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Ethnic Inequalities in the Functional Dentition Among British Adults: A Multilevel Analysis

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Objective: To explore the role of socioeconomic factors, area deprivation and behaviours in explaining ethnic differences in the functional dentition among East London adults using multilevel modelling. ***Methods***: Data from a community-based health survey in East London included information on 1898 adults aged between 16 to 65 years old and belonging to 9 ethnic groups. Supervised questionnaires gathered information on demographic characteristics, socioeconomic indicators, dental behaviours and area deprivation (IMD 2007). A functional dentition was defined as having all 6 anterior plus at least 4 posterior contacts in clinical examination. ***Results***: The multilevel logistic regression showed that Black Africans were 75% (95%CI: 1.21-2.52) and Black Caribbean 77% (95%CI: 1.05-2.98) more likely to have a non-functional dentition than White British participants in fully adjusted models. Other factors associated with a non-functional dentition were older age and no educational attainment. ***Conclusion***: Black adults are at greater risk of non-functional dentition independently from sociodemographic characteristics, oral health-related behaviours and area-level characteristics. Proportionate universalism could be effective in reducing these health gaps.

Keywords*: functional dentition, ethnic inequalities, multilevel approach*

Introduction

In the United Kingdom (UK), ethnic inequalities in oral health are difficult to elucidate because they vary according to the condition studied, and minority ethnic groups do not necessarily exhibit worse oral health than the host population (Arora *et al.*, 2016; Delgado-Angulo *et al.*, 2016a;b; Delgado-Angulo *et al.*, 2019). Despite the decline in the prevalence of tooth loss, ethnic inequalities persist (Kassebaum *et al.*, 2014). A national study showed that Asian groups were less likely to have lost all their teeth (Delgado-Angulo *et al.*, 2019) whereas a population survey in East London showed that Asian and Black groups had fewer missing teeth than White British adults (Delgado-Angulo *et al.*, 2016a). Furthermore, the 2009 Adult Dental Health Survey reported that Asian adults were less likely to have a non-functional dentition when compared to White adults, but no differences were noted between Black and White adults (Arora *et al.*, 2016).

It has been suggested that ethnic inequalities are related to several factors that are specific to ethnic minorities, including socioeconomic and behavioural factors (Arora *et al.*, 2016; Bastos *et al.*, 2018; Dressler *et al.*, 2005). These characteristics explain the observed differences between ethnic groups only to a certain extent (Celeste *et al.*, 2013; Delgado-Angulo *et al.*, 2019; Nazer and Sabbah, 2018), suggesting that other factors may underlie the differences. Area deprivation is one of those factors, as it has been reported that the circumstances of the area where people live may affect their health independently of individual socioeconomic position (Becares *et al.*, 2012; Diez Roux, 2016; Phelan and Link, 2015). Ethnic minorities are usually overrepresented in deprived areas, often characterised by higher crime levels and poor physical environment characteristics (Diez Roux, 2016), a fact that contributes to exacerbate existent ethnic health inequalities (White *et al.*, 2012).

Tooth loss is believed to result from the cumulative interplay between determinants at different levels (Tiwari *et al.*, 2016). Hence, identifying the factors play a larger role in shaping ethnic inequalities is fundamental to inform the development of social and health policy to improve equity efforts and decrease disease burden. With that in mind, the aim of this study was to explore the role of socioeconomic factors, behaviours and the contribution of area deprivation in explaining ethnic differences in the functional dentition among English adults using a multilevel approach.

Method

This study used a secondary data analysis of the East London Oral Health Inequality (ELOHI) Study, which included adults aged between 16 to 65 years old who lived in Dagenham, Waltham Forest, or Redbridge and Barking between 2009 and 2010. These areas were selected because of their ethnically diverse and socially deprived populations, which aids the understanding of oral health inequalities. The study protocol was approved by the Outer Northeast London Research Ethics Committee (08/H0701/93) (Delgado-Angulo *et al.*, 2016a;b).

