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Greater child dental health inequality in England compared to Wales and Northern Ireland, despite lower average disease levels

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***Introduction*:** Dental caries and inequalities in dental health are major public health concerns. ***Aim*:** To report variation in dental caries experience across deprivation quintiles and the magnitude of inequalities between countries. ***Design*:** Secondary analyses of cross-sectional data from the 2013 Child Dental Health Survey (CDHS) in England, Wales, and Northern Ireland. ***Materials and methods*:** Distribution of dental caries across deprivation quintiles were estimated using as proportions and means. The magnitude of inequalities was calculated using the Relative Index of Inequality (RII). ***Main outcomes*:** Dental caries experience as indicated by the prevalence (%dmft/DMFT>0) and severity (dmft/DMFT) of 'obvious' and 'clinical' decay experience in both primary and permanent dentitions. ***Results*:** Children from more deprived quintiles showed higher prevalence and severity of dental caries. RIIs for dental caries were greater in England than Wales or Northern Ireland, indicating greater relative inequalities despite lower average dental caries experience. The prevalence and severity of dental caries among the most deprived children in England were 1.7 to 3.7 times greater than those of the least deprived. ***Conclusion*:** There is a deprivation gradient in child dental caries in all three countries, with England showing the greatest inequalities.

Keywords: *Dental Caries, Dental Health Surveys, DMF Index, Socioeconomic status*

Introduction

Dental caries has declined among UK children in the past four decades **(**Murray *et al.,* 2015). It remains, however, still a major public health problem, despite being largely preventable. The last Child Dental Health Survey (CDHS), which was carried out in 2013 in England, Wales, and Northern Ireland, reported a high prevalence of dental caries, with one-third of children aged 12 and nearly half of those aged 15 affected by obvious dental caries (DMFT>0) in their permanent teeth. The prevalence of caries in the primary dentition was also high, with 31% and 46% of 5- and 8- year-old children experiencing obvious dental caries experience (%dmft>0) (Health & Social Care Information Centre 2015a).

Like most health conditions, dental disease is unequally distributed; the more deprived experience a greater burden. Although tackling health inequalities has been central to national health policies in Britain in recent decades **(**Marmot *et al.,* 2010), evidence of inequalities in children's oral health is overwhelming. For example, there was a remarkable variation in oral health between children according to eligibility for free school meals in the 2013 CDHS (Vernazza *et al.,* 2016). Social inequalities have been labelled as one of the main 'contemporary challenges' in child dental health (Health & Social Care Information Centre, 2015 b).

In line with national policies, reducing social inequalities in child dental health has been a fundamental policy goal in England, Wales, and Northern Ireland. In England, a series of interventions have been planned as a part of the 'Children's Oral Health Improvement Programme Board Action Plan 2016 – 2020' to 'reduce the oral health gap for disadvantaged families'. A Welsh policy outlined in 'Together for Health: A National Oral Health Plan for Wales 2013-18' has also listed inequalities in child dental health as a key issue (Welsh Government, 2013). In Northern Ireland, 'Happy Smiles' was launched to reduce 'inequalities in oral health' in children (Health and Social Care Board, 2016).

In this study, we aimed to report the prevalence and severity of dental caries experience in the primary and permanent dentition across categories of deprivation in the individual countries, allowing an examination of how these vary. The findings of this study may serve as a baseline to monitor the progress of policies to address oral health inequalities in these countries.

Method

Data for this study came from the 2013 CDHS undertaken across England, Wales and Northern Ireland. The CDHS was a cross-sectional representative survey of 5, 8, 12 and 15-year old children (n=9,866) attending state and independent schools in the three countries. Full details of this survey, its sampling methods and protocols can be found in Anderson et al. (2015).

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Consistent with the official reports of CDHS, two of the study outcomes were prevalence and severity of 'obvious decay' and 'clinical decay' experience in the primary and permanent dentition. Prevalence of decay was indicated by the proportion of children with at least one affected tooth and severity by the mean number of teeth affected. Our analyses considered dental caries in the primary dentition of children aged five and eight and in the permanent teeth of 8-, 12-, and 15- year-olds. The definition of 'obvious' and 'clinical' decay experience was also consistent with official reporting of the 2013 CDHS (Health & Social Care Information Centre, 2015a). Before 2013, the UK child dental health surveys reported 'obvious' decay, which was defined as caries into dentine plus the number of teeth restored or extracted because of decay. The 2013 CDHS, in addition to 'obvious' decay experience, recorded caries affecting enamel, which was labelled 'clinical' decay. Detailed information on the diagnostic criteria can be found in Vernazza et al. (2016).

