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Deprivation and child dental attendance in England: exploring the shape and moderators

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Objective: To describe the shape of the relationship between area deprivation and dental attendance (DA) in children aged 5 years and under in England and the modifying effect of caries prevalence, ethnicity, family profile and dentist-to-population ratio. ***Basic research design***: DA rates were calculated at lower-tier local authority level (LA, n=326) using NHS data for the year to March 2017. LA deprivation was determined by Index of Multiple Deprivation 2015. Caries prevalence was retrieved from the 2016/17 National Dental Epidemiology Programme; ethnicity and family profile from Census 2011 and dentist-to-population ratio from NHS statistics. Fractional polynomial (FP) models explored the shape of the relationship. Multivariable regression models were adjusted for covariates. The effect of moderators was estimated by adjusted marginal effects. ***Clinical setting***: English Lower-tier LAs. ***Main outcome measure***: Shape of the relationship between DA and deprivation and its moderators. ***Results***: Best-fitting second-order FP model (p=0.582) did not provide a better fit for the relationship than the linear model. Therefore, the linear model was selected for final analysis. Deprivation was associated with decreased DA rates (Coefficient=-0.39, 95%CI=-0.53,-0.24; p=<0.001); while White ethnicity (Coefficient=0.35, 95%CI=0.29, 0.41; p=<0.001), single parenthood (Coefficient = 2.21, 95%CI=0.91,3.51; p=0.001) and caries prevalence (Coefficient =0.34, 95%CI=0.25,0.44; p=<0.001) with increased rates. These moderated the relationship. ***Conclusions***: We hypothesised that the shape of the relationship between deprivation and DA could be curvilinear with higher rates in the extreme ends of deprivation. However, the analysis showed a linear association, moderated by the effect of ethnicity, single parenthood and disease level.

Keywords: *socioeconomic factors, dental caries, dentistry, dental health services, dental attendance*

Introduction

Dental attendance at an appropriate interval allows early detection and treatment of oral diseases. Contemporary recommendations for dental recall (NICE, 2004) suggest an individual risk-based determination of the most appropriate recall interval, which should be no greater than 12 months for those aged under 18 years. Regardless, "dental attendance in the past year" has become a standard indicator in reporting dental attendance. For example, administrative data in England report child dental attendance within the past year (Office for National Statistics, 2009) and the US strategy Healthy People 2020 sets out to increase 'use of the oral health care system in the past year' (Healthy People 2020, 2019).

A 2017 review of child dental health data in England found 'a positive picture overall regarding access to dental care' (Appleby *et al.*, 2017). For example, in a national dental survey of children (2013) nine out of 10 children were reported to have visited a dentist for a check-up in the previous year (Holmes *et al.*, 2016). In England, the National Health Service (NHS) provides free dental care for children under the age of 18, which may explain relatively high level of attendance. Despite this, inequality in uptake is apparent; for example, the same national survey 2013 found that children who were eligible for free school meals (an indicator of family deprivation) were less likely to have visited the dentist for a check-up. By contrast, a recent analysis of administrative data from England did not support lower children dental attendance in more deprived areas (Ravaghi *et al.*, 2019). A similar study of administrative data, found no pro-rich pattern in attendance at area level for children aged 1 year and under (Salomon-Ibarra *et al.*, 2019). While this picture may not concord with the global pattern of inequalities in dental service utilisation (Reda *et al.*, 2017), it may reflect the complex range of influences on use of dental services. Inequality in dental treatment uptake has increased relevance in the light of emerging evidence for rising inequalities in children dental health in England (Ravaghi *et al.*, 2019), particularly given the recent emphasis on dental services as a vehicle for child oral health improvement such as the NHS England initiative Starting Well 13 and Staring Well Core (NHS England, 2017).

Conceptually, the relationship between deprivation and child dental attendance may not be linear; rather it might be modified by disease risk and the nature of the attendance outcome measure, for example low disease risk being associated with attendance for preventive interventions and high disease risk with attendance for unscheduled care. Therefore, this study hypothesised that the shape of the relationship between deprivation and children dental attendance could be curvilinear with higher

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dental attendance (for all reasons) in the extreme ends of deprivation spectrum. In addition, the relationship between deprivation and dental attendance may be moderated by other factors. For example, dental attendance could be influenced by demographic factors such as ethnicity, as minority ethnic groups are less likely to access primary care services compared to the White majority (PHE, 2018). Parental factors such as single parenthood have also influenced child oral health (Hooley *et al.*, 2012). There might be also variations in dental attendance by the availability of dental services as indicated by lower dentist-to-population ratios (Boulos and Phillipps, 2004). Therefore, the aim of this study was first, to describe the shape of the relationship between deprivation and dental attendance in children aged 5-year-old and under in England; whether the relationship is linear or non-linear. Second, to examine the modifying effect of disease level (caries prevalence), ethnicity, family profile and dentist-to-population ratio on the relationship between deprivation and dental attendance.

