurance and provision of essential public services.[12] The most common approach for studying welfare policies is the regime typology developed by Esping-Andersen (1990) in his seminal work on how social policies and welfare production varied rather in kind and not only in degree

among rich capitalist countries into three ideal-typical regime types. The liberal regime relying primarily on the market, with the U.S. as the archetypical country; the corporative regime type putting a stronger reliance on the employment-relationship and the family with Germany as the archetypical country; and a third regime type, followed only by a small number of Nordic countries, in which universalism is a key concept and with a higher reliance on the state in the production and distribution of welfare. This latter regime is labelled "social-democratic" or Scandinavian.

Welfare regime typologies have been criticised on methodological and theoretical grounds.[8,9,13] One obvious shortcoming is that most welfare typologies were derived exclusively for Western High-Income Countries (HIC) later on added with an extended list of countries from South and Eastern Europe.[14,15] Despite its widespread use and notable insights, various authors have identified shortcomings in this typology, including some misclassification problems, the methodology used, and especially a gender-related critique highlighting the neglect of how welfare state policies influence gender relations, especially with regard to the distribution of unpaid and paid work, which in turn affect power relations between women and men.[16] Alternative typologies have been proposed to account for some of those drawbacks. One alternative frequently used in the public health literature and specifically in analyses of health inequalities is the typology by Ferrera[17] along with the complementary Eastern European type. Ferrera's typology 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–it has shown high within-regime homogeneity and between-regime heterogeneity, and it has been used in various earlier studies on cross-national comparisons of health inequalities. Nonetheless, it does not address all criticisms, it does not include Low and Middle-income Countries (LMIC), which have been added recently as social insecurity or informal security for countries with high percentage of informal workers and unstable policies.[18] An extended typology comparing HIC and LMIC may be promising but has not been widely used yet. Results from the traditional Esping-Andersen's typology show that the Scandinavian regime have better population health and lower mortality rates.[9] Surprisingly, the same countries have a high degree of relative inequalities, which has been labelled a paradox or puzzle in cross-national health research.[19,20]

There is scant evidence about the association of welfare policies on oral health, mostly based on HIC and often with only a small sample of countries.[21–26] Results predominantly show that countries within the Scandinavian regime type present better oral health.[22,23,25,26] Again, paradoxically, and following research on mortality inequality, those countries do not have the lowest socioeconomic oral health inequalities.[21,22] To explain such findings, it has been argued that government public spending on specific social and economic policies would be more accurate and dynamic factors than the traditional typology approach.[10,13,27] However, important country-level factors related to oral health have not been adjusted for in previous research and it is believed that the ultimate driving force behind welfare policies is economic development[28]; therefore, generous benefits would only be expected where the government could afford. Additionally, economic development may also increase urbanisation and availability, and so the consumption, of sugary food and other related risks to oral health.[29] Welfare policies can take different shapes in countries with similar economic level, which makes the study of the political determinants of health a very interesting and insightful area of research. Only by investigating why some countries have larger socioeconomic inequalities in health than others can policy-makers implement effective public health interventions that enhance health while reducing inequalities. Therefore, the current study, as part of the Lancet Commission on Oral Health, aimed to evaluate the association between welfare regimes and edentulism, and to investigate if welfare regimes modify the magnitude of socioeconomic inequalities in edentulism.

Methods

Data sources

National oral health surveys and general health surveys containing oral health data carried out since 2000 were identified by previous knowledge of the research team and systematic searches on the Global Health Data Exchange catalogue (http://ghdx.healthdata.org/). That is a public repository of data, including surveys, and other health-related information created by the Institute of Health Metrics and Evaluation, a public health research institute of the University of Washington in Seattle. To be eligible, surveys had to be nationally representative, conducted in or after 2000, evaluating at least one of the outcomes: dental caries, periodontal disease, tooth loss, self-rated oral health, and pattern of dental visits. The current database relies on submissions from national authorities and research institutes contacted individually to provide original surveys; therefore the number of countries included is not fully comprehensive and selection bias is acknowledged due to incomplete reporting in some countries. The present analysis is based exclusively on secondary de-identified micro-data with no direct contact with participants. Ethical approval and informal consent were obtained by original national authorities and research institute that carried out data collection (see Supplementary Box 1 for details). Additionally, at least one sociodemographic characteristic should have been assessed. Two co-authors (AJB and FC) handled all

datasets and harmonised all variables at the International Center for Equity in Health (https://www.equidade.org/home.php). Then, the dataset was transferred to the first author (RKC) and a statistician (HL) for the current data analyses.

Outcome variable

Edentulism was evaluated using clinical oral examination or self-reported number of natural teeth. Those with no remaining natural tooth were considered as edentulous (yes = 1, no = 0). The list of study countries and surveys with the year of data collection is included in Appendix 1.

Main exposure: welfare regimes

The regime typology approach here adopted was the Ferrera classification which included selected high-income countries, mostly European, expanding to the Eastern group.[14] That typology has five categories: Corporative, Liberal, Southern Europe, Eastern Europe and Scandinavian. Some more countries, not originally included, were added into one of the five categories following the latest update.[15]

For LMIC, we adopted the classification proposed by Wood & Gough[18] including two additional categories for countries with a large informal labour market: (a) Informal Security Regime and (b) Insecurity Regimes. Those two categories were, respectively, institutional arrangements where people rely (a) heavily on community organisations and family or (b) have no social arrangements to rely on when in need of social protection. A list of countries in each typology can be seen in Supplementary Box 2.

Country-level covariables

The World Bank database was the source of three country-level variables. The country Gini coefficient and Gross National Income level were based on the World Bank classification. We included the following categories: high-income (HIC), upper-middle income (UMIC), lower-middle and low-income (LMLIC). Due to the high level of collinearity with welfare regimes, these variables were used for descriptive purposes only (Supplementary Table S1). The percentage of inhabitants living in urban areas was also obtained from the World Bank database. For all variables, an average of the years 2007–2018 was produced to match the years of the dental surveys. Urbanisation was dichotomised at the median country values (median urbanisation = 73%) to get about 20 countries in each category.

