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Dental health of 5-year-olds following community-based oral health promotion in Glasgow, UK

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Summary. *Aim.* A community development oral health promotion programme based on the principles of the Ottawa Charter was conducted in an attempt to improve the dental health of children under 5 years of age in two severely socioeconomically challenged pilot districts in Glasgow, UK. Later phased extension involved all of the area's most deprived communities. The aim of the present study was to assess dental health outcomes by secondary analysis of routine caries datasets for Glasgow 5-year-olds over the interval from 1997–1998 to 2003–2004.
Design. Wilcoxon tests assessed change in $d_3$mft scores and logistic regression was used to analyse binomial scores (e.g. % $d_3$mft = 0).
Results. After adjusting for age and deprivation (DepCat) in pilot districts 1 and 2, significant redistributions of the relative frequency of $d_3$mft scores were observed ($P = 0{\cdot}012$ and $P < 0{\cdot}001$, respectively), mean $d_3$mft decreased from 5·5 to 3·6 and from 6·0 to 3·6, respectively, and the proportions with $d_3$mft = 0 increased from 11% to 29% and from 10% to 32%, respectively [$P = 0{\cdot}010$, odds ratio (OR) = 0·25, and $P = 0{\cdot}006$, OR = 0·30, respectively, for $d_3$mft > 0]. Following extension of the programme into all of Glasgow's socioeconomically challenged areas, the mean $d_3$mft values of 5-year-olds reduced in all DepCat 7 communities, and across Glasgow as a whole from 4·9 to 4·1 and from 3·5 to 3·1, respectively, while the proportion with $d_3$mft = 0 increased from 20% to 32% ($P < 0{\cdot}001$) and from 34% to 42% ($P < 0{\cdot}001$), respectively.
Conclusion. Dental health improvements were observed in pilot districts and across all DepCat 7 communities following the roll-out of the programme. This change was of sufficient magnitude to impact upon area-wide statistics for Glasgow.

Introduction

This paper describes the evaluation of dental health outcomes following a community-based programme of oral health promotion in Glasgow, UK, and discusses the programme's relevance to improving infants' oral health in extremely deprived urban communities.

The dental health of 5-year-old children resident in National Health Service (NHS) Greater Glasgow is amongst the poorest in Scotland [1], and indeed, Western Europe [2]. In 1998, no dental health improvement had been recorded in this age group in Glasgow since the mid-1980s [2]. The NHS records show that a sizable minority (32% in 2003) of the 5-year-old population of Glasgow reside in the most challenged socioeconomic status (SES), i.e. Carstairs' [3] deprivation category DepCat 7 life circumstances. There is a direct relationship between extreme disadvantage, as described by McLoone [4], and the incidence and prevalence of dental caries in this age group in Scotland [2,5]. Additionally, oral health needs assessment in some Glasgow communities has revealed alarming levels of dental health morbidity in infants as young as 3 years of age, i.e. mean $d_3$mft = 3·9 and 38% $d_3$mft > 0 at 3 years of age [6]. These values are poorer than the average for Scotland's 5-year-old population in the corresponding year [7].

As a consequence of the publication of *Scotland's Health, a Challenge to Us All: The Oral Health Strategy for Scotland* [8], NHS Greater Glasgow commissioned a pre-5-year-old oral health gain strategic development programme in 1996. This developed a 'from birth' caries preventive strategy aimed at bringing about dental health improvements for pre-5-year-old children living in two of Glasgow's most deprived districts (populations and birth rates,

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26,000 and 46,000, and *c*. 250 and *c*. 525 per annum, respectively). A community-based oral health programme approach, previously untested in Glasgow and entitled 'Time to Smile', focused on the early lifestyle determinants of caries. This programme was implemented in two discrete pilot communities facing extreme deprivation. The programme's interim monitoring report [9] informed a subsequent review of Glasgow's Community Dental Service [10] and led to incremental extension of the approach. One recommendation of this review was the establishment of oral health action teams (OHATs) in each of Glasgow's 15 primary healthcare administrative areas (local health care co-operatives, LHCCs). The ideal composition of an OHAT includes an oral health promoter, lead general dental practitioner, community dental officer, community pharmacist, liaison health visitor, public health practitioner, education sector staff and community workers/volunteers; membership is subject to local multiprofessional and community interest. Consequently, from 2000, the programme was delivered by OHATs as they became established. The sequence of OHAT implementation was prioritized according to needs assessments of respective infant populations. By 2001, virtually all remaining severely deprived communities (populations total, $n = 287{,}600$, birth rate *c*. 3450 per annum) had active OHAT programmes.

