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Social inequalities in adult oral health in 40 low- and middle-income countries

Bishal Bhandari, Jonathon T Newton and Eduardo Bernabé

Division of Population and Patient Health, King's College London Dental Institute at Guy's, King's College and St Thomas' Hospitals, London, UK.

Objective: This study evaluated social inequalities in adult oral health across several low- and middle-income countries. **Methods:** We used data from 40 countries that participated in the World Health Surveys. Participants' socio-economic position was assessed using the wealth index. Oral health was assessed using two perceived measures, namely total tooth loss and whether they had any problems with their mouth and/or teeth during the last 12 months (perceived needs). Absolute and relative wealth inequalities in oral health were measured using the slope index of inequality (SII) and the relative index of inequality (RII), respectively, after adjusting for participants' sex, age and education. **Results:** There were wealth inequalities in total tooth loss and perceived needs in most countries. However, significant monotonic gradients were found in 21 countries for total tooth loss and in 18 countries for perceived needs. Two distinctive patterns of social inequality in oral health were found across countries using the RII and the SII. For total tooth loss, pro-rich inequality was found in 25 countries (significant RII/SII in eight countries) and pro-poor inequality was found in 15 (significant RII/SII in three countries). For perceived needs, pro-poor inequality was found in 26 countries (significant RII/SII in six countries) and pro-rich inequality was found in 14 (significant RII/SII in five countries). **Conclusions:** The well-documented social gradient in adult oral health favouring the rich was not present in all low- and middle-income countries. Pro-poor inequalities in total tooth loss, and particularly in perceived dental-treatment needs, were observed in some countries.

Key words: *Socio-economic factors, oral health, tooth loss*

INTRODUCTION

There is overwhelming evidence of socio-economic inequalities in adult oral health. Oral diseases are disproportionately represented in adults of low socio-economic position (SEP). However, poor oral health is not limited to the lower end of the social scale as there is a social gradient in oral health that is determined by an individuals' position on the social ladder[1,2]. Most evidence on social inequalities in adult oral health comes from developed countries[3–6]. A robust association between SEP and adult oral health has been found regardless of which SEP indicator is used, which oral health outcome is assessed and whether all the population or only a segment (such as senior adults) is evaluated.

Recent literature has focused on monitoring social inequalities in adult oral health by assessment of trends within countries or comparisons between countries. Monitoring social inequalities in health is important to improve understanding of the social determinants of health and to evaluate policies to promote health and reduce health inequalities[7,8]. Within countries, despite large declines in the prevalence and incidence of oral diseases at global, regional and country levels over the past two decades[9–11], social inequalities in oral health persist and may be widening[3–6]. There is also evidence of variations in social gradients in oral health between countries, even among rich neighbouring countries, like those in Europe[3, 5] and North America[4]. Based on these combined findings, some have argued that social inequalities in adult oral health are universal[1,2].

Despite the paucity of studies monitoring social inequalities in oral health in developing countries, a few national surveys in developing countries show contradicting evidence[12–16]. A significant social gradient in caries experience was found among Vietnamese adults ≥18 years of age[12]. Although a significant gradient in self-reported worse oral health status, according to household consumption, was found among 15- to 75-year-old Thai subjects during bivariate

analysis, this association was fully attenuated after controlling for sociodemographic factors[13]. On the other hand, education was not related to severe caries (defined for the study as having 16 or more decayed or missing teeth) among Pakistani adults ≥25 years of age[14]. Moreover, a significant interaction was found between the count of durable goods in the household and community development: in communities with low development it was the more advantaged who were more likely to have severe caries, whereas in communities with a high level of development it was those with few foods who were most likely to have severe caries[14]. In Mexico, the prevalence of edentulism decreased with increasing household wealth in adults ≥35 years of age[15], whereas the opposite trend was found for the prevalence of self-reported oral/dental problems in adults ≥18 years of age[16]. There is also evidence in medicine showing that the shape of the social gradient in health varies according to economic development and the stage in which the country is in regarding demographic, epidemiologic and nutrition change[17–19]. Therefore, this study aimed to evaluate social inequalities in adult oral health across several low- and middle-income countries, using a comparable data set and measurement method.

