The impact of dental caries and local-area deprivation on 5-year-olds' oral health-related quality of life (OHRQoL)

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Abstract

Objective: To explore the impact of area-level deprivation on 5-year-olds' (school year 1) oral health-related quality of life (OHRQoL) in Wales. *Basic research design:* During the 2022/23 academic year, a sample of 5-year-old children in state-maintained schools in Wales were selected to undergo a clinical examination. A random stratified sample of 15,625 children were invited to participate. The British Association for the Study of Community Dentistry diagnostic criteria was used to calculate d3mft (decayed, missing, and filled teeth) and PUFA (pulpal involvement, ulceration, fistula, and abscess) scores for each child. *Main outcome measures:* Before the examination, parents/guardians completed the Early Childhood Oral Health Impact Scale (ECOHIS), a validated measure of OHRQoL. *Results and Conclusion:* Data were gathered from 8,463 children from 612 schools, with a mean age of 5.95 years. 28.6% had experienced dental caries. Mean d3mft was 1.07 (3.39 in those with caries experience) and PUFA was present in 2.0%. 18.4% of parents/guardians reported a negative impact on the ECOHIS and this increased to 35.1% amongst children with caries experience (d3mft>0). The most common impacts reported were pain (11.6%, 23.6% if d3mft>0) and feelings of guilt in parents/guardians (6.7%, 16.5% if d3mft>0). The highest levels of impact were recorded amongst children from deprived communities, and this persisted after controlling for caries experience or untreated decay (p<0.05). These data reinforce the need for measures to tackle early childhood caries alongside other efforts to minimise childhood disadvantage.

Introduction

Dental epidemiological programmes provide a detailed picture of dental health across different population groups for surveillance, service planning, and evaluation purposes. Inspections of 5-year-old children across the UK report that dental caries remains prevalent:

23.7% in England (Public Health England, 2023), 26.5% in Scotland (Public Health Scotland, 2023), and 31.6% in Northern Ireland (Department of Health, 2023). However, clinical measures of prevalence and severity alone do not reflect the psychosocial impact that oral disease can have on a child (Quadri et al., 2021). Dental caries and associated sequalae have been linked with detrimental impacts on the child's speech and language development, school attendance, and school performance (Watt et al., 2024), parental workplace absenteeism, expenditure, and guilt (Quadri et al., 2021). The experience of childhood oral disease and its treatment can negatively affect the oral health-related quality of life (OHRQoL) of both the child and their families (Alanzi et al., 2023; Pahel et al., 2007).

Like other chronic non-communicable conditions, oral disease is socially patterned, with socio-economic inequalities in both prevalence and severity (Public Health England, 2021). Socioeconomic position is a broad term that refers to the social and economic factors that influence how individuals or groups are structured within a society. It can be measured at the individual and area levels. International studies have shown a link between individual-level deprivation (lower parental socioeconomic status, determined by educational level or income) and worse OHRQoL in children (e.g., Knorst et al., 2021). Therefore, there is evidence that the wider impact of poor oral health is experienced unevenly across different socioeconomic groups.

This study examined the association between an area-level measure of deprivation and OHRQoL impact whilst controlling for the prevalence and severity of oral disease. The data may provide a more detailed understanding of the impact of poor oral health to inform healthcare priorities and the development of programmes to reduce the impact of dental disease.

Methods

This was a secondary analysis of the NHS Dental Epidemiological Programme for Wales data based on oral health inspections of 5-year-olds (school children in year one). The programme is a collaboration between Public Health Wales, the Welsh Oral Health Information Unit (WOHIU) at Cardiff University and Local Health Boards. The inspection was conducted in accordance with British Association for the Study of Community Dentistry (BASCD) guidance on national epidemiological programmes (Pine et al., 1997a; Pitts et al., 1997).