Data on supply of sugars and sweeteners was obtained from the Food Balance database, measuring kg per capita per year at the country level. The data is compiled by the Food and Agriculture Organisation of the United Nations and is available on their website (https://www.fao.org/faostat/en/#data/FBS). Sugar supply showed a non-linear relation with edentulism and was dichotomised at the median country value (40 kg/per capita/year).

Data for the rate of dentists per 10 thousand inhabitants was obtained from the World Health Organization oral health status report (https://www.who.int/publications/i/item/9789240061484). This is based on the most up-to-date information available by each country up to 2022 from different sources and compiled by the Oral Health Programme, Department of Noncommunicable Diseases. As dental services are part of welfare policies, this was considered a mediator of our main explanatory variable and only used it for descriptive purposes (see Supplemental Table S1).

Individual-level covariables

Three key variables were included in the analysis: a composite measure of socioeconomic position labelled wealth (categorised into quintiles), sex, and age. The wealth index was calculated using principal component analysis (PCA) and was based on various socioeconomic factors available in each survey, such as household assets, education level, family income, and occupation. The first component score obtained from the PCA served as a measure of wealth, which was then categorised into quintiles for further analysis. Participants' sex was determined based on biological criteria, with individuals classified as either male or female based on their self-reported information. Age was recorded in years and categorised into five groups for analytical purposes: 20–34 years, 35–49 years, 50–64 years, 65–79 years, and 80 years or older. Two variables presented a large number of missing information because some countries did not include them in their survey and they were used only as sensitivity analysis. Dental care use was a combination of time since last dental visit (<12 months versus >12 months) and reason for visit (treatment or prevention/check-up) and residence location (rural versus urban area). Race and ethnicity were not collected in all datasets and present, it was not standardised; therefore, it was not used in the current analysis.

Data analysis

Descriptive analyses were performed, obtaining the prevalence of edentulism stratified by covariables. Original sampling weights from each survey were used to estimate prevalences after reweighting (calibrating) them to give each country about the same weight. To adjust for country differences in age distribution, standardised prevalence was produced using the direct method with the overall population as the reference. For regression models, age and sex were included as independent confounding individual-level variables, while urbanisation and sugar supply were included as independent confounding country-level variables. Welfare regimes were considered effect modifiers of the wealth quintiles effect on edentulism.

Multilevel logistic regression model with a random intercept was fitted, with individuals nested in their respective countries, the second-level units. The logit link function was applied incorporating the calibrated survey weight. The weights were recalibrated to assign the same weight to each country, ensuring that all countries contribute equally to the pooled results. Within each country, observations were weighted proportionally to the original survey weights, yielding results consistent with the original survey design.[30] The exponentiated beta values are odds ratios (OR), representing relative inequalities, while the inverse of logit function was used to obtain the adjusted prevalences for the intercept and prevalence difference, representing absolute inequalities. Using regression models, it was possible to test for interactions between individual-level wealth quintiles and welfare regimes. Wealth quintiles were also analysed as a continuous variable to assess the strength of the linearity because there was not a smooth gradient in some welfare categories. The variance partitioning coefficient (VPC) was calculated using Method D proposed by Goldstein et al,[31] where the variance of the first level is fixed at 3.29 ($\pi 2/3$) for dichotomous variables under the assumption of a threshold model. The percentage of variance explained was calculated including the variance of the fixed linear predictor model, according to the formula of 14.21 of Snijders and Bosker.[32] Due to the collinearity between country income levels and the welfare regimes, analysis proceeded only with the welfare regime variable. This analysis was performed using Stata 19.

Sensitivity analysis

Several strategies were adopted to assess the robustness of the results. This includes stratified analysis by age and GDP per capita, with additional variables such as dental care use and residence location. Interaction terms other than welfare and wealth were tested. Finally, different multilevel regressions were tested. Logistic regression with random intercept was performed to estimate the effect of wealth score on edentulism using both the traditional method and the *inverse probability of treatment weighting* (IPTW). Given the clustered data from different countries, stabilised IPTW by random intercept model was calculated for wealth score. Logistic regression models with random intercept using IPTW were done within each welfare regime to evaluate whether the effect of wealth score (quintiles) on edentulism was modified by welfare. In this case, $IPTW = \frac{f(Wealthscore)}{f(Wealthscore \vee C)}$. Here, C refers to confounders including individual-level age and sex, and contextual-level urbanisation and total sugar and sweetener supply. To adjust for country differences of these confounders in each welfare, the standardised prevalence was produced with the overall population as the reference using a random intercept model including the interaction of wealth score and the welfare regime with $IPTW = \frac{f(Wealthscore \vee welfare)}{f(Wealthscore \vee welfare, C)}$. These analyses were done using R 4.3.3 (https://www.R-project.org/).

Role of the funding source

The funding organisation had no role in defining aims, study design, data collection, data analysis, interpretation or writing of the report.

Results

Individual-level data from 44 countries were obtained for adults aged 20 years or over, and data was collected between 2007 and 2018. For the current analysis, four datasets did not provide information on the outcome of interest and were excluded. The 40 datasets included comprised 117,397 individuals, of which 7430 had missing information in the wealth score, making an analytical sample of 109,965. The response rate of each survey varied by country between 89.2% (e.g. Chile) and 100.0% (e.g. Cyprus, Mexico, UK, and Rwanda). The pooled sample had 7.3% (95% Confidence Interval; 95% CI: 6.7–7.9) of edentulous people, 55.5% were women, 25.1% were 20–34-year-old and 35.2% were 35–49-year-old (Table 1). There were 30 countries with a sugar supply higher than 40 kg/per capita yearly, while 21 countries had more than 73% of their population living in urban areas (Supplementary Table S1). There were striking differences among welfare regimes regarding mean Gross Domestic Product (GDP) per capita (US$) and number of dentists per inhabitants (Supplementary Table S1). Four welfare categories had only HIC (Corporative, Scandinavian, Liberal, Southern Europe) one category (Insecurity) had only LIC and two categories were mixed with HIC and UMIC (Eastern Europe and Informal Security). Likewise, the number of dentists inhabitant in the Liberal regime (the second lowest) was 30 times higher than in the Insecurity regime (the lowest level), showing strong collinearity.