METHODS

Data source

Data were obtained from the World Health Survey (WHS) conducted in 2002–2004, which was sponsored by the World Health Organization (WHO) to provide valid, reliable and comparable information across 70 countries from all world regions regarding health status and health systems. In each country, the target population was adults ≥18 years of age living in private households. Participants were selected using multistage stratified cluster sampling with the intention of collecting nationally representative samples. However, in six countries the survey was carried out in geographically limited regions and random sampling was not used. Sample size varied from 1,000 to 10,000 between countries whilst ensuring that the sample was nationally representative of the population[20].

Fifty of the 70 countries included in the WHS were classified as low- and middle-income economies, according to the 2003 classification of the World Bank, and were initially selected for this analysis. We excluded China, Comoros, Congo, India, Ivory Coast and the Russian Federation because their samples were not nationally representative; Zambia and Guatemala because their data files had no survey information needed to produce nationally representative estimates; and Tunisia and Mauritania because their study samples (participants with complete data in relevant variables) represented only 20.4% and 45.4% of the full sample of the participants, respectively.

Variables selection

Participants' SEP was determined using the wealth index[21,22], which classifies households based on their ownership of a range of permanent income indicators (household assets) ranging from a bicycle, mobile phone, fixed-line telephones and refrigerator to a computer, dishwasher, washing machine and car. Country-specific items were also added to the list of assets to fit the standard of living of particular countries, and the final list included between 11 and 20 items. A principal components analysis (PCA) was then performed separately for each country to determine the weights to create an index of the asset variables. The weights for the first component were then applied to each person's data thus giving a continuous asset index measure[21]. Because the PCA was performed separately for each country, the absolute value of the wealth index cannot be compared between countries. We thus categorised this index into tertiles to improve cross-country comparability of social gradients.

Two perceived oral health indicators were the outcome variables. The first measured total tooth loss through the question 'Have you lost all of your natural teeth?' and the second measured dental treatment needs through the question 'During the last 12 months, did you have any problems with your mouth and/or teeth?' Binary response options (no/yes) were used with the two items.

Covariates were participants' sex, age and education. Age was categorised as 18–29, 30–39, 40–49, 50–59, 60–69 and ≥70 years of age. Education was measured using a seven-point response scale, and responses were collapsed into three categories (primary school or less; secondary school; and college and higher education) to enhance cross-country comparability. For one country (Turkey), the categorical classification of education was missing and years of education was converted into three categories based on the Turkish Ministry of Education classification. Although education is a common SEP indicator in high-income countries, we treated it as a confounder because it reflects childhood SEP (i.e. it happened before the creation of wealth in adult life), more so in developing than in developed countries[23]. Furthermore, education has its own effects on health status, which may offset low economic status; more education, however, does not necessarily lead to greater wealth in low- and middle-income countries.

Statistical analysis

STATA/IC 12 for Windows (Stata Corp., College Station, TX, USA), using the *survey* command, was

used for data analysis. All analyses considered the complex survey design (stratification and clustering), as well as the sample weights, to produce nationally representative estimates. Of the 214,240 respondents in the 40 countries, 28,458 (13.3%) had missing data on total tooth loss, 27,097 (12.6%) on problems with mouth and/or teeth, and 6,147 (2.9%) on one or more covariates. As there is ongoing debate on whether multiple imputation methods are useful with missing outcome data[24,25] (the two oral health measures explained the largest proportion of missing data), we opted to exclude participants with missing data from the analysis (casewise deletion).

We first presented the crude prevalence of total tooth loss and problems with mouth and/or teeth in the full sample of each country and then stratified the data according to household wealth. Linear trends for the association of household wealth with each oral health outcome were assessed, fitting the former as a continuous variable in survey logistic regression models. Results were presented for low-, lower-middle and upper-middle-income countries (LIC, LMIC and UMIC, respectively).

The Slope Index of Inequality (SII) and the Relative Index of Inequality (RII) were used to measure, respectively, the magnitude of absolute and relative inequalities in oral health according to household wealth. These regression-based indicators take the whole socio-economic distribution into account, rather than only comparing the two most extreme groups[8,26]. To that end, wealth tertiles were transformed into a summary measure (ridit score) that was scaled from 0 (first/bottom tertile) to 1 (third/top tertile) and were weighted to reflect the share of the sample at each wealth tertile. Ridit scores reflect the average cumulative frequency of the group, a midpoint of the range in the cumulative distribution, as described in detail elsewhere. For instance, if the first wealth group included 34% of the population, the range of participants in this category would be 0.00–0.34 and assigned a ridit score of 0.17 (= 0.34/2); if the second wealth group included 32% of the population the range of participants would be 0.34–0.66 and the corresponding ridit score would be 0.50 (= 0.34 + 0.32/2); and if the third wealth group included 34% of the population the range of participants would be 0.66–1.00 and the corresponding ridit score would be 0.83 (= 0.66 + 0.34/2). Ridit scores, instead of the wealth tertiles, were used in regression models to estimate SII and RII[27].