In multistage stratified random sampling, the sampling frame was a list of all the addresses stratified by the number of wards in Barking and Dagenham, Redbridge and Waltham Forest (17, 21 and 20 respectively). Fifty-five addresses per ward were randomly selected, 3193 in

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total, and residents were contacted via post and invited to participate in the study. Vacant or commercial premises, and ineligible addresses (457 and 208, respectively) were excluded, and the final sampling frame consisted of 2528 valid addresses. Of them, 1437 households gave consent to participate in the study, yielding a response rate of 57%.

Data were collected via clinical examination and supervised questionnaires at the participants' homes. A group of trained and calibrated dentists (Kappa=0.84) examined all participants' teeth, including third molars, using dental mirrors, periodontal probes and artificial light. Posterior and anterior occluding pairs were counted during clinical examinations. Functional dentition, the outcome of this study, was defined as having all six anterior contacts plus at least four posterior contacts.

After the clinical examination, participants answered a supervised questionnaire to collect information on ethnicity and the confounders of its association with functional dentition, namely: demographic characteristics, socioeconomic position (SEP), and oral health-related behaviours (sugar intake, smoking, toothbrushing and dental attendance). These confounders are structural (age, gender, education, and occupation) and intermediary determinants (living conditions -IMD- and behaviours) of oral health (World Health Organization, 2010).

Ethnicity was self-allocated into one of 26 ethnic subgroups using an adaptation of the UK census 2001 categories and later classified into 9 groups, namely: White British, White Other, Black African, Black Caribbean, Black Other, Pakistani, Indian, Bangladeshi, and Asian Other (Delgado-Angulo *et al.*, 2018). SEP indicators included education and the National Statistics Socio-Economic Classification (NS-SEC). Participants' highest qualification was recorded as: 'no qualification', 'secondary school', 'A-levels' - (a subject-based qualification after completing secondary school serving as the bridge to higher education and future career paths - ,) and 'University degree or above'. The NS-SEC groups were derived using the self-coded method based on current (or last) occupation, employment status, size of organisation and supervisor status; full-time education participants and those who had never worked or were in long-term unemployment were coded as never/unemployed (Macmillan, 2002) for complete coverage of the population; these groups were aggregated into 'Managerial', 'Intermediate' and 'Routine' occupations and a fourth category comprising unemployed individuals and those in full-time education. Information on dental behaviours was dichotomised as follows: *last dental visit*: ≤1 year ago vs. >1 year ago, *toothbrushing frequency*: ≤once a day vs. ≥twice a day, and *tobacco use*: never vs. past or present smoker. Sugary items (chocolate, biscuits, cakes, confectionery, soft drinks and fruit juice) consumption was reported using 7-point scales and were scored as follows: >1/day (2), 1/day (1), most days (4/7=0.57), 1/week (1/7=0.14), 1/month (1/30=0.03), <1/month (0), never (0), where weighted scores (in brackets) matched the lower frequency of consumption for each option (Bernabe *et al.*, 2014) and scores were aggregated to produce a total score ranging from 0 to 12. *Sugars intake* was classified based on the total score as namely ≤2/day (score from 0 to 1.5) and >2/day (score of 1.5 up to 12). Area deprivation was measured by the Index for Multiple Deprivation 2007, based on the participants' postcode; the IMD is a census area-level measure made up of seven domains (income, employment, health and disability, education skills and training, barriers to housing services, crime and living environment).

All analyses were weighted to adjust for the unequal probability of selection, non-response and differences in the age-by-gender-by-ethnicity distribution between the sample and the general population living in the three boroughs according to the UK 2001 Census. Analyses were performed in STATA version 18 (StataCorp LP, College Station, TX, USA). Demographic and socioeconomic characteristics were compared between participants with functional and non-functional dentition using chi-squared tests. Multilevel analysis was used to test the effect of area deprivation on the association between ethnicity and non-functional dentition with participants (level 1) nested in postcodes (level 2). The association between ethnicity and the presence of a non-functional dentition was tested in sequential logistic regression models adjusting for IMD, demographic characteristics, SES indicators and oral health-related behaviours.

Results

The final sample comprised 1898 of the initial 2266 individuals. Participants were excluded due to missing data on variables of interest: functional dentition (n=9), ethnicity (n=67), education level (n=168), socioeconomic classification (n=78) oral health-related behaviours (n=46).