Methods

Area level data for 326 lower-tier and unitary local authorities (LA) were obtained from NHS administrative data sources, a dental survey and a nationwide census. Dental attendance rates in LAs were calculated from NHS administrative data obtained through a freedom of information request. This contained the number of children aged 5 years and under seen at least once by an NHS primary care dentist from April 2016 to March 2017 in each LA as well as the child population for each LA as estimated by the Office for National Statistics. The calculated rates include dental visits for any reason and excluded hospital and private dental visits.

Deprivation level of each lower-tier LA was determined by Index of Multiple Deprivation (IMD) Average Score retrieved from English Indices of Deprivation 2015. The English IMD is based on 37 indicators grouped in seven domains: income deprivation, employment deprivation, education, skills and training deprivation, health deprivation and disability, crime, barriers to housing and services and living environment. Data on ethnicity and family structure for LAs were retrieved from the 2011 Census. Ethnic profile of LAs was indicated by the proportion of White population in each LA; White ethnicity included English, Welsh, Scottish, Northern Irish, Irish, Gypsy or Irish Traveller, British and any other White group. The proportion of single parents was calculated based on the percentage of lone parents with one or more than one dependent child. Dental caries was indicated by the prevalence of dental caries obtained from the 2016/17 National Dental Epidemiology Programme. Dentist-to-population ratio in each LA was obtained from the information provided by NHS Digital data. This represented the number of primary care dentists with NHS activity, including General Dental Service, Personal Dental Services, Mixed and Trust-Led Dental Services per 100,000 population during the period April 2017 to March 2018.

First, fractional polynomial (FP) models were used to investigate the shape of the relationship between deprivation and dental attendance, whether the relationship the linear or non-linear provides better fit. The FP models evaluate whether the effect of a continuous variable (in this case deprivation) on the outcome (i.e. dental attendance) is better modelled by a linear function or by a non-linear member of the class of FP functions. Models with FP functions were fitted for a set of powers terms (–2, –1, –0.5, 0, 0.5, 1, 2, and 3) with 0 representing the logarithm of the variable. These power terms yield the possible shapes the association between the outcome and predictor variables can take. To identify the most appropriate model, the deviance of the best fitting second-order model (m=2) was compared with that of the linear model. If the second order model provided a better fit than the linear model and this was statistically significant (p <0.05), then this was compared with the best fitting first-order model (m=1). Otherwise, the linear model is chosen for final analyses. STATA's 'fracpoly' command was used to fit the FP models. The local polynomial smoothing was used to visualise the shape of the relationship between dental attendance and deprivation.

Second, to examine the effect of possible variables, multivariable regression models were adjusted for covariates (ethnicity, single parenthood, dental caries prevalence and dentist-to-population ratio). To identify the moderators of the relationship between dental attendance and deprivation, interaction terms for ethnicity, single parenthood, dental caries prevalence and dentist-to-population ratio were added to the final regression model (Royston, 2017). Adjusted marginal effects were estimated after controlling for other covariates. Predicted average marginal effects were visualised using STATA command 'marginsplot'.

Results

The average rate of dental attendance for children aged 5 years and under in England was 37%. Rates ranged from 10.6 to 56.5%.

Table 1 shows the results of the fractional polynomial regression analysis, which assessed the shape of the relationship between dental attendance and deprivation. The second-order polynomial model (m=2) was compared to the linear and first-order polynomial models (m=1). The best-fitting first-order model (m=1) had a power 0.5, whereas the best-fitting second-order polynomial (m=2) had powers (3, 3) However, the second-order model was not significantly better in terms of model fit to data than either the linear (p=0.582) or the first order models (p=0.403). As FP models did not provide better fit than a simple linear model, the linear model was selected for final analyses and the association between dental attendance and deprivation was treated as linear.