Welfare regimes and edentulism

In the pooled sample (Tables 1 and 2), the highest prevalence of edentulism was observed in Eastern European countries (8.4%, 95% CI: 7.6–9.3), followed by Corporative (8.1%, 95% CI: 7.0–9.3) and Informal Security (7.9%, 95% CI: 7.0–8.5), while the lowest was observed in the Insecurity regime (0.8%, 95% CI: 0.4–1.5). Among HIC, the Scandinavian regime had the lowest prevalence (4.7%, 95% CI: 3.5–6.1), followed by Southern Europe (7.0%, 95% CI: 5.7–8.5) and the Liberal regime (7.4%, 95% CI: 6.4–8.6).

The association of edentulism with welfare regimes was estimated using multilevel logistic regression with random intercept after adjustment by age, sex, sugar supply and urbanisation (Table 3). As expected, age was the strongest predictor of edentulism; individuals aged 80 years or more were 155 times (odds ratio,

	Total (%)	(95% CI)	n	Edentulism % (cases)	(95% CI)
Edentulism					
No	92.7	(92.1–93.3)	107,156		
Yes	7.3	(6.7–7.9)	10,241		
Individual level variables					
Age group					
20–34 years	28.1	(27.1–29.1)	23,587	0.4 (62)	(0.2–0.5)
35–49 years	30.7	(29.8–31.7)	38,261	1.0 (478)	(0.8–1.2)
50–64 years	22.5	(21.4–23.8)	27,458	6.8 (1474)	(6.1–7.7)
65–79 years	15.8	(14.9–16.6)	24,591	26.0 (6967)	(24.4–27.7)
80+ years	2.9	(2.6–3.2)	3498	42.7 (1260)	(39.0–46.5)
Sex					
Male	46.6	(45.5–47.7)	48,220	6.1 (3677)	(5.6–6.6)
Female	53.4	(52.3–54.5)	69,177	8.3 (6564)	(7.6–9.1)
Quintiles of wealth score					
Poorest	19.4	(18.6–20.2)	23,815	18.5 (3436)	(16.8–20.3)
Second	19.9	(19.4–20.5)	22,618	7.9 (2317)	(7.1–8.8)
Middle	21.0	(20.3–21.6)	22,821	4.1 (1436)	(3.6–4.7)
Fourth	20.4	(19.8–21.1)	20,380	2.6 (1183)	(2.1–3.1)
Wealthiest	19.3	(18.4–20.1)	20,331	1.5 (516)	(1.2–1.8)
Country level variables					
Country level of income					
High	5.0	(1.9–12.7)	5936	7.4 (3898)	(6.9–7.9)
Upper middle	20.4	(16.9–24.4)	69,053	8.5 (6215)	(7.8–9.3)
Low/Lower middle	74.6	(68.7–79.7)	42,408	0.8 (128)	(0.4–1.5)
Urbanisation					
Below Median (<73%)	50.4	(43.6–57.3)	57,099	6.9 (2098)	(6.0–7.9)
Above Median (=>73%)	49.6	(42.7–56.4)	60,298	7.7 (8143)	(7.1–8.3)
Total Sugar & Sweetener supply					
<40 kg/capita/year	27.7	(22.2–34.1)	46,959	5.6 (1156)	(4.5–7.0)
≥40 kg/capita/year	72.3	(65.9–77.8)	70,438	7.9 (9085)	(7.4–8.5)
Welfare Regimes					
Corporative	15.2	(11.3–20.2)	5708	8.1 (504)	(7.0–9.3)
Eastern Europe	30.3	(24.7–36.5)	11,245	8.4 (1119)	(7.6–9.3)
Informal Security	20.1	(15.3–26.0)	73,449	7.8 (6610)	(7.0–8.5)
Social/Labour Insecurity	5.0	(1.9–12.7)	5936	0.8 (128)	(0.4–1.5)
Liberal	6.5	(4.4–9.6)	12,953	7.4 (1309)	(6.4–8.6)
Scandinavian	7.7	(4.9–11.8)	2946	4.7 (187)	(3.5–6.1)
Southern Europe	15.1	(10.1–22.2)	5160	7.0 (384)	(5.7–8.5)

Table 1: **Weighted prevalence of edentulism and sample size (n) according to individual and contextual variables in adult population of 40 countries.**

OR = 155.8, 95% CI: 64.62–375.63) more likely to be edentulous than those aged 20–34 years. Results showed that the chances of being edentulous in Informal Security countries were higher (OR = 3.84; 95% CI: 1.60–9.24) than in Scandinavian countries. The lowest chances were found among Insecurity countries with OR = 0.54 (95% CI: 0.12–2.48). Among HIC, all regimes had higher chances of edentulism than the Scandinavian regime (Table 3).

Wealth inequalities in edentulism by welfare regimes

In the total sample, the prevalence of being edentulous by wealth quintiles went from 18.5% (95% CI: 16.8–20.3) in the lowest wealth quintile (the poorest) to 7.9% (95% CI: [7.1–8.8), 4.1% (95% CI: 3.6–4.7), 2.6% (95% CI: 2.1–3.1) and 1.5% (95% CI: 1.2–1.8) in the highest (richest) quintile. Within welfare regimes, inequalities varied considerably, although following a similar gradient–except for the Insecurity regime that presented a very low prevalence with no significant differences among wealth groups (Table 2). In all countries, the wealthiest group had the lowest prevalence, and the poorest had the highest in crude and age-adjusted prevalence (Supplementary Table S2, Fig. 1).