The sampling frame consisted of all 5-year-old children who attended state-funded mainstream primary schools in Wales during the 2022-2023 academic year. A stratified random sample was used to select potential participants following the guidance of (Pine et al., 1997b). Lists of all mainstream schools and their predicted school year one class sizes were sourced from each Local Education Authority (LEA). This comprised 32,890 children in 1250 schools. Schools were randomly selected to generate a sample size of at least 120 children to help ensure a recommended minimum of 90 children per upper super output area (USOA) within each Unitary Authority. This represented a required minimum of 8,460 examinations across 94 USOAs. Schools were classified as either small (n<31) or large schools (n>=31) and the stratified sample represented the balance of each school size within each USOA. School information was recorded on a Microsoft Excel worksheet which calculated the proportion of children in small or large schools within the USOA and the minimum number of children needed from each school type to achieve the 120 while maintaining this ratio. The schools were selected based on numbers randomly allocated to each school until the minimum sample was reached. A total of 15,625 children from 659 schools were included in the final sample. The sample lists for each USOA were collated for each Unitary Authority and shared with the examining teams from the relevant Health Boards.

Parents of sampled children were sent an invitation pack containing a cover letter, information sheet, consent form, and the ECOHIS questionnaire (Pahel et al., 2007). Clinical data were collected by dentists (n= 13) and dental therapists (n=3) who had been trained and calibrated according to BASCD guidance (Pine et al., 1997a). Calibration incorporated two training rounds of examinations and one calibration round; one participating dentist was a trained gold standard examiner. All examiners conducted timed inspections of sixteen children's teeth and mouth per round: each child being seen by each examiner in turn. Mean d3mft scores and confidence intervals were calculated for each examiner. The gold standard examiner's data acted as a baseline with examiners successfully calibrating if their mean d3mft scores were 0.5 d3mft from the gold standard and were within the 95% confidence interval of the group mean.

A visual examination method was used, with obvious decay into dentine (d3t) the threshold for caries reporting. Children were seated in a reclining chair, lit by a Daray lamp with an LED 4,000-lux bulb. The use of probes and cotton wool were allowed but not the wearing of loupes. Examiners sat to the side of the child to inspect all surfaces of the child's teeth and their mouth. A recorder noted the clinical data in a predesigned form.

Participating children's OHRQoL was assessed using the Early Childhood Oral Health Impact Scale (ECOHIS) (Pahel et al., 2007). The ECOHIS was developed to be completed by parents/guardians for use with children up to six years old and is widely used. The scale comprises thirteen statements about the direct impact of oral disease on the child and those that impact on the broader family. The child impact statements include symptoms (pain); function (difficulty drinking hot or cold beverages, eating some foods, pronouncing any words, or missed school); psychological impacts (trouble sleeping, been irritable or frustrated); and self-image and social interaction (avoided smiling or laughing, avoided talking). Family impacts include parental distress (been upset, felt guilty) and family function

(taken time off work, financial impact on the family) (Pahel et al., 2007). Parents/guardians rate the frequency of each impact over the child's lifetime as either 'Never', 'Hardly ever', 'Occasionally', 'Often', 'Very Often', or 'Don't know'. The ECOHIS was printed on the rear of the consent forms to match the responses with the child's clinical data during data. The ECOHIS and consent forms were returned to the school by parents/guardians before the inspection.

Demographic data included the child's age at the time of inspection (in years and months) and the relative level of local area deprivation for each child. Welsh Index of Multiple Deprivation (WIMD) 2019 ranks relative deprivation in small areas based on an aggregate of eight domains of deprivation (Income, Employment, Health, Education, Access to Services, Housing, Community Safety, and Physical Environment) (Welsh Government, 2019). WIMD 2019 quintiles were assigned using the school postcode as a proxy for residential location for the examined children. Data were weighted using small area populations obtained from Local Education Authorities.

The clinical variables comprised the average number of teeth with visually evident untreated dental caries (d3t) and the presence and tooth-level severity of dental caries and treatment experience (d3mft). Dental caries and treatment experience (d3mft) was defined as one or more teeth with evidence of untreated dental caries, missing (due to caries), or filled primary teeth. The PUFA-index recorded pathology due to dental caries (pulpitis, ulceration, fistula, and/or abscess). This records visible pulpal involvement (p), ulceration caused by dislocated tooth fragments (u), fistula (f) and abscess (a) associated with carious teeth. PUFA scores were calculated as dichotomous outcomes for each child.