Deprivation was measured using the Index of Multiple Deprivation (IMD), which combines domains such as income deprivation, employment, and education to estimate overall deprivation for small areas (e.g. Lower-layer Super Output Areas in England). CDHS 2013, for the first time, reported the country-specific IMD data. The most recently available IMD values were used (2010 for England and Northern Ireland; 2011 for Wales). CDHS 2013 allocated children to one of the quintiles of deprivation in their corresponding country based on their place of residence.

We carried out descriptive analyses to report the distribution of dental caries experience across deprivation categories. Prevalence ratios (PR) for dental caries were calculated using unadjusted Poisson regression models. For the number of teeth affected, the incidence risk ratios (IRR) were calculated using negative binomial regression models. The 95% confidence intervals (CI) were reported for all statistical estimates. The PR indicates how likely a person in each category is to have experienced dental caries compared to the reference group. For example, a PR of 1.6 for children in the most deprived category indicates that a person in this group is 1.6 times more likely to have experienced the condition compared to the least deprived category. The IRRs represent the number of times the mean values are greater in each category than the reference group. An IRR value of 1.8 for severity of dental caries suggests that the mean number of teeth affected in the most deprived category is 1.8 times greater than that of the least deprived category. All analyses were carried out using STATA version 13. All estimates were calculated accounting for the sample weight and complex sampling design.

To compare inequalities, we estimated the Relative Index of Inequalities (RII). The values of RII are interpreted similarly to prevalence ratios and incidence risk ratios; however, the calculation of the RII accounts for all deprivation groups and the number of people in each category. A RII value of 1.5, for the prevalence of dental caries, indicates that those in the hypothetical top of the deprivation distribution are 1.5 times more likely to experience dental caries than those in the hypothetical bottom, accounting for the number of children in each category. This index has been widely used to evaluate the magnitude of inequalities in dental health in Scotland (Blair *et al*., 2013) and the United States (Capurro *et al*., 2013). Use of the RII has also been recommended by World Health Organisation (2013) for monitoring health inequalities.

Results

Table 1 describes the sample of the 9,866 children: 50.8% were male and 49.2% were female. Frequencies and weight-adjusted proportions are also reported for country, age groups and country-specific indices of multiple deprivation.

Generally, caries prevalence and severity increased with increasing deprivation. Those in more deprived categories were consistently more likely to be affected; also, they experienced more decayed teeth (with some inconsistencies in Northern Ireland). For example, 27.1% of children in the least deprived category in England experienced obvious decay in their primary teeth; this

Table 1. Characteristics of 9866 children

	Number	*%*
Sex		
Male	4812	50.8
Female	5054	49.2
Age		
5 years	2549	26.3
8 years	2367	24.6
12 years	2532	23.8
15 years	2418	25.3
Country		
England	5,642	91.4
Wales	2,151	5.1
Northern Ireland	2,073	3.5
Index of Multiple Deprivation (England)		
Most deprived quintile	2,214	31.3
2nd quintile	1,073	19.5
3rd quintile	756	16.8
4th quintile	724	17.1
Least deprived quintile	649	15.3
Index of Multiple Deprivation (Wales)	627	21.5
Most deprived quintile	496	25.5
2nd quintile	358	18.6
3rd quintile	363	20.0
4th quintile	167	14.3
Least deprived quintile		
Index of Multiple Deprivation (Northern Ireland)		
Most deprived quintile	360	18.6
2nd quintile	496	23.1
3rd quintile	563	24.9
4th quintile	395	21
Least deprived quintile	208	12.4

increased with greater deprivation to reach 47% in the most deprived group. A similar pattern was observed for the number of teeth affected; for example, the mean number primary teeth with obvious decay in England was 0.58 and 1.49 in the least and the most deprived quintiles, respectively. Overall, the prevalence and severity of dental caries was significantly lower in England than Wales or Northern Ireland for all caries indicators but one. The only exception was the absence of a significant difference between England and Northern Ireland with regard to prevalence (p= 0.35) and severity of 'clinical' decay (p= 0.28) in the primary teeth. Wales and Northern Ireland did not show significant differences for the majority of dental caries indicators (data available on request from the corresponding author).