The lowest level of relative inequalities was found in the Insecurity regime where the poorest quintile had with OR = 1.31 (95% CI: 0.54–3.19) more chances of being edentulous than the wealthiest (Table 4). The

Welfare regime	Quintiles of wealth score					Total sample
	Wealthiest	Fourth	Middle	Second	Poorest	
Corporative						
%	1.6	1.7	3.4	6.8	26.3	8.1
(95% CI)	(0.9, 2.8)	(1.0, 2.8)	(2.4, 4.7)	(5.3, 8.7)	(22.7, 30.3)	(7.0, 9.3)
Eastern Europe						
%	1.5	1.8	5.2	10.5	21.7	8.4
(95% CI)	(0.9, 2.3)	(1.3, 2.6)	(4.4, 6.2)	(9.1, 12.0)	(19.3, 24.4)	(7.6, 9.3)
Informal Security: Liberal						
%	2.9	7.1	6.2	10.8	10.2	7.8
(95% CI)	(2.3, 3.8)	(6.0, 8.3)	(5.1, 7.4)	(9.4, 12.3)	(8.8, 11.8)	(7.0, 8.5)
Insecurity: Social/Labour						
%	0.8	0.9	0.4	0.6	1.3	0.8
(95% CI)	(0.5, 1.1)	(0.2, 3.2)	(0.1, 1.2)	(0.5, 0.8)	(0.5, 3.1)	(0.4, 1.5)
Liberal						
%	0.8	2.5	4.0	9.8	18.8	7.4
(95% CI)	(0.5, 1.3)	(1.8, 3.4)	(2.7, 5.9)	(7.6, 12.7)	(15.2, 23.2)	(6.4, 8.6)
Scandinavian						
%	0.7	1.1	1.2	3.8	15.9	4.7
(95% CI)	(0.2, 2.1)	(0.5, 2.2)	(0.7, 2.2)	(2.3, 6.2)	(12.9, 19.3)	(3.5, 6.1)
Southern Europe						
%	0.2	0.9	3.1	4.2	21.6	7.0
(95% CI)	(0.1, 0.7)	(0.4, 1.8)	(1.9, 5.1)	(2.9, 5.9)	(18.0, 25.7)	(5.7, 8.5)
Total sample						
%	1.5	2.6	4.1	7.9	18.5	7.3
(95% CI)	(1.2, 1.8)	(2.1, 3.1)	(3.6, 4.7)	(7.1, 8.8)	(16.8, 20.3)	(6.7, 7.9)

Table 2: **Weighted prevalence of edentulism according to welfare regimes and wealth quintiles (from Wealthiest-fifth to Poorest-first) among adult population 20 years and over in 40 countries.**

highest level of relative inequalities was found in the Liberal countries (OR = 20.6; 95% CI: 15.3–27.8, comparing the poorest versus wealthiest). The interaction term between welfare and wealth quintiles was statistically significant ($p < 0.001$). Using the wealth quintiles as a continuous variable, it was found that the regimes with the largest to smallest relative inequalities were Liberal, Scandinavian, Southern Europe, Corporative, Eastern Europe, Informal Security and Insecurity. IPTW methods yielded similar with some differences (Supplementary Table S3).

The lowest level of absolute inequalities was also found in the Insecurity regime. The second lowest was in Scandinavian regime, where the prevalence difference between the poorest and wealthiest quintiles was 5.5 percentage points (Table 4). The highest level of absolute inequalities was found in the Liberal countries, with 17.3 percentage points of difference between the poorest and wealthiest quintiles. The interaction term between welfare and wealth quintiles was statistically significant ($p < 0.001$). Using the wealth quintiles as a continuous variable, it was found that the regimes with the largest to smallest relative inequalities were Liberal, Eastern Europe, Corporative, Southern Europe, Informal Security, Scandinavian and Insecurity. Using IPTW showed similar results with some differences (Supplementary Table S4).

	Crude		Fully adjusted[a]	
	OR	(95% CI)	OR	(95% CI)
Country level variables				
Welfare regimes				
Scandinavian	1		1	
Insecurity: Social/Labour	0.16	(0.05–0.49)	0.54	(0.12–2.48)
Informal security: Liberal	1.59	(0.66–3.83)	3.84	(1.60–9.24)
Southern Europe	1.71	(0.83–3.52)	2.39	(0.98–5.87)
Liberal	1.85	(0.84–4.09)	2.87	(1.23–6.72)
Corporative	1.99	(0.97–4.10)	2.57	(1.11–5.92)
Eastern Europe	2.08	(1.02–4.23)	3.30	(1.32–8.20)
Individual level variables				
Quintiles of wealth score[b]				
Wealthiest	1		1	
Fourth	1.81	(1.23–2.65)	1.67	(1.23–2.27)
Middle	2.99	(2.08–4.29)	2.30	(1.69–3.14)
Second	6.06	(4.08–9.00)	2.89	(2.10–3.96)
Poorest	16.53	(10.39–26.30)	4.79	(3.40–6.76)
	Empty model		Model 2	
VPC	13.20%	(5.87–26.85)	7.37%	(4.28–12.41)
Variance 2nd level	0.50		0.26	
BIC	62,235		39,303	

[a]Adjusted by urbanisation, sugar and sweetener supply, age and sex. [b]From Wealthiest-fifth to Poorest-first quintile.

Table 3: **Odds Ratio of having edentulism according to individual and contextual variables in adult population of 40 countries using multilevel logistic regression with random intercept and calibrated sampling weight.**

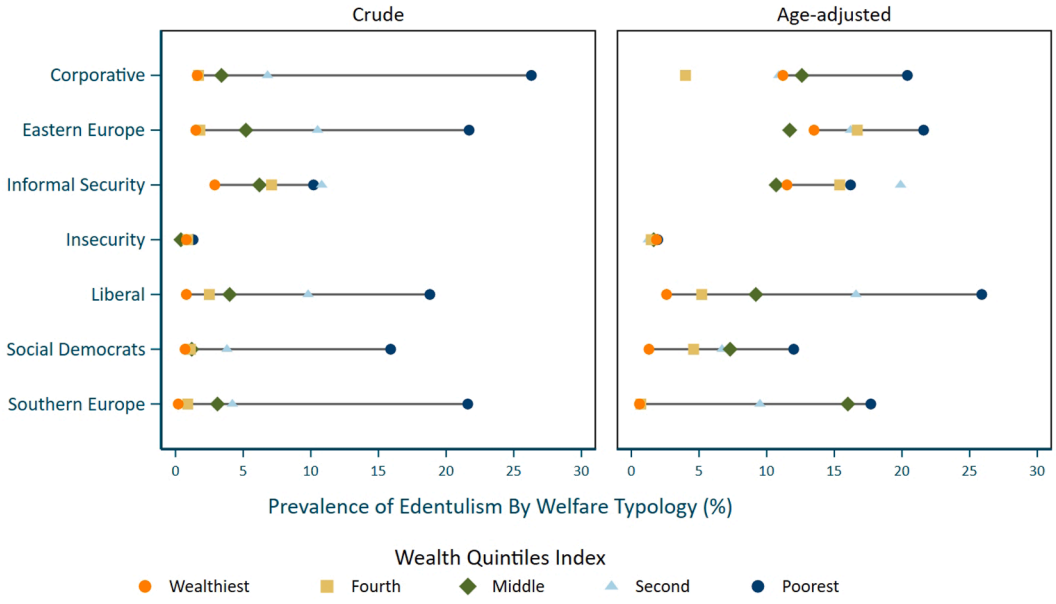

Fig. 1: Wealth inequality plot in prevalence of edentulism according to welfare regime typology among adult population in 40 countries.