Linear and logistic regressions were used to estimate SII and RII, respectively, in models adjusting for sex, age and education. SII and RII were calculated with their corresponding 95% confidence interval (CI). SII represents the absolute difference in total tooth loss and problems with mouth and/or teeth when moving from the bottom wealth tertile to the top wealth tertile. On the other hand, RII measures the odds of reporting total tooth loss or problems with mouth and/or teeth in the top tertile compared with the bottom tertile[8,26]. An SII value lower than 0 (or an RII value lower than 1) indicates that the oral health outcome is more common among the worse-off, whereas an SII value higher than 0 (or an RII value higher than 1) indicates that the oral health outcome is more prevalent among the better-off[8,26].

RESULTS

We used data from 180,996 adults, ≥18 years of age, living in 40 low- and middle-income countries (17 LIC, 13 LMIC and 10 UMIC). The number of adults participating in the WHS in these countries ranged from 929 in Latvia to 38,746 in Mexico, and the analytical sample used for each country represented between 61.0% and 99.5% of all WHS participants. Those excluded because of missing data were significantly older, more educated and wealthier than those with complete data.

The prevalence of total tooth loss ranged from 1.1% in Kenya and Myanmar to 15.7% in Hungary (*Table 1*). There were wealth-related inequalities in total tooth loss in most countries. Significant monotonic gradients in total tooth loss according to wealth tertiles were found in 21 of 40 countries and they were more common in more developed economies (35% of LIC, 46% of LIMC and 90% of UMIC). Two distinctive patterns were found based on the adjusted RII and SII values (*Table 2*). For the majority of countries (nine LIC, eight LMIC and eight UMIC), RII was lower than 1 (ranging from 0.13 for Swaziland to 0.94 for Paraguay) and SII was lower than 0 (ranging from −16.8% for Zimbabwe to −0.2% for Burkina Faso), suggesting that the prevalence of total tooth loss was higher in the bottom wealth tertile than in the top wealth tertile. For the remaining countries (eight LIC, five LMIC and two UMIC), RII was higher than 1 (ranging from 1.05 for Senegal to 7.08 for Vietnam) and SII was higher than 0 (ranging from 0.3% for Senegal to 12.8% for Namibia), suggesting that total tooth loss was more prevalent in the top wealth tertile than in the bottom wealth tertile. However, RII and SII were significant in 11 countries (three LIC, six LMIC and two UMIC), with total tooth loss being more common among the worse-off in Lao, Zimbabwe, Bosnia and Herzegovina, the Dominican Republic, Swaziland, Turkey, Latvia and Uruguay and among the better-off in Vietnam, Namibia and the Philippines.

The prevalence of problems with mouth and/or teeth ranged from 12.8% in Myanmar to 63.7% in

Table 1 Crude prevalence of total tooth loss among adults ≥ 18 years of age (n = 179,763), according to household wealth tertiles (World Health Survey, 2002–2004)