Poorer socioeconomic groups reportedly make less use of dental services [11,12] for asymptomatic care [13,14], and therefore, have less opportunity to receive appropriate advice and early treatment [15]. The formation of collaborative networks of voluntary community activists in Glasgow has led to oral health promotion activities being delivered in many settings outside the more conventional dental surgery environment. This has given greater access for the majority of the most 'at risk' children to receive programme initiatives. The scientific literature relating to dental caries and its prevention [15] was translated into jargon-free language to describe caries-risk behaviours and how these might be modified by the community. The key feature of this programme has been to support communities to identify everyday opportunities to reduce the frequency of caries-promoting events and to increase the frequency of caries-protective behaviours. The dental health improvement programme developed partnership-working methodologies which accorded fully with the *Ottawa Charter for Health Promotion*'s fundamental prerequisite conditions for health, i.e. provision of education, food, stable environment, sustainable resources, social justice and equity [16]. Table 1 displays examples of the types of interventions which evolved with community partners in one OHAT district.

Numerous joint interventions were devised with parents/carers, extended families, health visitors, nursery teachers, primary school staff, local authorities, care workers, administrators, pharmacists, dental and dietetics practitioners, as well as voluntary, retail and media organizations [6,9]. Key objectives were to maximize opportunities for dental health promotion by: (1) sustained distribution of free consumables (e.g. 1000 p.p.m. F^- dentifrice and toothbrushes) to support daily brushing at home and in group settings from the time of eruption of the first tooth; (2) advocating nursery food and drinks policies to bring about reductions in the frequency of consumption of sugars in children's daily lives by substituting free fresh fruit, milk and cooled water for the previous sugared foods and drinks; and (3) promoting asymptomatic dental attendances from the earliest age in populations with little understanding of the benefits of restorative/clinical preventive care options versus dental extractions, and for whom fear and anxiety about dentistry and cultural reliance on 'crisis-care' extractions under general anaesthesia was widespread [17–20].

Prior to 1997–1998, the community which later became pilot district 2 had been the designated control population for the original ecological study. Indications of beneficial outcomes emerging from the initial pilot district 1 in 1997–1998 persuaded the Greater Glasgow Health Board that it would be unethical to withhold the interventions from pilot district 2.

The aim of this study was to assess dental health outcomes by the secondary analysis of routine epidemiological datasets.

Subjects and methods

In Glasgow, cross-sectional caries surveys of randomly selected 5-year-old children in primary school reception classes are carried out routinely as part of a national programme. From 1987, this was known as the Scottish Health Boards' Dental Epidemiological Programme (SHBDEP), becoming the National Dental Inspection Programme from 2002. These epidemiological surveys are conducted according to British Association for the Study of

Table 1. Ottawa Charter Principles and associated community-development-based oral health promotion activities in one Oral Health Action Team (OHAT) district.

Ottawa Charter principle actioned	OHAT activity	Volume (2004–2005)
Advocate, Enable, Mediate, Strengthen Community Action	Consultation groups	Assembled 15 representative groups, attendees included: parents, children, local politicians & health professionals
Develop Personal Skills, Strengthen Community Action	Programme information leaflet inviting comments	Distribution throughout district
Advocate, Enable, Mediate, Develop Personal Skills, Strengthen Community Action	Locality based questionnaires to: schools, voluntary groups, individuals and nurseries	287 responses, 33 from nurseries
Build Healthy Public Policy, Create Supportive Environments	Nurseries: staff education – brushing with F^- dentifrice; activity – daily tooth brushing programme	87/87, 72/87
Build Healthy Public Policy, Create Supportive Environments	Healthy snacks policies: negotiated with nurseries; policies implemented	87/87, 47/87
Strengthen Community Action, Develop Personal Skills	Community oral health promotion events, dental health songbooks, events and decorations, etc.	50 nursery-based
Strengthen Community Action, Develop Personal Skills	Nursery training and parent workshops	At > 50 locations
Advocate, Enable, Mediate, Strengthen Community Action	Topic-specific community development/consultation, etc.	To obtain local opinions on proposed oral health strategy for Glasgow, *c*. 40 multisectoral attendees
Reorient Health Services, Develop Personal Skills	'Change to Cup' scheme and free toothpaste and toothbrush distribution (health visitors)	Target: all children aged 8–12 months, 17/17 health visitors participating
Reorient Health Services, Develop Personal Skills	Dental registration promotion schemes	12/15 GDP practices
Reorient Health Services, Strengthen Community Action, Enable, Develop Personal Skills	'Get Cooking' classes	Various setting and locations, opportunistic
Reorient Health Services, Strengthen Community Action, Develop Personal Skills	Perinatal oral health sessions	40 sessions
Reorient Health Services, Strengthen Community Action, Develop Personal Skills	Weaning fair (subsidized utensils and food-blenders)	18 (390 parents/carers attended)
Reorient Health Services, Enable, Develop Personal Skills	Playbox resource	29 × one-month loans
Reorient Health Services, Enable, Develop Personal Skills	Free F^- dentifrice and toothbrush distribution (dental practices and pharmacy outlets)	9/15 dental practices, 10/15 pharmacy outlets
Advocate, Enable, Mediate, Strengthen Community Action	'Training the Trainers' (volunteers from playgroups)	5 oral health champions, based in 5 playgroups