Sensitivity analyses

Different approaches were tested to ascertain the robustness of the results. Firstly, stratified analysis by age groups showed stronger associations among younger age groups (<60 years old), but they were not significant because the sample size was reduced, and uncertainty increased (Supplementary Table S5). Second, removing LIC did not affect the overall pattern

Relative inequalities	Corporative		Eastern Europe		Informal security: liberal		Insecurity: Social/ Labour		Liberal		Scandinavian		Southern Europe	
	OR 95% CI		OR 95% CI		OR 95% CI		OR 95% CI		OR 95% CI		OR 95% CI		OR 95% CI	
Quintiles of wealth score														
Wealthiest	Ref		Ref		Ref		Ref		Ref		Ref		Ref	
Fourth	1.28 (0.77–2.12)		1.21 (0.78–1.90)		1.95 (1.11–3.43)		0.86 (0.22–3.38)		3.12 (2.82–3.45)		1.46 (0.64–3.35)		4.47 (1.15–17.42)	
Middle	2.1 (1.26–3.49)		2.39 (1.47–3.89)		1.7 (0.89–3.23)		0.32 (0.11–0.95)		5.08 (2.50–10.32)		1.74 (0.68–4.45)		10.12 (5.03–20.35)	
Second	2.85 (1.94–4.20)		2.69 (1.62–4.47)		2.42 (1.21–4.87)		0.53 (0.47–0.61)		10.46 (7.06–15.48)		5.18 (1.23–21.84)		6.98 (2.56–19.07)	
Poorest	6.4 (4.68–8.74)		4.08 (2.27–7.32)		2.2 (1.06–4.59)		1.31 (0.54–3.19)		20.59 (15.25–27.82)		**7.5** (2.44–22.98)		20.18 (6.14–66.31)	
Quintiles as a continuous variable (from poorest to richest)	1.68 (1.55–1.82)		1.42 (1.24–1.61)		1.17 (1.02–1.33)		1.05 (0.98–1.12)		2.00 (1.97–2.02)		1.76 (1.49–2.07)		1.74 (1.38–2.19)	
Absolute inequalities														
Intercept[a] -prevalence (95% CI)	2.4 (1.3–4.2)		3.8 (1.8–7.9)		5.3 (3.1–9.0)		1.9 (0.8–4.3)		1.0 (0.6–1.8)		0.8 (0.2–2.7)		0.7 (0.2–2.4)	
	PD (pp)	**P-value**	**PD (pp)**	**P-value**	**PD (pp)**	**P-value**	**PD (pp)**	**P-value**	**PD (pp)**	**p-value**	**PD (pp)**	**P-value**	**PD (pp)**	**P-value**
Quintiles of wealth score[b]														
Wealthiest	Ref		Ref		Ref		Ref		Ref		Ref		Ref	
Fourth	3.0	0.34	4.6	<0.01	9.9	0.02	1.7	0.83	3.1	<0.01	1.1	0.37	3.0	0.03
Middle	4.9	<0.01	8.7	<0.01	8.7	0.11	0.6	0.04	4.9	<0.01	1.3	0.25	6.6	<0.01
Second	6.5	<0.01	9.7	<0.01	12.0	<0.01	1.0	<0.01	9.6	<0.01	3.9	0.03	4.7	<0.01
Poorest	13.5	<0.01	14.0	<0.01	11.0	<0.01	2.5	0.56	17.3	<0.01	**5.5**	<0.01	12.4	<0.01
Quintiles as a continuous variable (from poorest to richest)	14.3	<0.01	12.8	<0.01	6.5	0.02	0.3	0.16	21.9	<0.01	6.8	<0.01	13.8	<0.01

Note: Adjusted by age, sex, sugar supply and urbanisation. [a]Prevalence in the reference category: wealthiest quintile, higher urbanisation level, higher sugar supply level, men, age 50–65 years. [b]From Wealthiest-fifth to Poorest-first quintile.

Table 4: **Odds Ratio (OR) and prevalence difference (PD) in percentage points (pp) of having edentulism according to individual and contextual variables in an adult population 20 years or over of 40 countries, using multilevel logistic regression with calibrated sampling weight.**

because the two LICs belonged to the same welfare regimes (Insecurity) (Supplementary Table S6). Third, the adjustment by dental care use was tested using a combination of time since the last visit (Visiting the dentist in the previous 12 months: yes/no) and the reason for the visit (treatment versus prevention/check-up). Adding dental care to the model significantly reduced the sample size but did not change the main conclusions (Supplementary Table S7). Fourth, an individual-level variable regarding residence location (rural and urban areas) was tested and did not change significantly the overall conclusion; for this analysis, the USA was the only country without information (Supplementary Table S8). Finally, a series of interactions between covariates with welfare and with the GDP group were tested. Such analyses confirmed higher inequalities among HIC, but models with GDP resulted in worse model fit (higher Akaike Information Criteria and Bayesian Information Criteria) than models with the welfare variable.

Discussion

The present study showed that among high- and upper-middle income countries, Scandinavian regime type presented lower prevalence and smaller absolute inequalities in edentulism. While Eastern European and Informal Security regimes presented the highest prevalence, countries belonging to the Liberal regime had the largest inequalities in both absolute and relative terms. Strikingly, the prevalence was very low in the two low-income countries included in the analysis, where there were barely any wealth inequalities in edentulism.