Characteristics of the participants with and without a functional dentition are shown in Table 1. Participants who retained a functional dentition were more likely to be younger adults, better educated and belong to Pakistani or Asian other ethnic groups.

The unadjusted multilevel logistic regression model showed greater chance of not having a functional dentition among Black Caribbeans (OR: 1.69, 95%CI 1.09-2.62) and a reduced chance among Pakistanis (OR: 0.61, 95%CI 0.43-0.87) and Asian others (OR: 0.73, 95%CI 0.55-0.98) when compared to White British participants (Table 2). These differences remained significant after taking into account the effect of the IMD. Considering the IMD increased the chance of not having functional dentition with each decrease in IMD group, but this effect was only significant when comparing the poorest and most affluent quintiles (OR: 1.42, 95%CI 1.04-1.92). Subsequent adjustment for demographic characteristics (Model 3) introduced some changes on the ethnic groups having functional dentition and these changes were strengthened with further adjustment for individual socioeconomic indicators (Model 4) and remained unchanged when adding oral health-related behaviours to the model. The fully adjusted model showed that Black Africans had 75% (95%CI: 1.21-2.52) and Black Caribbean 77% (95%CI: 1.05-2.98) greater chance of not having functional dentition than White British participants. Additionally, older age groups had more chance of having non-functional dentition, 2.20 (95%CI: 1.30-3.72) and 4.01 (95%CI: 1.05-2.98) times more likely among 45-54 and 55-65 year-olds, respectively, than those aged 16-25. Participants whose educational attainment reached degree or higher level had 35% less chance (95%CI 0.43-0.98) of not having a functional dentition than participants with no educational attainment.

Table 1. Characteristics of 1898 adults with and without a functional dentition.

	Functional dentition						
	Yes			*No*			
	n[a]	*%*	*95% CI*	*n*[a]	*%*	*95% CI*	*p (chi sq.)*
Gender							0.330
Male	415	65.9	(59.7-71.6)	189	34.1	(28.4-40.3)	
Female	886	69.2	(65.3-30.8)	408	30.8	(27.1-34.7)	
Age group							<0.001
16-24 years old	106	79.5	(67.1-88.0)	40	20.5	(12.0-32.9)	
25-34 years old	501	72.7	(67.3-77.5)	198	27.3	(22.6-32.7)	
35-44 years old	503	75.4	(70.9-79.4)	199	24.6	(20.6-29.1)	
45-54 years old	121	58.6	(49.9-66.8)	83	41.4	(33.2-50.1)	
55-65 years old	70	44.7	(34.8-55.0)	77	55.3	(45.0-65.2)	
Ethnicity							0.040
White British	376	66.2	(60.4-71.6)	180	33.8	(28.4-39.6)	
White other	109	68.7	(58.7-77.2)	43	31.3	(22.9-41.3)	
Black African	165	55.3	(46.8-63.6)	110	44.7	(36.4-53.2)	
Black Caribbean	50	66.8	(52.9-78.4)	36	33.2	(21.6-47.1)	
Black other	94	64.9	(53.2-75.0)	37	35.1	(25.0-46.8)	
Pakistani	150	83.3	(75.8-88.8)	43	16.7	(11.2-24.2)	
Indian	82	68.6	(54.4-80.0)	34	31.4	(20.0-45.6)	
Bangladeshi	46	62.7	(48.5-74.9)	25	37.3	(25.1-51.5)	
Asian other	229	73.1	(65.9-79.2)	89	26.9	(20.8-34.1)	
Education							0.047
None	104	56.0	(42.2-69.0)	76	44.0	(31.0-57.8)	
Secondary school	291	66.7	(59.4-73.2)	158	33.3	(26.8-40.6)	
A-levels	333	66.8	(60.2-72.9)	148	33.2	(27.1-39.8)	
Degree or higher	573	73.2	(68.3-77.7)	215	26.8	(22.3-31.8)	
Occupation							0.256
Managerial	574	67.5	(61.8-72.7)	226	32.5	(27.3-38.2)	
Intermediate	200	61.2	(52.9-68.9)	102	38.8	(31.1-47.1)	
Routine	245	69.0	(61.2-75.8)	130	31.0	(24.2-38.8)	
Never worked	282	72.5	(64.7-79.2)	139	27.5	(20.8-35.4)	
Last dental visit							0.839
Up to a year ago	718	67.3	(62.6-71.7)	334	32.7	(28.3-37.4)	
More than a year ago	583	68.0	(62.1-73.4)	263	32.0	(26.6-37.9)	
Toothbrushing frequency							0.479
Less than twice a day	388	65.6	(58.0-72.5)	174	34.4	(27.5-42.1)	
Twice a day or more	913	68.5	(64.4-72.3)	423	31.5	(27.7-35.6)	
Sugar consumption							0.227
Up to twice a day	836	66.0	(61.3-70.4)	382	34.0	(25.6-38.7)	
More than twice a day	465	70.4	(64.6-75.6)	215	29.6	(24.4-35.4)	
Smoking status							0.726
Non-smoker	866	68.8	(63.9-73.2)	398	31.2	(26.8-36.1)	
Former smoker	218	65.4	(57.5-72.5)	109	34.6	(27.5-42.5)	
Current smoker	217	67.3	(59.8-74.1)	90	32.7	(25.9-40.3)	
IMD							0.338
1st quintile (wealthiest)	293	67.9	(59.3-75.4)	119	32.2	(24.6-40.7)	
2nd quintile	267	64.1	(56.4-71.0)	113	35.9	(29.0-43.6)	
3rd quintile	254	73.7	(65.6-80.5)	109	26.3	(19.5-34.5)	
4th quintile	253	63.2	(55.7-70.1)	130	36.8	(29.9-44.3)	
5th quintile (poorest)	234	69.8	(62.2-76.5)	126	30.2	(23.5-37.8)	