Table 2 presents the linear regression model after adjustment for all variables. Deprivation remained a significant predictor of dental attendance (Coefficient= -0.39; 95% CI= -0.53, -0.24) after controlling for the effect of ethnicity, single parenthood, dental caries and dentist-to-population ratio. The adjusted model explained nearly 40% of the variation in dental attendance (R-squared=0.3983). White ethnicity, single parenthood and dental caries were directly associated with an increase in dental attendance; however, dentist-to-population ratio was not.

Table 1. Fractional polynomial models comparisons for the shape of the association between dental attendance and deprivation[+].

IMD Models	*df* [a]	*Deviance*	*Deviance difference*	*P Value*[b]	*Powers*	
Linear	1	2203.19	1.96	0.582	1	
m = 1	2	2203.06	1.84	0.403	0.5	
m = 2	4	2201.23	_	_	3 3	*

[a]Degress of freedom
[b]P Value from deviance difference comparing reported models with m=2 Model
[+]Best fitting second-order model (m=2) compared to linear model and best fitting first-order model (m=1).
*Best powers of IMD among 44 models fit: (3 3)

Table 2. Regression analysis for the association of deprivation (IMD 2015) and dental attendance in 0 to 5-year-old children.

	Model 2	
Independent variable	*Coef.*	*95% CI*
Deprivation (IMD)[a]	-0.39	(-0.53, -0.24)
White Ethnicity[b]	0.35	(0.29, 0.41)
Single parenthood[b]	2.21	(0.91, 3.51)
Caries prevalence[b]	0.34	(0.25, 0.44)
Dentist to population ratio[c]	0.03	(-0.01, 0.07)
R^2		0.3983

[a]Index of Multiple Deprivation Average Score.
[b]Percentage of White ethnicity population, Single parents and 5-year olds with dental caries in every local authority.
[c]Dentists per 100,000 population in every local authority.
Statistically significant values are indicated in bold.

To evaluate the effect of modifying variables, interaction terms were added to the final models. There were significant interactions between deprivation and three covariates, dental caries (F (6,295=34.44; p=0.009), White ethnicity (F (6,295); p=<0.001) and single parenthood (F (6,295=33.98; p=0.02). In LAs with the lowest prevalence of dental caries and lowest proportion of single parents the decrease in dental attendance with increasing deprivation was steeper compared to those LAs with the highest level of dental caries and higher proportion of single parents (Figure 1 and Table 3). However, in LAs with the lowest proportion of White population, there was an increase in dental attendance with increasing deprivation, but it was not statistically significant.

Figure 1 and Table 3 show the marginal effects of dental attendance for the 1st, 25th, 50th and 75th percentiles of the moderator. Marginal effects in this table indicate the amount of change in the predicted values of dental attendance for one unit change in deprivation score adjusted for other covariates. For example, in LAs with a higher proportion of dental caries (i.e. 75% Percentile) dental attendance rate is expected to decrease by 0.35 for every one-unit increase in deprivation score, whereas in LAs with the lowest proportion of dental caries (i.e. 1% Percentile), dental attendance is expected to decrease by 0.59 for every one-unit increase in deprivation (Table 3).

Discussion

This study investigated the relationship between deprivation and dental attendance for young children, using administrative and survey data for England. Our analyses showed that fractional polynomial models did not provide a better fit for the shape of the association between dental attendance and deprivation than the linear model. After controlling for confounders (ethnicity, single parenthood, dental caries and dentist-to-population ratio) deprivation remained a significant predictor of dental attendance. White ethnicity, single parenthood and dental caries were directly associated with an increase in dental attendance. Dentist-to-population ratio was not associated. Moreover, the association between dental attendance and deprivation was moderated by the effect of ethnicity, single parenthood and dental caries.

We hypothesised that the relationship would be non-linear with higher dental attendance rates at the extreme ends of deprivation; however, this hypothesis was rejected. There was a linear relationship between child dental attendance rates and deprivation at area level with children in more deprived areas being less likely to be taken to dentist. However, deprivation only marginally explained variation in dental attendance. The strength and direction of this relationship was moderated by the effect of ethnicity and family profile as well as disease level in the area. Most notably, there was a variation