ECOHIS OHRQoL variables of interest comprised the prevalence and the severity of any OHRQoL impact in the three ECOHIS domains. Prevalence of ECOHIS impact was recorded for a response of 'Occasionally', 'Often', or 'Very Often' for one or more item (Pahel et al.,

2007). This was repeated to explore any impact in the child and family domain questions. To calculate the severity of impact, each response was allocated a score ranging from 0 'Never' to 4 'Very Often' and the sum of the responses in each domain (overall, child, or family impact).

Data were analysed using StataSE 17.0. Only records with complete clinical and OHRQoL data were included. Descriptive statistics summarised the demographic data and the mean scores and prevalence of untreated decay, decay experience, the presence of PUFA, ECOHIS scores, and the child and family domain scores. Mann Whitney U tested the association between ECOHIS impacts with a d3mft>0 and untreated caries (d3t>0). A Zero-Inflated Poisson Regression was tested the relationship between the ECOHIS severity scores and WIMD (2019) deprivation quintile whilst controlling for untreated dental caries (d3t) or dental caries and treatment experience (d3mft). The threshold for significance was 0.05 for all tests.

The legal basis of the NHS Wales DEP is contained within Section 520 of the Education Act 1996 and Schedule 1 of the 2006 NHS (Wales) Act. As dental inspection programmes are covered by this legislation, additional Research Ethics Committee approval was not required. Parents of sampled students were invited to take part in the inspection by a bilingual letter. On the day of the inspection, if any children were reluctant to take part, or became distressed or uncomfortable then their participation was stopped.

Results

A total of 9,376 children were examined, 60.0% of the children sampled. This exceeded the minimum expected sample size of 8,460 for the inspection. ECOHIS questionnaires were completed for 8,463 of the children examined, 90.3% of the sample for whom clinical data were collected.

Data were collected in 21 of 22 Unitary Authorities. Too few examinations were conducted in one Unitary Authority; therefore, their data represents two of the three Unitary Authorities comprising the Health Board.

The children had a mean age of 5.95 years (SD 0.32). Mean d3mft was 1.07 (95% CI 1.03, 1.11) and 31.7% (95% CI 30.1,32.5) had decay experience. Untreated caries was present in 29.5% (95% CI 27.7, 29.4) and PUFA signs were evident in 2.0% (Table 1).

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Almost a fifth of parents/carers (18.4%) reported that their child's oral status had impacted on the quality-of-life of their child or family. In children with dental caries experience (d3mft>0), over a third of parents/carers (35.1%) reported an impact. Of these, 15.4% reported negative impact(s) affecting the child (29.8% if d3mft >0, 29.2% if d3t>0) and 8.8% reported negative family impact(s) (20.4% if d3mft>0, 19.8 if d3t>0).

A mean ECOHIS severity score of 0.18 was reported for all children, this increased to 3.94 in those with dental caries and treatment experience (d3mft) and to 3.74 in those with untreated decay (d3t). Mean child-related impacts score was 0.15 (2.69 if d3mft>0, 2.56 if d3t>0). Mean scores for family-related impacts was 0.09 (1.26 if d3mft>0, 1.18 in d3t>0).

The greatest single impact score for children was pain (0.50 for all children, 0.83 if d3mft>0, and 0.81 if untreated caries was evident (d3t>0). In those without caries, trouble sleeping scored the highest (0.65). Within the family domain impacts, feelings of guilt received the highest scores (0.21 for all children, 0.52 if d3mft>0, 0.59 if d3t>0).

The presence of an OHRQoL impact was associated with the presence of dental caries and treatment experience (d3mft>0) or untreated dental caries (d3t>0) (both p >0.001). The three ECOHIS OHRQoL scores were also associated the presence of caries and treatment experience (d3mft>0) or untreated caries (d3t>0) (both p >0.001) (Table 2).