Table 2 presents the prevalence and incidence risk ratios for dental decay across deprivation categories. As expected, the PRs and IRRs were generally greater for more deprived categories. For example, children in the most deprived category in England were 2.3 times more likely to have experienced 'obvious' dental decay in their permanent dentition. The risk ratio for mean number of affected teeth in this deprivation category was 2.65 times greater than that of the least deprived group.

Table 2. Inequalities in dental caries experience in England, Wales, and Northern Ireland, 2013

Obvious Decay (Primary dentition)	*Prevalence Ratio (PR) % Children affected (95% CI)*			*Incidence Risk Ratio (RR) No. teeth affected (95% CI)*		
IMD Quintile	*England*	*Wales*	*Northern Ireland*	*England*	*Wales*	*Northern Ireland*
Least deprived	Reference	Reference	Reference	Reference	Reference	Reference
2nd	1.06 (0.71, 1.58)	1.32 (1.01, 1.73)	1.25 (0.84, 1.86)	1.50 (0.94, 2.40)	1.29 (0.89, 1.86)	1.06 (0.62, 1.81)
3rd	1.30 (0.97, 1.75)	1.35 (1.00, 1.82)	1.31 (0.94, 1.81)	1.75 (1.21, 2.54)	1.50 (0.92, 2.43)	1.21 (0.73, 2.01)
4th	1.64 (1.27, 2.13)	1.67 (1.26, 2.20)	1.31 (0.90, 1.89)	2.39 (1.79, 3.21)	1.96 (1.24, 3.09)	1.23 (0.71, 2.13)
Most deprived	1.74 (1.32, 2.29)	1.78 (1.45, 2.20)	1.74 (1.26, 2.39)	2.57 (1.86, 3.55)	1.76 (1.20, 2.57)	1.76 (1.06, 2.91)
RII	**2.18 (1.64, 2.88)**	**2.01 (1.52, 2.66)**	**1.64 (1.21, 2.22)**	**3.05 (2.16, 4.32)**	**2.18 (1.21, 3.93)**	**1.85 (1.14, 2.98)**
p	**<0.001**	**<0.001**	**0.002**	**<0.001**	**0.012**	**0.013**
Clinical Decay (Primary dentition)	*% Children affected*			*No. teeth affected*		
IMD Quintile	*England*	*Wales*	*Northern Ireland*	*England*	*Wales*	*Northern Ireland*
Least deprived	Reference	Reference	Reference	Reference	Reference	Reference
2nd	1.02 (0.81, 1.28)	1.08 (0.90, 1.29)	1.02 (0.76, 1.36)	1.16 (0.81, 1.65)	0.92 (0.68, 1.26)	0.99 (0.65, 1.53)
3rd	1.07 (0.86, 1.32)	1.09 (0.76, 1.57)	1.13 (0.85, 1.48)	1.30 (0.95, 1.80)	1.15 (0.65, 2.03)	1.16 (0.78, 1.73)
4th	1.27 (1.03, 1.57)	1.13 (0.92, 1.39)	1.16 (0.84, 1.60)	1.76 (1.27, 2.43)	1.28 (0.97, 1.69)	1.23 (0.76, 1.99)
Most deprived	1.42 (1.15, 1.75)	1.28 (1.14, 1.44)	1.55 (1.17, 2.04)	2.07 (1.51, 2.84)	1.28 (1.02, 1.60)	1.84 (1.22, 2.77)
RII	**1.71 (1.33, 2.20)**	**1.34 (1.13, 1.60)**	**1.68 (1.23, 2.29)**	**2.76 (1.87, 4.08)**	**1.53 (1.15, 2.03)**	**2.05 (1.31, 3.20)**
p	**<0.001**	**0.002**	**0.001**	**<0.001**	**0.005**	**0.002**
Obvious Decay (Permanent dentition)	*% Children affected*			*No. teeth affected*		
IMD Quintile	*England*	*Wales*	*Northern Ireland*	*England*	*Wales*	*Northern Ireland*
Least deprived	Reference	Reference	Reference	Reference	Reference	Reference
2nd	1.27 (1.03, 1.59)	1.39 (0.63, 3.08)	0.93 (0.64, 1.36)	1.27 (0.91, 1.77)	1.49 (0.60, 3.75)	0.93 (0.59, 1.46)
3rd	1.54 (1.10, 2.16)	1.54 (0.75, 3.15)	0.91 (0.64, 1.31)	1.54 (1.00, 2.37)	1.74 (0.71, 4.24)	1.00 (0.61, 1.65)
4th	1.91 (1.37, 2.67)	1.85 (0.84, 4.08)	1.04 (0.69, 1.56)	2.10 (1.39, 3.18)	2.22 (0.90, 5.46)	1.25 (0.79, 1.98)
Most deprived	2.30 (1.71, 3.09)	2.00 (0.92, 4.33)	1.30 (0.90, 1.89)	2.65 (1.79, 3.92)	2.57 (0.95, 6.93)	2.08 (1.28, 3.39)
RII	**2.86 (2.02, 4.05)**	**2.04 (1.25, 3.32)**	1.51 (1.00, 2.28)	**3.66 (2.25, 5.95)**	**2.77 (1.31, 5.85)**	**2.87 (1.63, 5.04)**
p	**<0.001**	**0.006**	0.05	**<0.001**	**0.01**	**<0.001**
Clinical Decay (Permanent dentition)	*% Children affected*			*No. teeth affected*		
IMD Quintile	*England*	*Wales*	*Northern Ireland*	*England*	*Wales*	*Northern Ireland*
Least deprived	Reference	Reference	Reference	Reference	Reference	Reference
2nd	1.15 (0.96, 1.38)	1.29 (0.81, 2.03)	0.92 (0.70, 1.20)	1.19 (0.89, 1.58)	1.63 (0.83, 3.21)	0.94 (0.59, 1.49)
3rd	1.35 (1.08, 1.67)	1.43 (0.93, 2.19)	0.92 (0.70, 1.22)	1.27 (0.91, 1.76)	1.65 (0.95, 2.86)	0.81 (0.52, 1.27)
4th	1.47 (1.16, 1.86)	1.65 (1.03, 2.63)	1.07 (0.78, 1.45)	1.52 (1.08, 2.15)	2.27 (1.13, 4.55)	1.09 (0.66, 1.81)
Most deprived	1.66 (1.28, 2.15)	1.53 (1.01, 2.30)	1.19 (0.88, 1.60)	2.00 (1.37, 2.90)	2.14 (1.09, 4.22)	1.54 (0.95, 2.50)
RII	**1.89 (1.35, 2.64)**	**1.48 (1.16, 1.89)**	1.38 (0.98, 1.94)	**2.56 (1.51, 4.36)**	**2.15 (1.28, 3.61)**	**1.90 (1.05, 3.43)**
p	**<0.001**	**0.003**	0.068	**0.001**	**0.006**	**0.034**