[a] Counts are unweighted

Discussion

Black ethnic groups showed a greater prevalence of a non-functional dentition than White British participants even after controlling for sociodemographic characteristics, behaviours and area deprivation. The only other two factors that influenced the prevalence of a non-functional dentition were age and educational attainment.

To the best of our knowledge, this is the first study in the UK trying to elucidate the role of contextual characteristics, IMD, on the association between ethnicity and a functional dentition; however previous studies in

Table 2. Multilevel logistic regression models for the association between ethnicity and having a non-functional dentition.

	Model 1		*Model 2*		*Model 3*		*Model 4*		*Model 5*	
	OR	*(95% CI)*	*OR*	*(95% CI)*	*OR*	*(95% CI)*	*OR*	*(95% CI)*	*OR*	*(95% CI)*
Fixed effects (n=1898 adults)										
Ethnicity										
White British	1.00	(Reference)	1.00	(Reference)	1.00	(Reference)	1.00	(Reference)	1.00	(Reference)
White other	1.00	(0.71-1.41)	0.98	(0.69-1.38)	1.12	(0.78-1.61)	1.01	(0.66-1.54)	0.91	(0.59-1.41)
Black African	1.20	(0.90-1.60)	1.14	(0.85-1.52)	1.50**	(1.11-2.04)	1.73**	(1.23-2.45)	1.75**	(1.21-2.52)
Black Caribbean	1.69*	(1.09-2.62)	1.62*	(1.05-2.52)	1.94**	(1.23-3.07)	1.76*	(1.05-2.96)	1.77*	(1.05-2.98)
Black other	0.76	(0.51-1.12)	0.72	(0.49-1.07)	0.79	(0.52-1.20)	0.89	(0.56-1.41)	0.93	(0.58-1.47)
Pakistani	0.61**	(0.43-0.87)	0.61**	(0.43-0.87)	0.72	(0.49-1.05)	0.71	(0.46-1.09)	0.65	(0.42-1.03)
Indian	0.85	(0.56-1.30)	0.85	(0.56-1.31)	1.02	(0.66-1.59)	0.99	(0.61-1.60)	0.95	(0.57-1.56)
Bangladeshi	1.23	(0.76-1.99)	1.28	(0.79-2.07)	1.65*	(1.00-2.71)	1.47	(0.83-2.60)	1.38	(0.76-2.50)
Asian other	0.73*	(0.55-0.98)	0.75*	(0.56-1.00)	0.91	(0.67-1.23)	0.98	(0.70-1.38)	0.96	(0.67-1.37)
IMD										
1st quintile (wealthiest)			1.00	(Reference)	1.00	(Reference)	1.00	(Reference)	1.00	(Reference)
2nd quintile			1.07	(0.79-1.45)	1.12	(0.81-1.54)	1.16	(0.83-1.64)	1.16	(0.82-1.64)
3rd quintile			1.18	(0.88-1.59)	1.19	(0.87-1.63)	1.02	(0.72-1.45)	1.03	(0.73-1.46)
4th quintile			1.29	(0.96-1.74)	1.41*	(1.03-1.93)	1.34	(0.95-1.89)	1.31	(0.93-1.86)
5th quintile (poorest)			1.42*	(1.04-1.92)	1.49*	(1.08-2.05)	1.42	(1.00-2.01)	1.33	(0.94-1.90)
Gender										
Male					1.00	(Reference)	1.00	(Reference)	1.00	(Reference)
Female					1.08	(0.88-1.33)	1.03	(0.81-1.30)	1.03	(0.80-1.32)
Age group										
16-24 years old					1.00	(Reference)	1.00	(Reference)	1.00	(Reference)
25-34 years old					1.04	(0.72-1.51)	1.13	(0.74-1.72)	1.22	(0.79-1.89)