When the three ECOHIS domain (child, family and total impact) severity scores were plotted against WIMD 2019 quintiles on, differing patterns of impact were observed, depending on the decay experience (Figure 1). Child impact and overall score showed a positive gradient for children with decay experience (d3mft>0) and untreated decay (d3t), the effects were less evident for family impact scores.

In multivariate regression analysis controlling for decay experience (d3mft), overall OHRQoL scores of those in the most deprived quintile had an incident rate ratio (IRR) of 1.19 (95% CI 1.06, 1.33) compared to the least deprived. When the severity of untreated caries (d3t) was controlled for, the IRRs in both the most and second most deprived quintiles (IRRs 1.32 and 1.18 respectively) were higher than the least deprived (Table 3).

Child impact ECOHIS scores were associated with relative deprivation. When caries experience (d3mft) was controlled for in a multivariate analysis, children from the least deprived quintile (reference group in Table 3) still experienced better OHRQoL than those in the second most and most deprived quintiles (IRRs 1.10 and 1.23 respectively). When untreated caries (d3t) experience was controlled for, children from 'Middle' (IRR 1.10), 'Second most deprived' (IRR 1.18), and 'Most deprived' (IRR 1.34) quintiles were more likely to report an ECOHIS impact than those in the least deprived reference group.

Family domain scores were less related to deprivation. No association between family impacts and deprivation was observed when d3mft was controlled for but controlling for the severity of untreated decay (d3t) revealed greater impact in the most deprived quintile.

Discussion

Decay experience was evident in over one in three children examined, and OHRQoL impacts were reported for nearly one in five children. Symptoms, specifically pain, were the most frequently reported impact. When controlling for untreated decay, there remained a social gradient in OHRQoL impacts across the deprivation quintiles. This was particularly evident in the child-related domains of the ECOHIS. That is, children with similar levels of untreated disease experience different levels of impact based on their socioeconomic position. This association was somewhat attenuated when controlling for decay and treatment experience (i.e., missing and filled teeth), although differences persisted between the most and least deprived groups.

The relationship between oral disease and OHRQoL is complex and influenced by individual psychosocial and environmental factors (Knorst et al., 2021). Contextual factors may also limit people's available resources and influence priorities in their daily life. The participant's socioeconomic situation may shape their perceptions and expectations of oral health. Greater OHRQoL impact could be due to poorer access to dental, or other health-promoting services or activities in socio-economically deprived areas, as described by the Inverse Care Law (Tudor Hart, 1971) leading to increased health-risk exposure. Indeed one of the WIMD (2019) domains (Welsh Government, 2019) includes access to services in the . local area. Childhood caries may also become normalised and viewed as unavoidable within a community(Alanzi et al., 2023). Reported lower levels of oral health literacy in parents in lower socioeconomic groups (Barasuol et al., 2020) may also lead to underestimations of oral disease levels in their child which may lead to treatment not being sought until later in the disease progression. Parental impact was only significant in the most deprived quintile in the untreated caries-controlled (d3t) statistical model. Gomes et al. (2014) also reported that

parental guilt was only associated with severe disease, when treatment needs become more pressing. Rather than lack of early engagement with dental services being solely out of choice, local-area contextual factors such as public transport and availability of local services may be influential.