Bolded estimates: significant values of RII at confidence level of 95% are bolded.

Table 2 also reports the RIIs for each country and caries indicator. Overall, the values of RIIs were significant for most caries indicators, confirming the greater burden of dental caries among children from more deprived areas. Exceptions were the absence of significant inequalities in Northern Ireland for the prevalence of 'obvious' (RII=1.51, 95% CI=1, 2.28; p=0.05) and 'clinical' decay (RII=1.38, 95% CI=0.98, 1.94; p=0.068) in permanent teeth, though the most deprived categories still had the highest prevalence of dental caries.

The RIIs for England were consistently larger than those of Wales or Northern Ireland (Table 2 & Figure 1). This pattern was present for all caries indicators. The smallest and largest inequalities for England were for the prevalence of 'clinical' decay in primary teeth (RII=1.71, 95% CI=1.33, 2.22; p<0.001) and the mean number of permanent teeth with 'obvious' decay (RII=3.66, 95% CI=2.25, 5.95; p<0.001), respectively. These indicate that the prevalence and severity of these conditions among the most deprived people in England were 1.7 to 3.7 times greater compared to the least deprived groups.

Discussion

We found greater dental caries inequalities among children in England than in Wales or Northern Ireland despite the lower caries experience in England. This finding highlights the importance of paying attention to the pattern of disease distribution across socioeconomic groups as well as its overall prevalence and severity. Nevertheless, there were inequalities in all three countries with the most deprived tending to experience the highest prevalence and severity in both primary and permanent teeth.

Our study highlights the severity of inequalities in child dental health in England. Recently, Ravaghi et al. (2019) proposed that the dental health gap between deprived and less deprived areas in England widened between 2007 and 2017, and it was noted that this occurred despite apparent equal NHS dental attendance.