35-44 years old					1.04	(0.72-1.51)	1.19	(0.77-1.82)	1.29	(0.82-2.02)
45-54 years old					1.68*	(1.08-2.61)	2.06**	(1.25-3.41)	2.20**	(1.30-3.72)
55-65 years old					3.31*	(2.05-5.35)	3.56***	(2.05-6.18)	4.01***	(2.27-7.11)
Education										
None							1.00	(Reference)	1.00	(Reference)
Secondary school							0.77	(0.52-1.13)	0.80	(0.54-1.18)
A-levels							0.72	(0.48-1.07)	0.71	(0.47-1.06)
Degree or higher							0.64*	(0.43-0.95)	0.65*	(0.43-0.98)
Occupation										
Managerial							1.00	(Reference)	1.00	(Reference)
Intermediate							1.29	(0.94-1.77)	1.26	(0.91-1.73)
Routine							1.16	(0.85-1.58)	1.15	(0.84-1.57)
Never worked							1.31	(0.95-1.80)	1.27	(0.92-1.76)
Last dental visit										
Up to a year ago									1.00	(Reference)
More than a year ago									0.95	(0.76-1.19)
Toothbrushing frequency										
Less than twice a day									1.00	(Reference)
Twice a day or more									1.01	(0.79-1.28)
Sugar consumption										
Up to twice a day									1.00	(Reference)
More than twice a day									1.09	(0.87-1.36)
Smoking status										
Non-smoker									1.00	(Reference)
Former smoker									1.05	(0.77-1.44)
Current smoker									0.85	(0.61-1.17)

Two-level logistic regression models were fitted for each periodontal measure, with participants clustered within postcodes.
Model 1: unadjusted model; Model 2: adjusted for IMD quintiles; Model 3: further adjusted for demographic characteristics; Model 4: additionally adjusted for SES indicators; Model 5: fully adjusted model (demographic characteristics, SES indicators and oral health-related behaviours
* $p<0.05$ ** $p<0.01$ *** $p<0.001$

other countries have investigated the issue. These results are in line with those reported by Chalub et al. (2016), who studied the influence of the social determinants of health on the functional dentition in Brazilian adults using multilevel analysis. A functional dentition was more common among younger adults, males, those with higher education and income and those having attended a dental appointment in the last 12 months. Participants with black skin colour were less likely to have a functional dentition than the white population.

Other multilevel analyses of inequalities in tooth loss have reported that adults living in socially deprived areas or those with greater income inequality had fewer teeth than those in better-off regions. These studies also showed more teeth lost among participants with dark skin than the host population (Roberto *et al.*, 2020; Vettore *et al.*, 2020).