The possibility that the findings in this study may reflect a type 1 error owing to how the data were collected/analysed also needs to be considered. Opinions are mixed on the accuracy of parental/guardian assessments of their children's OHRQoL as they risk underestimation of the child's subjective experiences. Pani et al. (2012) found that mothers' ECOHIS scores were significantly associated with the child's d3mft scores, but this may not necessarily reflect the impact of oral disease on the child. Subjective impacts such as social and emotional well-being are more difficult for young children to communicate compared to observable and communicable impacts such as symptoms or functional impacts (Reissmann et al., 2017). This may explain the prevalence of pain as the most frequently identified impact, which would concur with other studies (e.g., Alanzi et al., 2023). Additionally, the examinations only recorded visually evident caries into dentine so in the analysis it was not possible to control for any impact associated with the management of earlier carious lesions. The Zero-Inflated Poisson model had a degree of overdispersion which may lead to underestimation of standard errors of the parameter estimates. As a result, the confidence intervals surrounding the model estimates may be wider than presented here. The analysis also used a proxy for deprivation, e.g., the school postcode rather than the child's home postcode. This risks random misclassification of deprivation quintile in children attending the school but living outside the local area. In England, the average distance travelled to school was 1.8 miles (Department for Transport, 2024), which may not markedly influence IMD quintile rankings for most children. However, this distance may increase in more rural areas of Wales. Using the school as a proxy also masks potentially confounding school-level or local-area-level

contextual issues such as the availability of sugary snacks or proximity of high-sugar food outlets.

There is a paucity of research exploring how the mechanisms of inequality and deprivation influence oral health and OHRQoL and research exploring how community-level and service use have been recommended (Public Health England, 2021). The data presented in this paper was gathered as part of a national inspection and as such illustrates the oral health and OHRQoL of the population at a single point in the child and family's life. To further understand the influences on young children's oral health longitudinal research which focusses on a range of domains of influence is needed (Watt et al., 2024). Such evidence will further inform the individual, social, and policy-level measures needed to tackle the incidence and impact of early childhood caries.

In conclusion, over one in five 5-year-old children experienced an oral impact on their OHRQoL. Moreover, this impact OHRQoL disproportionately affects children from socio-economically deprived communities, even after clinical disease and treatment levels were controlled for. These findings reinforce the need for measures to tackle the prevalence and severity of early childhood caries alongside measures to reduce the impact that the disease has on 5-year-olds' OHRQoL.

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Table 1: Demographic and clinical characteristics of 8,463 Year 1 children

Demographic information:	***Mean age (years (SD))***	5.95 (0.33)
	Local Health Board (%):	
	Aneurin Bevan UHB	17.7
	Betsi Cadwaladr UHB	21.7
	Cardiff and Vale UHB	17.8
	Cwm Taf Morgannwg UHB	16.1
	Hywel Dda UHB*	7.8
	Powys THB	4.8
	Swansea Bay UHB	14.1
	WIMD 2014 deprivation quintile (%):	
	1 (least deprived)	21.9
	2 (second least deprived)	23.6
	3 (middle deprived)	16.0
	4 (second most deprived)	21.8
	5(most deprived)	16.7
Clinical findings:	***Prevalence of $d_3mft > 0$ (%):***	31.7
	Mean d_3mft (95% CI):	1.07 (1.03, 1.11)
	Mean $d_3mft > 0$ (95% CI):	3.39 (3.29, 3.49)
	Prevalence of $d_3t > 0$ (%):	29.6
	Mean d_3t (95% CI):	0.88 (0.85, 0.92)
	Mean d_3t untreated caries >0 (95% CI):	3.09 (2.99, 3.19)
	PUFA factors (%):	
	Absent	98.0
	Present	2.0