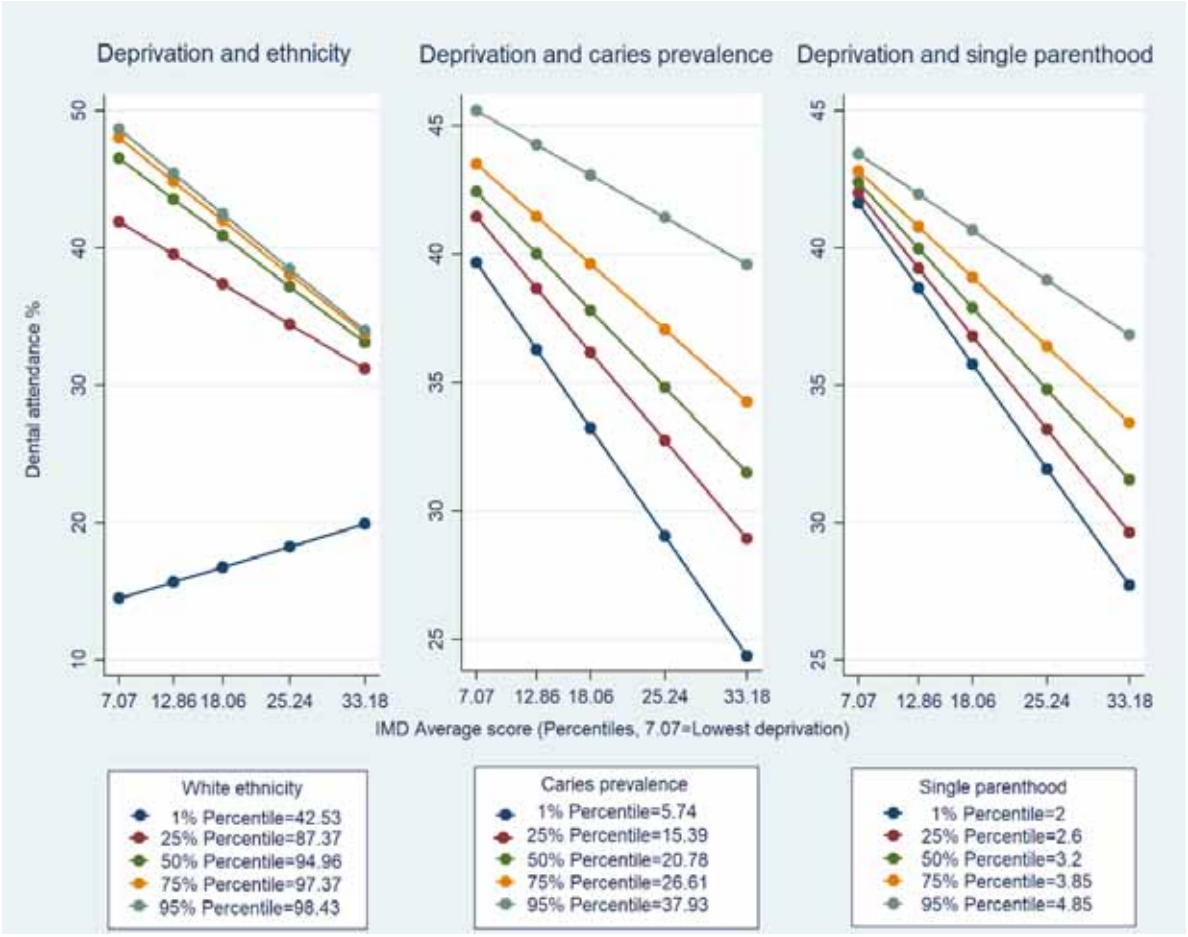

Figure 1. *Predicted estimates for dental attendance according to deprivation by ethnicity, single parenthood and caries prevalence.*

Table 3. Marginal effect of dental attendance rate (95% Confidence Intervals) for the interaction of deprivation and White ethnicity, single parenthood and caries prevalence at 1%, 25%, 50% and 75th percentiles.+

White ethnicity	*Coef.*	*95% CI*
1% Percentile	0.21	(-0.11, 0.53)
25% Percentile	-0.41***	(-0.55, -0.27)
50% Percentile	-0.52***	(-0.67, -0.36)
75% Percentile	-0.55***	(-0.71, -0.39)
Single Parenthood	*Coef.*	*95% CI*
1% Percentile	-0.53***	(-0.72, -0.34)
25% Percentile	-0.47***	(-0.63, -0.31)
50% Percentile	-0.41***	(-0.56, -0.27)
75% Percentile	-0.35***	(-0.49, -0.21)
Caries Prevalence	*Coef.*	*95% CI*
1% Percentile	-0.59***	(-0.79, -0.38)
25% Percentile	-0.48***	(-0.64, -0.32)
50% Percentile	-0.42***	(-0.56, -0.28)
75% Percentile	-0.35***	(-0.50, -0.21)

*** *P Value* <0.001

+Model was adjusted for covariates.

according to ethnicity; in LAs with the largest proportion of non-White population, deprivation was associated with a slight increase in dental attendance, although not statistically significant. Whereas in those areas with a lower prevalence of dental caries and lower proportion of single parents, the decrease in dental attendance with increasing deprivation was steeper. Somewhat counter-intuitively, this association was less steep for areas with a higher prevalence of dental caries and higher proportion of single parents. For the latter modifier, it is possible that we were observing an effect of symptom-driven attendance associated with higher caries prevalence modifying the relationship.