In the UK, Alobaidi et al. reported ethnic inequalities in the non-functional dentition, for certain ethnic groups only. Irish adults had greater odds, whereas Indian adults had lower odds, of having a non-functional dentition than White British after adjustment for demographic characteristics, SEP quintiles and area deprivation. In contrast, there are many studies in America showing that tooth loss disproportionately affects Black adults (Huang and Park, 2015; Liu *et al.*, 2014; Naorungroj *et al.*, 2017; Nazer and Sabbah, 2018; Reid *et al.*, 2004; Wu *et al.*, 2011).

One possible explanation for these ethnic disparities is perceived racial discrimination, including within healthcare settings (Bastos *et al.*, 2018). Racism is currently debated as a perpetuating cause of ethnic health inequalities (Ford and Airhihenbuwa, 2010; Phelan and Link, 2015), mainly through inequalities, including access to and use of goods and services, as well as health conditions (Phelan and Link, 2015). Discrimination may be associated with tooth loss, as individuals frequently exposed to stress are less likely to use dental services (Sanders *et al.*, 2007) and those who reported being treated worse than other races were less likely to have a dental visit and had greater risk of tooth loss after adjusting for race and other confounders (Singhal and Jackson, 2022).

It would be impossible to ignore the effect of age on tooth loss and, in this study, adjusting for age seem to strengthen the association of ethnicity on tooth loss especially among Black Africans.

Oral health-related behaviours did not appear to be associated with having a functional dentition when demographic characteristics and IMD were considered. Although weak, non-significant relationships were observed in bivariable analyses. A possible explanation for this is temporality; data on behaviours were collected at the same time as the functional dentition was recorded, which is a long-time measure of oral health. Another possibility is the oral behaviours are socially patterned (Singh *et al.*, 2013), and controlling for those characteristics could completely explain their effect on the functional dentition.

Educational attainment also predicted the chances of a non-functional dentition. Efforts to reduce educational gaps between ethnic minorities and Whites British, including funding and quality of public schools, could help decrease the differences between ethnic groups in the long term. Our findings suggest that a combination of whole population and targeted strategies (i.e., proportionate universalism) could be effective in improving everybody's health and reducing health gaps between specific ethnic groups. Our findings showed that Black adults are the ethnic minority at the greatest disadvantage. The important role of the environment needs to be recognised more. Further research could consider how the characteristics and composition of neighbourhoods can contribute to reduce or exacerbate ethnic inequalities in oral health, as it is important to investigate the effect of discrimination on such inequalities.

The main limitation of this study is the use of cross-sectional data, which limits the ability to infer causality. Another limitation is the low participation rate (57%) which with the risk of sampling bias; however, the use of weights and complex survey design during analysis compensate for unequal probabilities of selection and non-response. On the other hand, the use of clinical examinations to collect functional dentition data reduces the possibility of measurement error. Similarly, the number of occluding pairs, the basis for the definition of functional dentition has been deemed more important than the number of teeth to ensure chewing efficiency (Elias and Sheiham, 1998; Helkimo *et al.*, 1978). Moreover, the use of a multilevel approach allowed to assess the contribution of both individual and area-level factors in the ethnic inequalities in the functional dentition.

In conclusion, consistent with previous literature, this analysis confirms the presence of ethnic inequalities in adult oral health. Black adults were more likely to have a non-functional dentition than White British adults. Differences in individual and area-level characteristics partially explain ethnic inequalities in functional dentition; however, especially among Black individuals, differences persisted.

Ethical Approvals

This study did not require ethics approval since it involved only secondary data analysis of East London Oral Health Inequality (ELOHI) Study, its study protocol approved by the Outer North-East London Research Ethics Committee (08/H0701/93).

Conflict of Interest

The authors declare no conflict of interest in relation to this study.

Data Availability Statement

Data not publicly available.

Author contributions

EKDA had solely responsibility for the study conception and design; both EKDA and HA had joint responsibility in the analysis and interpretation of results, and manuscript preparation.

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