Group	Country	n*	All sample (%)	Lowest tertile (%)	Middle tertile (%)	Highest tertile (%)	P value for trend†
LIC	Bangladesh	5,411	1.2	0.8	1.6	1.2	0.489
	Burkina Faso	4,694	1.6	1.8	1.5	1.3	0.291
	Chad	4,128	5.1	7.5	4.7	3.2	0.001
	Ethiopia	4,789	1.2	1.7	1.1	0.5	0.016
	Georgia	2,718	12.9	17.0	13.2	9.2	<0.001
	Ghana	3,448	1.6	1.6	1.7	1.6	0.994
	Kazakhstan	4,460	10.7	11.7	9.8	10.7	0.759
	Kenya	4,189	1.1	1.1	1.4	0.6	0.262
	Lao	4,831	1.8	2.3	2.3	0.8	0.005
	Malawi	5,117	2.5	2.3	3.1	2.1	0.798
	Mali	3,379	1.9	1.7	2.2	2.0	0.708
	Myanmar	5,886	1.1	1.6	0.9	1.0	0.278
	Nepal	8,657	1.7	1.8	1.9	1.6	0.556
	Pakistan	5,798	5.3	5.8	5.7	4.0	0.147
	Senegal	2,295	5.4	4.8	6.8	4.8	0.907
	Vietnam	3,261	2.1	1.5	1.4	3.2	0.018
	Zimbabwe	3,644	15.1	22.1	11.7	8.6	<0.001
LMIC	Bosnia & Herzegovina	1,026	15.2	21.7	9.2	11.1	0.003
	Brazil	4,960	14.7	18.4	15.8	11.0	<0.001
	Dominican Republic	4,376	8.1	13.0	8.0	6.2	<0.001
	Ecuador	3,876	8.1	8.0	10.1	6.2	0.162
	Morocco	4,466	9.6	8.7	10.4	9.4	0.767
	Namibia	3,675	15.5	13.3	12.5	21.3	0.003
	Paraguay	5,079	4.7	4.4	6.1	3.6	0.125
	Philippines	10,019	6.4	5.5	6.5	7.0	0.097
	South Africa	1,992	8.8	9.3	6.9	10.4	0.783
	Sri Lanka	5,372	4.2	6.8	4.0	3.4	0.117
	Swaziland	1,905	7.7	12.8	7.2	3.2	<0.001
	Turkey	10,828	13.6	16.3	15.1	9.8	<0.001
	Ukraine	2,195	10.1	12.6	10.3	8.0	0.329
UMIC	Croatia	967	11.6	21.0	7.8	9.3	0.003
	Czech Republic	875	11.4	22.6	8.2	2.6	<0.001
	Estonia	991	11.8	19.3	10.6	5.3	<0.001
	Hungary	1,386	15.7	28.2	13.2	6.1	<0.001
	Latvia	839	10.3	17.9	9.7	1.7	<0.001
	Malaysia	5,842	9.0	10.2	9.2	7.7	0.042
	Mauritius	3,726	12.0	15.9	11.8	8.9	<0.001
	Mexico	24,075	7.3	7.2	7.2	7.6	0.665
	Slovakia	1,679	2.9	6.3	1.2	1.0	0.001
	Uruguay	2,909	7.3	11.1	6.5	4.3	<0.001

*Counts are unweighted.
†P value for trend was derived from unadjusted survey logistic regression models.
LIC, low-income countries; LMIC, lower-middle-income countries; UMIC, upper-middle-income countries.

Kazakhstan (*Table 3*). In most countries there were inequalities in problems with mouth and/or teeth when this was stratified according to household wealth. However, significant monotonic wealth gradients in problems with mouth and/or teeth were present in 18 of 40 countries and they were more common in less-developed economies (47%, 46% and 40% for LIC, LMIC and UMIC, respectively). The adjusted RII and SII values showed two opposite patterns (*Table 4*). For 26 countries (eight LIC, 11 LMIC and seven UMIC), RII (ranging from 1.02 for Mauritius to 2.19 for Uruguay) and SII (ranging from 0.4% for Mauritius to 16.7% for Slovakia) suggested that the prevalence of problems with mouth and/or teeth was higher in the top wealth tertile than in the bottom wealth tertile. For the second group of countries (nine LIC, two LMIC and three UMIC), RII (ranging from 0.49 for Ethiopia to 0.92 for Latvia) and SII (ranging from −10.6% for Malawi to −2.0% for Latvia) indicated that problems with mouth and/or teeth were more prevalent in the bottom wealth tertile than in the top wealth tertile. However, the adjusted RII and SII values were only significant in 11 countries (seven LIC, two LMIC and two UMIC), with problems with mouth and/or teeth being more prevalent among the worse-off in Ethiopia, Ghana, Malawi, Nepal and the Philippines and more prevalent among the better-off in Kazakhstan, Lao, Pakistan, the Dominican Republic, Mexico and Uruguay.