* Reporting two of the three Unitary Authorities

Table 2: ECOHIS impacts in the last year in 8,463 year one children

	ECOHIS oral health-related quality of life impacts	All children (*n*=8,463)		Caries-free (d3mft = 0) (*n*=5,850)		In those with d3mft >0 (*n*=2,613)		In those with untreated caries (d3t >0) (*n*=2,366)	
		Prevalence of impact (%)	Mean ECOHIS scores (95% CI)	Prevalence of impact (%)	Mean ECOHIS scores (95% CI)	Prevalence of impact (%)	Mean ECOHIS scores (95% CI)	Prevalence of impact (%)	Mean ECOHIS scores (95% CI)
Child impacts	Pain	11.6	0.50 (0.48,0.51)	5.9	0.35 (0.33,0.36)	23.6*	0.83 (0.79,0.86)	23.5*	0.81 (0.77,0.85)
	Difficulty drinking hot or cold beverages	2.4	0.12 (0.11,0.12)	0.0	0.06 (0.05,0.06)	5.9*	0.24 (0.22.0.27)	5.4*	0.23 (0.21,0.26)
	Difficulty eating some foods	4.9	0.20 (0.18,0.21)	1.6	0.09 (0.08,0.10)	12.2*	0.42 (0.39,0.45)	11.4*	0.40 (0.36,0.43)
	Difficulty pronouncing any words	2.5	0.10 (0.09,0.11)	1.8	0.07 (0.06,0.08)	3.9*	0.16 (0.14,0.18)	3.5*	0.15 (0.12,0.17)
	Missed preschool, day-care or school	2.3	0.10 (0.10,0.11)	0.4	0.04 (0.03,0.04)	6.2*	0.25 (0.23,0.27)	5.7*	0.23 (0.20,0.25)
	Had trouble sleeping	3.2	0.13 (0.12,0.14)	1.2	0.65 (0.06,0.07)	7.4*	0.28 (0.25,0.30)	6.7*	0.26 (0.23,0.28)
	Been irritable or frustrated	4.6	0.18 (0.17,0.19)	1.9	0.09 (0.08,0.10)	0.4*	0.37 (0.34,0.40)	10.0*	0.35 (0.32,0.38)
	Avoided smiling or laughing	1.2	0.05 (0.04,0.05)	0.5	0.02 (0.14,0.23)	2.6*	0.10 (0.09,0.12)	2.7*	0.11 (0.09,0.12)
	Avoided talking	0.6	0.03 (0.02,0.03)	0.3	0.01 (0.01,0.01)	1.4*	0.07 (0.05,0.08)	1.2*	0.06 (0.05,0.08)
Family impacts	Been upset	4.9	0.16 (0.15,0.17)	1.6	0.06 (0.05,0.07)	12.2*	0.39 (0.35,0.42)	11.6*	0.37 (0.34,0.41)
	Felt guilty	6.7	0.21 (0.20,0.28)	2.1	0.08 (0.06,0.08)	16.5*	0.52 (0.48,0.56)	15.7*	0.49 (0.45,0.53)
	Taken time off from work	2.7	0.11 (0.10,0.12)	0.9	0.04 (0.04,0.05)	6.7*	0.25 (0.23,0.28)	6.0*	0.23 (0.20,0.25)
	Financial impact on the family	1.3	0.05 (0.04,0.06)	0.6	0.03 (0.02,0.03)	2.8*	0.11 (0.09,0.12)	2.6*	0.10 (0.08,0.12)
	Any child domain impact: *(scoring range 0-36)*	15.4	0.15 (0.15,0.16)	8.7	0.78 (0.74,0.83)	29.8*	2.69 (2.53,2.85)	29.2*	2.56 (2.40,2.72)
	Any family domain impact: *(scoring range 0-16)*	8.8	0.09 (0.08,0.09)	3.5	0.20 (0.18,0.22)	20.4*	1.26 (1.16,1.34)	19.8*	1.18 (1.09,1.28)
	Any domain impact: *(scoring range 0-52)*	18.4	0.18 (0.18,0.12)	10.6	0.98 (0.92,1.04)	35.1*	3.94 (3.71,4.18)	34.5*	3.74 (3.51,3.98)

* *p* <0.05

Table 3: Multivariable Zero-inflated Poisson linear regression model of ECOHIS OHRQoL impact score (total score, child impact score and family impact score).