As paradoxical as it may initially seem, the Insecurity regime presented lower level of edentulism and inequalities than other welfare regimes. That the countries with the least social protection policies had a favourable oral health situation was, unarguably, not a consequence of the lack of such policies. Sustained economic development improves living conditions; nonetheless, it brings new health hazards that can greatly affect population health, such as nutrition transition. It should be remembered that dental caries was a disease of rich countries until 1982, when the World Health Organization reported for the first time a higher DMFT index (number of decayed, missing and filled teeth) in poorer countries than among the richer ones.[33] At that time, the reasons for increasing levels of dental diseases in LMIC were industrialisation and urbanisation coupled with an increased per capita income leading to a rising sugar consumption.[29,33] However, in our study, countries in the Insecurity regime, Ghana and Rwanda, had by far the lowest level of sugar supply and the lowest proportion of individuals living in urban areas, which may indicate reduced access to industrialised sugary ultra-processed foods and drinks. Although that could help understand the findings, adjusting for those variables has not been sufficient to reduce substantially the association perhaps because of measurement errors (i.e. ecological fallacy) at aggregate level and also because edentulism is driven by other causes such as access to dental care and diseases not related to sugar (i.e. periodontal diseases). As an example, those countries also had low access to dental care with a meagre dentist-population ratio of 0.1 and 0.2 dentists per 10 thousand inhabitants, respectively, while LMIC have ratios higher than six dentists per 10 thousand inhabitants.[4] Although access to proper dental care is essential when needed, and individuals may benefit from a preventive approach coupled with early diagnosis and minimally invasive treatment, the traditional model of dentistry has failed to fully tackle oral diseases.[3,34] Frequent dental visits neither warrant good oral health[35] nor reduce inequalities[36,37] and may unsurprisingly contribute to edentulism, if tooth extraction is the only or most common therapy for dental problems. Only recently, a typology of dental care systems has been proposed to capture the importance placed on oral health across countries, as well as the different approaches to tackle the demand for services.[38] This may identify system-level strategies (e.g. coverage for preventive, restorative or rehabilitation care), however, requires further research to be operationalised.

Among high and upper-middle-income countries, the Scandinavian regime showed the lowest prevalence of edentulism in crude and adjusted analysis. On the other end of the scale, Eastern European and Informal Security regimes had the highest age-adjusted prevalence. Previous studies have also reported better oral outcomes among the Scandinavian regime than in other HIC,[22,23,25,26,39] but unique to the current study is the inclusion of LMIC. Eastern European and Informal Security countries have similar GDP per capita and performed similarly in terms of the prevalence of edentulism, despite the differences in welfare policies between them. This sparks questions about what specific policies may influence oral health. It could also be that the relatively generous universal welfare systems in Scandinavian countries would mitigate structural determinants, enhancing health through several specific pathways, and, therefore, those countries would perform better because of general policies with ample effects. In support of this argument, it has been shown that HIC countries have much larger government social spending relative to LMIC, both in per capita and as a share of GDP,[40] spreading the effect of social protection via several indirect policies that could have different effects on edentulism. Higher governmental expenditure in public policies often aligns with higher coverage and reflects political traditions of social protection.[41] Therefore, the variability among HIC cannot be related to coverage and expenditure itself, rather it may be a product of a different set of social policies.

Importantly, the present report showed that the magnitude of inequalities varied across welfare regimes. There were larger absolute and relative inequalities in the Liberal regime and smaller absolute inequalities in the Scandinavian one. A few studies have addressed this, and, to some extent, we confirmed the "Welfare paradox" in which the Scandinavian countries have lower prevalence but not lower relative inequalities.[22,23] Despite good living standards, there is evidence that relative social position can play important role in explaining the social gradient, including edentulism.[42–44] Partially, larger relative inequalities may be explained by pure arithmetic properties. Relative inequalities may be larger when the prevalence in the reference group is low, but even then, there should still be low inequality in absolute terms. However, Scandinavian countries cover preventive care for children but not adults; while Corporative European countries may offer higher coverage of conservative care for adults, avoiding tooth extraction. These differences contribute to variations in edentulism prevalence and inequalities. Finally, information about fluoride availability is, indeed, scant for many countries, mostly LMIC and it was not possible to recover such information for the current study. HIC countries may have lower prevalence due to widespread of fluoride, either from toothpaste or community water fluoridation. Consequently, fluoridation is one of the few factors investigated for its potential effect on oral health inequalities. Nonetheless, the evidence is, unfortunately, not fully conclusive.[45,46]

Furthermore, the current study included more countries than previous studies[21–26,39] and two additional welfare categories. Adjusting for relevant country-level controlling factors–sugar supply and urbanisation—made the current analysis more robust. We reported the largest inequalities among Liberal countries, which provides evidence contrary to the argument that focused policies may reduce them. Critiques of high-risk strategies in oral health[47] pointed out that most cases of the outcome (i.e. edentulism) may be concentrated in the low-risk group. Focused policies refer to interventions targeting high-risk groups and requiring means-tests, with limited coverage. It may be a specific social benefit (e.g. food voucher) or preventive intervention (e.g. toothbrushing school program). In liberal welfare regimes, this can contribute to higher inequalities, consistent with observed data. Again, this suggests countries that rely exclusively on targeted policies. i.e. focus on vulnerable high-risk groups may be unable to change the structural factors that cause and maintain inequalities.[26,47–49]

Limitations of the current study need to be discussed, particularly as they hinder causal inference between the welfare policies and oral health. One issue is how to ascertain the temporal relation between exposure when the outcome is the product of life course exposure to unhealthy conditions with long latency. Although welfare policies constantly change over time, there is still a path dependency,[50] so differences among countries could remain relatively similar because the typology reflects long-standing political traditions.[51] Moreover, it is important to remember that a non-negligible fraction of those in our sample who are toothless may have grown up long before the maturity of welfare states. A second issue concerns the fact that only two Low-Income Countries were included in the analysis (Insecurity regime), and most Middle-Income Countries were clustered in the same category (Informal Security), despite within-countries differences in their approach to welfare policies. It has been proposed that some Latin American countries could be split into different categories and future studies may investigate innovative typology perspectives.[52] Finally, alternative approaches to welfare typology, include the institutional theory and overall spending in social policies.[8,10] Whereas the first focuses on the effect of coverage and generosity of specific policies (e.g. minimum income, family or unemployment benefits), the second concentrates on the overall costs on social protection and state services as a percentage of the total expenditure, assuming that these costs can also reflect generosity. Higher levels of generosity, as measured by expenditures, have been associated with better health[53] and both institutional and spending approaches may be related to lower levels of income and health inequalities.[10] The motivation to study the effects of specific policies is that other studies have concentrated on specific social policies to open up the black box of the regime typology.[54] Challenging the present results, higher coverage of public policies was associated with larger socioeconomic inequalities in tooth loss in Brazil,[48] perhaps because the more affluent part of society benefited from them at an earlier stage.