DISCUSSION

Our results indicate that wealth-related inequalities in self-reported total tooth loss and perceived dental-

Table 2 Absolute and relative measures of inequalities in total tooth loss, according to household wealth, in adults ≥ 18 years of age (World Health Survey, 2002–2004)

Group	Country	RII†	(95% CI)	SII†	(95% CI)
LIC	Bangladesh	2.47	(0.99 to 6.21)	1.0	(−0.1 to 2.1)
	Burkina Faso	0.86	(0.31 to 2.37)	−0.2	(−1.6 to 1.2)
	Chad	0.40	(0.16 to 1.01)	−4.0	(−8.3 to 0.2)
	Ethiopia	0.21	(0.04 to 1.08)	−1.7	(−3.2 to −0.1)
	Georgia	0.82	(0.35 to 1.93)	−1.7	(−8.5 to 5.0)
	Ghana	1.38	(0.41 to 4.65)	0.5	(−1.3 to 2.3)
	Kazakhstan	2.36	(0.94 to 5.96)	7.0	(−1.7 to 15.7)
	Kenya	1.60	(0.34 to 7.59)	0.4	(−1.0 to 1.8)
	Lao	0.18	(0.07 to 0.46)**	−2.9	(−4.5 to −1.3)**
	Malawi	1.14	(0.48 to 2.71)	0.4	(−1.7 to 2.4)
	Mali	1.66	(0.53 to 5.18)	1.0	(−1.2 to 3.3)
	Myanmar	0.51	(0.15 to 1.75)	−0.8	(−2.3 to −0.6)
	Nepal	0.71	(0.34 to 1.48)	−0.6	(−1.9 to 0.7)
	Pakistan	0.67	(0.25 to 1.80)	−1.5	(−5.8 to 2.8)
	Senegal	1.05	(0.45 to 2.45)	0.3	(−3.9 to 4.5)
	Vietnam	7.08	(1.89 to 26.46)**	3.8	(0.8 to 6.8)*
	Zimbabwe	0.23	(0.14 to 40.0)***	−16.8	(−22.7 to −0.9)***
LMIC	Bosnia & Herzegovina	0.31	(0.14 to 0.70)**	−8.7	(−15.7 to −1.7)*
	Brazil	0.65	(0.41 to 1.04)	−3.6	(−8.1 to 0.8)
	Dominican Republic	0.38	(0.18 to 0.82)*	−6.0	(−10.4 to −1.6)**
	Ecuador	0.50	(0.25 to 1.00)	−4.5	(−9.1 to 0.2)
	Morocco	1.11	(0.53 to 2.32)	0.8	(−5.2 to 6.7)
	Namibia	2.77	(1.58 to 4.87)**	12.8	(5.6 to 20.0)**
	Paraguay	0.94	(0.52 to 1.72)	−0.4	(−3.1 to 2.2)
	Philippines	1.82	(1.11 to 2.98)*	3.5	(0.7 to 6.3)*
	South Africa	1.92	(0.76 to 4.87)	5.0	(−2.4 to 12.3)
	Sri Lanka	0.61	(0.19 to 1.92)	−1.8	(−5.4 to 1.8)
	Swaziland	0.13	(0.05 to 0.31)*	−13.5	(−19.4 to −7.5)*
	Turkey	0.67	(0.46 to 0.97)***	−4.0	(−7.5 to −0.6)***
	Ukraine	1.42	(0.29 to 6.88)	2.4	(−8.7 to 13.5)
UMIC	Croatia	2.08	(0.73 to 5.94)	7.8	(−2.3 to 17.9)
	Czech Republic	0.44	(0.09 to 2.07)	−3.2	(−14.5 to 8.0)
	Estonia	0.64	(0.24 to 1.72)	−3.2	(−10.5 to 4.1)
	Hungary	0.54	(0.24 to1.24)	−5.2	(−12.7 to 2.2)
	Latvia	0.18	(0.05 to 0.69)*	−9.7	(−18.8 to −0.6)*
	Malaysia	0.81	(0.48 to 1.37)	−1.7	(−5.1 to 1.8)
	Mauritius	0.78	(0.50 to 1.20)	−2.4	(−6.1 to 1.4)
	Mexico	0.94	(0.65 to 1.36)	−0.3	(−2.4 to 1.9)
	Slovakia	2.66	(0.47 to 14.96)	0.8	(−1.4 to 3.0)
	Uruguay	0.29	(0.16 to 0.53)***	−6.4	(−10.2 to −2.7)**

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.
†Estimates were adjusted for participants' sex, age groups and education.
LIC, low-income countries; LMIC, lower-middle-income countries; UMIC, upper-middle-income countries; RII, relative index of inequality; SII, slope index of inequality.

treatment needs (problems with mouth and/or teeth in the past year) were present in countries from different WHO regions and at different levels of national income. Significant gradients were found in 11 of 40 countries evaluated, with evidence of both pro-rich and pro-poor wealth inequalities in oral health (gradients in total tooth loss and treatment needs favouring the better-off and the worse-off, respectively). These findings were not accounted for by participants' sex, age and level of education.