It is often assumed that child dental attendance is lower in more deprived areas, which was confirmed in this study, albeit the association being weak. Analyses of data from other age groups of children such as children younger than 2 and 0 to 18-year olds, however, have not shown such a relationship (Ravaghi *et al.*, 2019; Salomon-Ibarra *et al.*, 2019). This is not necessarily surprising; the Child Dental Health Survey 2013 also showed an inconsistent relationship between dental attendance and deprivation at different ages (Holmes *et al.*, 2016). Furthermore, a variation in attendance might not necessarily signify a matching variation in use of preventive interventions (Shaban *et al.*, 2017).

Apart from deprivation other covariates in this study; ethnicity, disease level (caries prevalence) and single parenthood, were independently related to dental attendance. Multivariable regression analysis showed that a greater proportion of White population, single parents and greater disease levels were associated with higher dental attendance rates. There is evidence from the UK that minority ethnic groups are less likely to access primary care services compared to the White majority (PHE, 2018). Surveys in adults have also reported more frequent dental visits among White ethnic groups in the UK (Arora *et al.*, 2016). There are lower levels of dental disease in White British/Irish children, especially among children from younger age groups (Rouxel and Chandola, 2018). Parental factors influencing child oral health have been reported, including single parenthood, but this might also be associated with lower income (Hooley *et al.*, 2012). The present study showed, surprisingly, that areas with a higher proportion of single parents tended to have higher dental attendance rates. Whilst previous studies in England have shown lower dentist-to-population ratios in deprived areas in England (Boulos and Phillipps, 2004) our study did not find an association between dental attendance and dentist-to-population ratio.

An important limitation of our study was that recorded child dental attendance could be for any reason, including a single occasion for urgent care and a lack of data on private and hospital provision. Residence was based on the location of the dental service, although it might be assumed that young children are more likely to attend dental services close to their family home. Data for covariates were taken from census estimates rather than actuals and dental caries data was from a survey of 5-year-olds only. Finally, data for dentist-to-population ratio was not available for the same time as dental attendance data; therefore, the data for the closet time period was used. Nevertheless, this is the first study to evaluate the shape of the relationship between dental attendance and deprivation using fractional polynomial models. Moreover, examining interaction terms between deprivation and covariates allowed to have a better understanding of the relationship of dental attendance and deprivation.

The findings of our study provide new insights into the relationship between dental attendance and deprivation and how it is moderated by other factors such as dental health. Nevertheless, the extent to which dental attendance is associated with reduced inequalities in dental health is inconclusive (Shen and Listl, 2018). Furthermore, an understanding of associations does not necessarily suggest interventions to improve oral health, for example some public health and health service interventions may increase the health inequality gap (Babones, 2009), as may those that widen the coverage of dental services (Kim *et al.*, 2019).

While the use of dental services for children in England is free, there has been a new focus to optimise their use to improve health and tackle inequalities. There is considerable investment to encourage young children to visit a dentist for both prevention and treatment of oral diseases. For instance, Dental Check by One, a campaign launched by the British Society of Paediatric Dentistry (2017) in partnership with the Office of the Chief Dental Officer for England promotes the importance of child dental attendance by the age of one, while the NHS Starting Well 13 and Staring Well Core programmes (NHS England, 2017) aim to improve child oral health focussing on dental attendance. It is also important to consider measures that will discern different types of attendance pattern when monitoring such programmes. This study has important implications for policy makers in planning of dental services to ensure children especially those from deprived areas and minority ethnic groups have access to preventive dental care.

Conclusions

We hypothesised that the shape of the relationship between deprivation and dental attendance in young children might be curvilinear with higher dental attendance in the extreme ends of deprivation; however, the analysis showed a linear association between dental attendance and deprivation and this was moderated by the effect of ethnicity, single parenthood and disease level. It is apparent from our study that the relationship between deprivation and dental attendance is complex and should not be subject to simple assumptions.

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