Our findings suggest that social policies in some welfare state regimes might improve population oral health while reducing socioeconomic inequalities in key oral health outcomes. This becomes more important among high and upper-middle-income countries with higher edentulism prevalence and larger inequalities. The current work also indicates that despite economic development being associated with a higher prevalence of edentulism, social protection may partially offset such an effect. The welfare state typology captures political traditions and may better reflect long-term policies that cannot be changed in a short time but that can impact both prevalence and socioeconomic inequalities in edentulism. Future research should expand the analysis to more Low- and Middle-Income Countries, explore the impact of specific social and health policies—for example on fluoridation–beyond welfare state typologies. New approaches to measure specific features of social policies, with broader range of indicators, focussing, for example, on coverage and

generosity, may unveil other related social and political determinants of oral health, and further details of how political traditions, expressed by welfare regimes, act on oral health.

Contributors

All authors contributed to the conception of the study. CGH, MAP, RGW AJB, NH, DMH, SB, JAG and GM contributed and obtained data. All authors had access to the data; RKC, HL, AJB, FC, MAP, LAY and JF accessed and verified the data that was handled by AJB and FC who pooled and harmonised all variables and take responsibility for the integrity and the accuracy of the data. RKC and HL independently conducted the statistical analyses. RKC wrote the first draft of the manuscript. All authors participated in the interpretation of results, critically reviewed and edited the manuscript. All authors approved the final version and are responsible for the decision to submit for publication.

Data sharing statement

This study used secondary de-identified microdata obtained from national oral health and health surveys, and the access depends on the public data-sharing policies of each country. Readers can access these datasets—either through open public repositories, such as the Global Health Data Exchange (GHDx), or via formal data request procedures required by national authorities. Datasets are listed in Supplementary Box 1.

Declaration of interests

None to declare.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lanepe.2025.101578.

References

1 Listl S, Galloway J, Mossey PA, Marcenes W. Global economic impact of dental diseases. *J Dent Res*. 2015;94:1355–1361.
2 Peres MA, Macpherson LMD, Weyant RJ, et al. Oral diseases: a global public health challenge. *Lancet*. 2019;394:249–260.
3 Watt RG, Daly B, Allison P, et al. Ending the neglect of global oral health: time for radical action. *Lancet*. 2019;394:261–272.
4 World Health Organization. *Global oral health status report: towards universal health coverage for oral health by 2030*; 2022. Geneva https://www.who.int/publications/i/item/9789240061484. Accessed November 22, 2023.
5 Bernabe E, Marcenes W, Abdulkader RS, et al. Trends in the global, regional, and national burden of oral conditions from 1990 to 2021: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet*. 2025;405:897–910.
6 Celeste RK, Darin-Mattsson A, Lennartsson C, Listl S, Peres MA, Fritzell J. Social mobility and tooth loss: a systematic review and meta-analyses. *J Dent Res*. 2022;101:143–150.
7 Sheiham A, Watt RG. The common risk factor approach: a rational basis for promoting oral health. *Community Dent Oral Epidemiol*. 2000;28:399–406.
8 Beckfield J, Bambra C, Eikemo TA, Huijts T, Mcnamara C, Wendt C. An institutional theory of welfare state effects on the distribution of population health. *Soc Theory Health*. 2015;13:227–244.
9 Brennenstuhl S, Quesnel-Vallée A, McDonough P. Welfare regimes, population health and health inequalities: a research synthesis. *J Epidemiol Community Health*. 2012;66:397–409.
10 Bergqvist K, Yngwe MA, Lundberg O. Understanding the role of welfare state characteristics for health and inequalities – an analytical review. *BMC Public Health*. 2013;13:1234.
11 Muntaner C, Borrell C, Ng E, et al. Politics, welfare regimes, and population health: controversies and evidence. *Sociol Health Illn*. 2011;33:946–964.
12 Eikemo TA, Bambra C. The welfare state: a glossary for public health. *J Epidemiol Community Health*. 2008;62:3–6.
13 Bambra C. Going beyond the three worlds of welfare capitalism: regime theory and public health research. *J Epidemiol Community Health*. 2007;61:1098–1102.
14 Eikemo TA, Bambra C, Judge K, Ringdal K. Welfare state regimes and differences in self-perceived health in Europe: a multilevel analysis. *Soc Sci Med*. 2008;66:2281–2295.
15 Minas C, Jacobson D, Antoniou E, McMullan C. Welfare regime, welfare pillar and southern Europe. *J Eur Soc Policy*. 2014;24:135–149.
16 Orloff AS. Gender and the social rights of citizenship: the comparative analysis of gender relations and welfare states. *Am Sociol Rev*. 1993;58:303–328.
17 Ferrera M. The 'Southern Model' of Welfare in Social Europe. *J Eur Soc Policy*. 1996;6:17–37.
18 Wood G, Gough I. A comparative welfare regime approach to global social policy. *World Dev*. 2006;34:1696–1712.
19 Bambra C. Health inequalities and welfare state regimes: theoretical insights on a public health 'puzzle'. *J Epidemiol Community Health*. 2011;65:740–745.
20 Mackenbach JP. The persistence of health inequalities in modern welfare states: the explanation of a paradox. *Soc Sci Med*. 2012;75:761–769.
21 Guarnizo-Herreño CC, Watt RG, Pikhart H, Sheiham A, Tsakos G. Inequalities in oral impacts and welfare regimes: analysis of 21 European countries. *Community Dent Oral Epidemiol*. 2014;42:517–525.
22 Guarnizo-Herreño CC, Watt RG, Pikhart H, Sheiham A, Tsakos G. Socioeconomic inequalities in oral health in different European welfare state regimes. *J Epidemiol Community Health*. 2013;67:728–735.
23 Sanders AE, Slade GD, John MT, et al. A cross-national comparison of income gradients in oral health quality of life in four welfare states: application of the Korpi and Palme typology. *J Epidemiol Community Health*. 2009;63:569–574.
24 Guarnizo-Herreño CC, Watt RG, Garzón-Orjuela N, Tsakos G. Explaining oral health inequalities in European welfare state regimes: the role of health behaviours. *Community Dent Oral Epidemiol*. 2019;47:40–48.
25 Guarnizo-Herreño CC, Tsakos G, Sheiham A, Watt RG. Oral health and welfare state regimes: a cross-national analysis of European countries. *Eur J Oral Sci*. 2013;121:169–175.
26 Baker SR, Foster Page L, Thomson WM, et al. Structural determinants and children's oral health: a Cross-National Study. *J Dent Res*. 2018;97:1129–1136.
27 Rostila M. Invited commentary: social cohesion, depression, and the role of Welfare States. *Am J Epidemiol*. 2020;189:354–357.
28 Lundberg O, Yngwe MA, Stjarne MK, Bjork L, Fritzell J. *The Nordic Experience: Welfare States and Public Health (NEWS)*. Stockholm: Center for Health Equity Studies; 2008.
29 Drewnowski A, Popkin BM. The nutrition transition: new trends in the global diet. *Nutr Rev*. 1997;55:31–43.
30 Elkasabi M, Ren R, Pullum TW. *Multilevel Modeling Using DHS Surveys: A Framework to Approximate Level-Weights. DHS Methodological Reports No. 27*. Rockville: USAID; 2020. https://dhsprogram.com/publications/publication-mr27-methodological-reports.cfm. Accessed October 7, 2025.
31 Goldstein H, Browne W, Rasbash J. Partitioning variation in multilevel models. *Understanding Statistics*. 2002;1:223–231.
32 Snijders TAB, Bosker RJ. *Multilevel analysis: an introduction to basic and advanced multi-level modeling*. London: SAGE; 1999.
33 Sheiham A. Changing trends in dental caries. *Int J Epidemiol*. 1984;13:142–147.
34 Nadanovsky P, Sheiham A. Relative contribution of dental services to the changes in caries levels of 12-year-old children in 18 industrialized countries in the 1970s and early 1980s. *Community Dent Oral Epidemiol*. 1995;23:331–339.
35 Riley P, Hv W, Je C, et al. *Recall intervals for oral health in primary care patients*. The Cochrane Collaboration; 2013.