These results should be interpreted with consideration of some study limitations. First, data on total tooth loss and dental-treatment needs were based on self-reports, which may raise concerns about their validity when compared with objective clinical assessments. However, self-reported measures are valid and reliable indicators of individuals' oral health status and are positively correlated with disease measures[28,29]. Self-reported tooth counts can be used to estimate the number of remaining teeth accurately[28,30], and self-assessed needs are positively correlated with disease measures and are valuable in assessing the needs of adults[31,32]. In addition, similar results were found in previous surveys conducted in some of these countries[15,16], even when using clinical measures[33]. Second, we used the wealth index to measure participants' SEP. The wealth index is considered a stable and effective indicator for monitoring long-term SEP of individuals and their households in developing countries where data on education and occupation are often inaccurate and not likely to capture the full extent of an individual's SEP[21,22]. Household income and consumption expenditure are other alternatives but have their limitations compared with

Table 3 Crude prevalence of problems with mouth and/or teeth in adults ≥ 18 years of age (n = 180,996), according to household wealth tertiles (World Health Survey, 2002–2004)

Group	Country	n*	All samples (%)	Lowest tertile (%)	Middle tertile (%)	Highest tertile (%)	P value for trend†
LIC	Bangladesh	5,425	42.6	43.7	42.5	41.8	0.365
	Burkina Faso	4,697	24.9	24.3	25.9	24.4	0.756
	Chad	4,157	29.3	33.1	29.4	25.4	0.001
	Ethiopia	4,851	19.4	22.2	17.9	15.4	0.001
	Georgia	2,709	49.4	47.0	51.0	50.4	0.447
	Ghana	3,496	17.8	20.8	19.2	14.3	<0.001
	Kazakhstan	4,469	63.7	63.0	64.1	64.0	0.741
	Kenya	4,231	27.8	31.5	28.9	23.0	0.005
	Lao	4,835	21.9	19.8	19.3	26.1	0.004
	Malawi	5,146	37.3	41.6	38.1	31.6	<0.001
	Mali	3,460	25.3	25.3	26.2	24.6	0.735
	Myanmar	5,886	12.8	12.4	13.2	12.6	0.890
	Nepal	8,623	34.0	36.6	35.1	31.2	<0.001
	Pakistan	5,884	18.7	17.5	17.7	22.7	0.039
	Senegal	2,332	29.9	34.0	25.8	28.5	0.180
	Vietnam	3,366	21.0	21.1	19.8	21.6	0.868
	Zimbabwe	3,686	33.6	32.7	33.2	34.9	0.387
LMIC	Bosnia & Herzegovina	1,020	33.9	33.1	34.9	34.2	0.831
	Brazil	4,960	35.3	32.8	34.3	38.0	0.007
	Dominican Republic	4,383	27.9	23.5	26.6	30.8	0.007
	Ecuador	3,901	23.6	18.3	25.8	25.2	0.014
	Morocco	4,467	43.4	39.6	43.3	46.3	0.040
	Namibia	3,731	22.1	23.3	21.6	21.4	0.363
	Paraguay	5,086	40.9	37.6	39.8	44.1	0.002
	Philippines	10,029	38.0	41.7	38.5	34.4	<0.001
	South Africa	1,964	17.1	17.7	18.1	15.2	0.510
	Sri Lanka	5,685	22.0	19.2	21.3	23.9	0.168
	Swaziland	1,918	21.6	22.5	17.5	24.0	0.669
	Turkey	11,026	34.2	33.3	34.4	34.3	0.587
	Ukraine	2,219	51.3	49.0	51.6	52.9	0.445
UMIC	Croatia	968	40.0	33.7	40.9	42.9	0.060
	Czech Republic	876	46.3	47.1	42.7	49.6	0.719
	Estonia	991	52.8	51.0	53.5	53.8	0.507
	Hungary	1,386	34.2	24.4	35.8	42.2	<0.001
	Latvia	842	47.5	42.7	50.8	49.8	0.178
	Malaysia	5,845	20.5	19.8	18.5	22.9	0.041
	Mauritius	3,733	23.8	21.7	26.3	23.1	0.503
	Mexico	24,075	27.0	22.8	28.8	31.5	<0.001
	Slovakia	1,728	41.3	35.8	42.2	46.3	0.111
	Uruguay	2,910	27.8	20.4	27.1	35.8	<0.001