One limitation of this study is the method used to obtain caries levels in primary and permanent teeth, where we pooled data from 5 & 8 year olds and from 12 & 15 year olds. However, the chronic and cumulative nature of caries experience means that the pattern of inequalities observed in primary or permanent teeth is unlikely to change between the two age groups.

Inequalities in health and health care have often been evaluated by comparing the health of those in the extreme categories of income or deprivation (e.g. the most and the least deprived). While being simple, this approach neglects the middle categories. Summary measures of inequalities such as RII overcome this limitation by taking into account all categories of SES and the numbers in each group. Further, the RII is suitable for comparing countries as it is not sensitive to the prevalence of the condition (Blair *et al.*, 2013). Given the difference in the prevalence and severity of dental caries experience between three countries, RII was likely to be more appropriate than indices of absolute inequalities such as slope index of inequality.

The finding of greater inequality despite lower disease experience is of interest to policy makers. Risk factor and whole population approaches are generally advocated for dental caries (Watt, 2005), including in English children (Tickle *et al.,* 2010). Whilst targeted approaches may be attractive to policy-makers since they can limit resource allocation and may be perceived as addressing important determinants such as behaviour and access to dental care (McLaren *et al.,* 2011), it is important that such approaches are capable of identifying discrete risk populations (Brewster, *et al.,* 2013). Furthermore, some interventions such as school-based oral health education (Qadri *et al.,* 2018) are likely to increase inequalities.

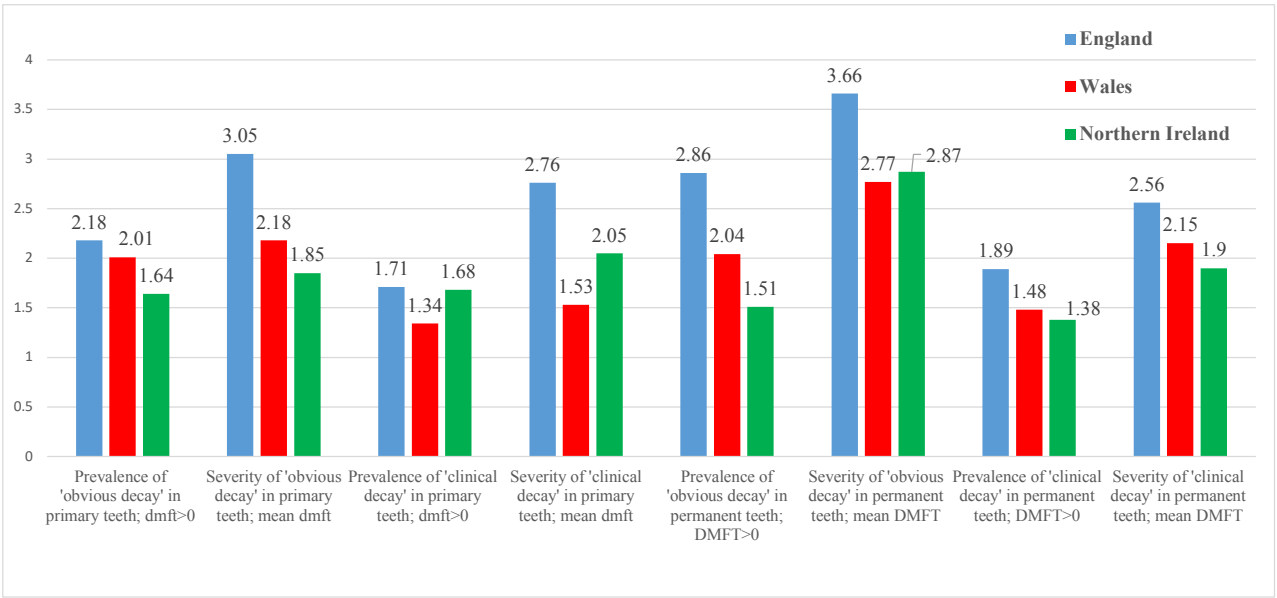

Figure 1. Relative indices of inequalities in dental caries experience between England, Wales and Northern Ireland, 2013

Conclusion

There were oral health inequalities in children dental caries with the more deprived children reporting higher prevalence and severity of dental caries in England, Wales and Northern Ireland. Inequalities in in England were greater than in Wales or Northern Ireland, despite decay being less frequent and severe in England.

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