|	Child impacts		Family impacts		All domains	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Caries and treatment severity (d3mft):	1.13	1.11, 1.14	1.09	1.07, 1.10	1.15	1.14,1.16
WIMD (2019) Quintile:						
Least deprived	*Ref*	*Ref*	*Ref*	*Ref*	*Ref*	*Ref*
Second least	1.02	0.92, 1.13	0.94	0.82, 1.10	1.01	0.91, 1.12
Middle	1.04	0.93, 1.16	1.00	0.86, 1.17	1.03	0.92, 1.16
Second most	1.10	1.00, 1.21	1.03	0.89, 1.18	1.09	0.99, 1.21
Most deprived	1.23	1.11, 1.4	1.06	0.90, 1.23	1.19	1.06, 1.33
	Child impacts		**Family impacts**		**All domains**	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Untreated caries severity (d3t):	1.10	1.09, 1.12	1.07	1.05, 1.08	1.13	1.11, 1.19
WIMD (2019) Quintile:						
Least deprived	*Ref*	*Ref*	*Ref*	*Ref*	*Ref*	*Ref*
Second least	1.06	0.96, 1.18	1.00	0.86, 1.15	1.07	0.96, 1.19
Middle	1.10	0.98, 1.23	1.05	0.90, 1.23	1.10	0.98, 1.24
Second most	1.18	1.06, 1.30	1.11	0.97, 1.28	1.18	1.07, 1.31
Most deprived	1.34	1.19, 1.50	1.15	0.99, 1.35	1.32	1.16, 1.49
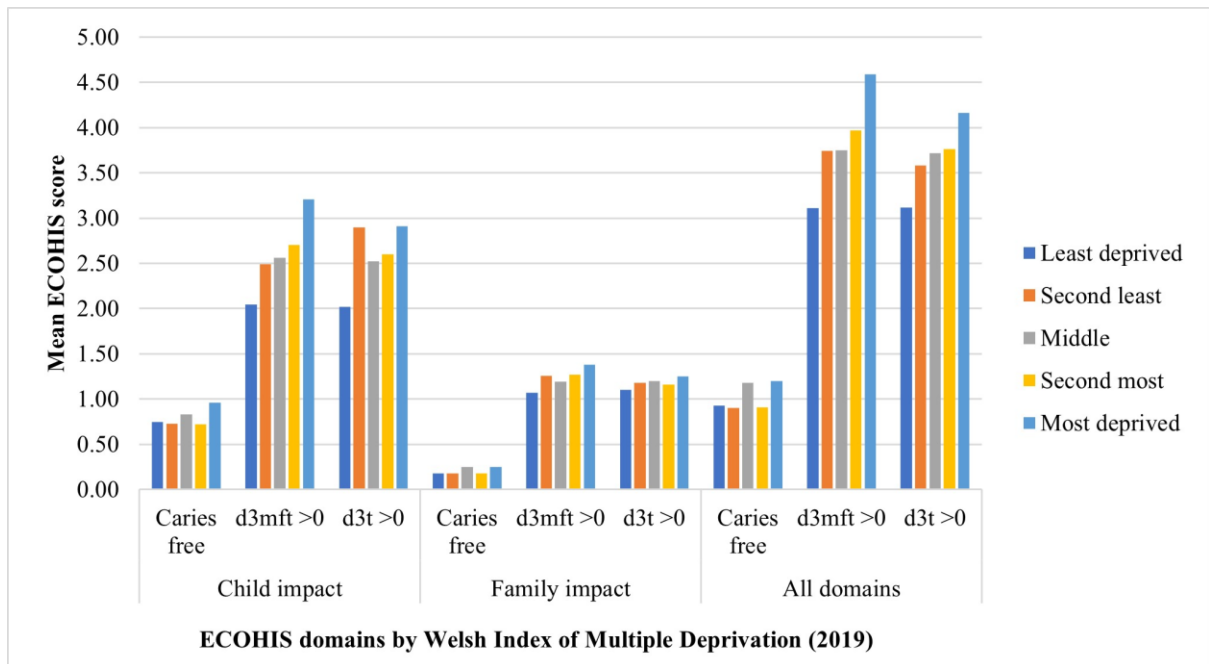
Figure 1: Mean ECOHIS oral health-related quality of life impact score by WIMD (2019) quintile, degree of tooth-level caries experience (d3mft) and untreated caries experience (d3t)