*Counts are unweighted.
†P value for trend derived from unadjusted survey logistic regression models.
LIC, low-income countries; LMIC, lower-middle-income countries; UMIC, upper-middle-income countries.

wealth[21]. In addition, the decision to use wealth tertiles was empirical because quartiles and quintiles did not provide equal-size groups or enough participants for meaningful comparisons in some countries. Third, we used linear and logistic regression to estimate SII and RII, respectively, despite recent suggestions to use log-binomial regression with a logarithmic link function to calculate the RII and with an identity link function to calculate the SII[27,34]. We encountered convergence issues for some countries when using log-binomial regression which persisted even when resorting to robust Poisson regression as an alternative. We compared our results with those from log-binomial regression for countries in which the latter model converged and found that the results were similar for RII and slightly higher for SII (when using logistic regression) but in the same direction. Fourth, no attempt to control for dental behaviours was carried out. As the aim was to assess the overall impact of SEP on oral health, it was deemed inappropriate to adjust for behaviours. Indeed, dental behaviours are considered as merely intermediates of the relationship between socioeconomic indicators and oral health[1,35].

The existence of wealth inequalities in adult oral health favouring the poor contradicts the a-priori assumption that social gradients in oral health are universal[1,2]. Pro-poor inequalities in total tooth loss may be explained by differences in life expectancy between the rich and the poor: tooth loss is age-dependent and will be more common among the rich if they live longer. Another explanation is that the poor may have less caries – the main reason for tooth loss – than the rich because sugar is still a commodity in some developing countries and, as such, only

Table 4 Absolute and relative measures of inequalities in problems with mouth and/or teeth, according to household wealth, in adults ≥ 18 years of age (World Health Survey, 2002–2004)

Group	Country	RII†	(95% CI)	SII†	(95% CI)
LIC	Bangladesh	0.90	(0.83 to 1.53)	−2.4	(−4.6 to 9.4)
	Burkina Faso	1.27	(0.95 to 1.69)	4.2	(−0.9 to 9.2)
	Chad	0.80	(0.54 to 1.17)	−4.5	(−12.1 to 3.1)
	Ethiopia	0.49	(0.30 to 0.80)**	−10.4	(−17.4 to −3.5)**
	Georgia	1.29	(0.79 to 2.12)	6.3	(−5.8 to 18.5)
	Ghana	0.59	(0.39 to 0.90)*	−7.3	(−13.0 to −1.6)*
	Kazakhstan	1.52	(1.01 to 2.27)*	9.3	(0.1 to 18.6)*
	Kenya	0.82	(0.51 to 1.30)	−4.0	(−12.8 to 4.9)
	Lao	1.61	(1.09 to 2.38)*	8.0	(1.4 to 14.6)*
	Malawi	0.62	(0.44 to 0.87)**	−10.6	(−18.3 to −3.0)**
	Mali	1.13	(0.76 to 1.69)	2.2	(−5.0 to 9.5)
	Myanmar	1.05	(0.70 to 1.59)	0.6	(−4.0 to 5.1)
	Nepal	0.71	(0.57 to 0.87)**	−7.4	(−12.0 to −2.9)**
	Pakistan	1.85	(1.13 to 3.04)*	8.5	(1.4 to 15.7)*
	Senegal	0.68	(0.34 to 1.37)	−7.8	(−22.2 to 6.5)
	Vietnam	1.27	(0.73 to 2.20)	4.0	(−4.6 to 12.6)
	Zimbabwe	0.76	(0.52 to 1.11)	−5.7	(−13.6 to 2.1)
LMIC	Bosnia & Herzegovina	1.05	(0.47 to 2.34)	1.0	(−16.7 to 18.7)
	Brazil	1.13	(0.85 to 1.49)	2.7	(−3.5 to 8.8)
	Dominican Republic	1.83	(1.15 to 2.89)**	11.9	(2.9 to 20.9)**
	Ecuador	1.32	(0.88 to 1.99)	4.9	(−2.2 to 11.9)
	Morocco	1.39	(0.86 to 2.23)	7.8	(−3.5 to 19.2)
	Namibia	1.04	(0.68 to 1.59)	0.5	(−6.5 to 7.5)
	Paraguay	1.17	(0.87 to 1.55)	3.6	(−3.2 to 10.3)
	Philippines	0.69	(0.53 to 0.88)**	−8.8	(−14.6 to −3.0)**
	South Africa	0.73	(0.39 to 1.35)	−4.1	(−12.5 to 4.2)
	Sri Lanka	1.71	(0.80 to 3.65)	9.1	(−4.5 to 22.6)
	Swaziland	1.54	(0.73 to 3.24)	7.3	(−5.2 to 19.8)
	Turkey	1.07	(0.84 to 1.35)	1.5	(−3.8 to 6.7)
	Ukraine	1.11	(0.60 to 2.07)	2.6	(−12.6 to 17.7)
UMIC	Croatia	1.47	(0.75 to 2.89)	9.1	(−6.7 to 25.0)
	Czech Republic	0.91	(0.40 to 2.09)	−2.3	(−22.5 to 18.0)
	Estonia	0.77	(0.40 to 1.48)	−6.2	(−21.8 to 9.4)
	Hungary	1.59	(0.93 to 2.71)	10.0	(−1.5 to 21.6)
	Latvia	0.92	(0.44 to 1.93)	−2.0	(−19.9 to 15.9)
	Malaysia	1.15	(0.84 to 1.58)	2.1	(−2.7 to 7.2)
	Mauritius	1.02	(0.75 to 1.41)	0.4	(−5.3 to 6.1)
	Mexico	1.83	(1.54 to 2.16)***	11.7	(8.4 to 15.1) ***
	Slovakia	2.06	(0.91 to 4.69)	16.7	(−2.2 to 35.5)
	Uruguay	2.19	(1.26 to 3.80)**	15.0	(4.2 to 25.8)**