36 Celeste RK, Boing AF, Peres KG, Peres MA. Life course social mobility, race and tooth loss in adulthood: the role of dental health services. *Oral Dis*. 2024;30:4782–4791. https://doi.org/10.1111/ODI.14918.
37 Guarnizo-Herreño CC, Scholes S, Heilmann A, et al. Dental attendance and behavioural pathways to adult oral health inequalities. *J Epidemiol Community Health*. 2021;75:1063–1069.
38 Guarnizo-Herreño CC, Singh A, Mathur MR, Sarawagi S, Peres MA. Making the case for a new typology of dental care systems. *Community Dent Oral Epidemiol*. 2024;52:767–774.
39 Elani HW, Harper S, Thomson WM, et al. Social inequalities in tooth loss: a multinational comparison. *Community Dent Oral Epidemiol*. 2017;45:266–274.
40 Bastagli F, Coady D, Gupta S. *Income inequality and fiscal policy*. 122012;12. IMF Staff Discussion Note; 2012:1–37.
41 Navarro V, Muntaner C, Borrell C, et al. Politics and health outcomes. *Lancet*. 2006;368:1033–1037.
42 Celeste RK, Nadanovsky P, Ponce de Leon A, Fritzell J. The individual and contextual pathways between oral health and income inequality in Brazilian adolescents and adults. *Soc Sci Med*. 2009;69:1468–1475. https://doi.org/10.1016/j.socscimed.2009.08.005.
43 Wilkinson RG. Socioeconomic determinants of health. Health inequalities: relative or absolute material standards? *BMJ*. 1997;314:591–595.
44 Yngwe MA, Fritzell J, Burström B, Lundberg O, Burström B, Lundberg O. Comparison or consumption? Distinguishing between different effects of income on health in Nordic welfare states. *Soc Sci Med*. 2005;61:627–635.
45 Iheozor-Ejiofor Z, Walsh T, Lewis SR, et al. Water fluoridation for the prevention of dental caries. *Cochrane Database Syst Rev*. 2024;10. https://doi.org/10.1002/14651858.CD010856.PUB3.
46 Shen A, Bernabé E, Sabbah W. Systematic review of intervention studies aiming at reducing inequality in dental caries among children. *Int J Environ Res Public Health*. 2021;18:1300–1311.
47 Batchelor P, Sheiham A. The limitations of a 'high-risk' approach for the prevention of dental caries. *Community Dent Oral Epidemiol*. 2002;30:302–312.
48 Celeste RK, Nadanovsky P. How much of the income inequality effect can be explained by public policy? Evidence from oral health in Brazil. *Health Policy*. 2010;97:250–258.
49 Rose G. Sick individuals and sick populations. *Int J Epidemiol*. 1985;14:32–38.
50 Paul P. Increasing returns, path dependence, and the study of politics. *Am Political Sci Rev*. 2000;94:251–267.
51 Esping-Andersen Gosta. *The three worlds of welfare capitalism*. Cambridge: Blackwell Publishers Ltd; 1990.
52 Ferre JC, Fellow P. Welfare regimes in twenty-first-century Latin America. *J Int Comp Soc Policy*. 2023;39:101–127.
53 Lundberg O, Yngwe MÅ, Stjarne MK, et al. The role of welfare state principles and generosity in social policy programmes for public health: an international comparative study. *Lancet*. 2008;372:1633–1640.
54 Nelson K, Fritzell J. Welfare states and population health: the role of minimum income benefits for mortality. *Soc Sci Med*. 2014;112:63–71.