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.
†Estimates were adjusted for participants' sex, age groups and education.
LIC, low-income countries; LMIC, lower-middle-income countries; UMIC, upper-middle-income countries; RII, relative index of inequality; SII, slope index of inequality.

accessible to the better-off[17]. A final explanation combines high costs of treatment and delay in seeking care. Dental services in developing countries are mainly financed via out-of-pocket spending, driving individuals to seek dental care only when there is an acute problem. Individuals may arrive at a dental practice with more severe disease, when tooth extraction might be the only possible care pathway. Under these circumstances, the poor could have more teeth (including tooth remnants) because they could not afford to have teeth extracted.

Wealth inequalities in perceived dental-treatment needs favouring the poor were more common than those for total tooth loss. Indeed, more countries reported pro-poor than pro-rich inequalities in perceived needs. A possible explanation for these findings is that the priorities of the poor tend to diverge from those of the rich; the poor having more urgent needs in life to be met than those related to the condition of their mouth and teeth, whereas the rich could identify their oral health needs through enhanced access to information and health education[16]. This is in addition to evidence suggesting that people with the same state of health judge their quality of life differently according to their social standing[36]. It is also possible that adults with oral diseases, who are over-represented in lower social groups, may have learned how to cope with frequent symptoms during the course of their condition, which in turn become less distressing with every recurrence, leading to changes in internal standards, values and beliefs (response shift)[37].

This is the first study exploring social inequalities in adult oral health in subjects from low- and middle-income countries. Governments can use these baseline data to track their own progress relative to geographic neighbours, economically-comparable countries or a development reference group. The data could also inform policy action to address oral health inequalities, although we need to understand country-specific conditions and tailor policies that take due consideration of these country-specific circumstances[7,8]. As the WHS data are relatively old, future studies should evaluate whether the present findings are replicated when using alternative SEP indicators and clinical oral-health indices.

In conclusion, this multicountry comparison provides evidence of the presence of social inequalities in adult oral health, according to household wealth, in low- and middle-income countries, regardless of economic development. However, the well-documented social gradient in adult oral health favouring the rich was not observed in all low- and middle-income countries. Pro-poor inequalities in total tooth loss, and particularly in perceived dental-treatment needs, were seen in several countries.

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Competing interest

The authors declare no competing interest.

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Correspondence to:
Bishal Bhandari,
Division of Population and Patient Health,
King's College London Dental Institute,
Denmark Hill Campus,
Bessemer Road,
London SE5 9RS, UK.
Email: bishal.bhandari@kcl.ac.uk