Community Dentistry standardized criteria [21] for caries surveys, and involve annual national training and calibration exercises immediately preceding each survey to ensure intra-examiner and inter-examiner reliability. Respective anonymous datasets for Glasgow at time 1 (1997–1998), time 2 (1999–2000), time 3 (2002–2003) and time 4 (2003–2004) were retrieved from Glasgow's archive. A deprivation category of home postcode was assigned to each subject's data prior to electronic transfer for secondary statistical analyses. Data were examined for caries trends in the two pilot districts, the targeted DepCat 7 communities, DepCat 1–6 districts (i.e. nonintervention communities data were

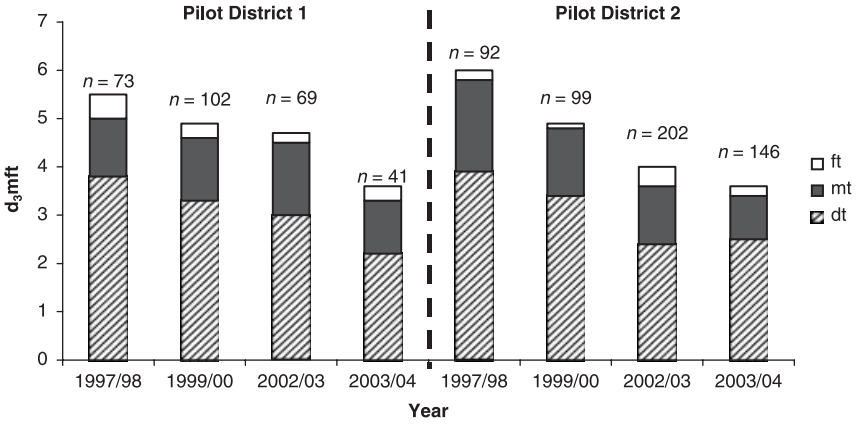

Fig. 1. Mean $d_3$mft scores of random samples of 5-year-old residents in pilot communities 1 and 2 from 1997–1998 to 2003–2004 (Scottish Health Boards' Dental Epidemiological Programme and National Dental Inspection Programme data).

used as 'proxy' control populations) and Glasgow as a whole. In addition, the 1995–1996 dataset for Glasgow was retrieved and examined to compare background trends preceding and following the targeted programme's introduction. A consultant statistician, experienced in statistical analyses of children's caries datasets, undertook statistical modelling exercises, which included Kruskal–Wallis tests, logistic regression modelling and negative binomial regression studies. Since age and DepCat are potential confounding variables, analyses for pilot district 2 and Glasgow as a whole required adjustment for both, while for pilot district 1 (entirely DepCat 7), the DepCat 7 and the DepCat 1–6 communities, it was necessary to adjust for age only. Analyses of the changes in $d_3$mft values by Wilcoxon tests and binomial scores (e.g. $d_3$mft = 0) by logistic regression were all adjusted as described above. The analyses were repeated using negative binomial models which confirmed the results from the logistic regression models, but these are not presented in this paper.

Results

Pilot district 1: 1997–1998 to 2003–2004

Reductions in mean $d_3$mft scores were observed in pilot district 1 (Fig. 1). Overall, mean $d_3$mft reduced from 5·5 [95% confidence interval (95%CI) = 4·5–6·4)] to 3·6 (95%CI = 2·5–4·7) between 1997–1998 and 2003–2004. Decreases in the mean number of untreated decayed teeth (dt) account for the majority of the reduction in $d_3$mft scores. There has been comparatively little change in the mean number of teeth extracted or treated restoratively over the period.

The percentage of 5-year-olds with no obvious decay experience increased from 11% to 29% (P = 0·010, OR = 0·25 for $d_3$mft > 0) (Fig. 2). Redistribution of the relative frequency of individual $d_3$mft scores occurred over time with a decreasing proportion of the 5-year-old population having experienced caries in six or more teeth (P = 0·012).

The proportion of children with missing teeth caused by extraction (mt > 0) decreased from 33% to 22%. The proportion of children with untreated decayed teeth (dt > 0) decreased from 82% to 59%.

Pilot district 2: 1997–1998 to 2003–2004

In the similarly deprived pilot district 2, 5-year-olds' dental health indices also improved following commencement of community interventions. Mean $d_3$mft decreased from 6·0 (95%CI = 5·2–6·8) to 3·6 (95%CI = 3·0–4·2) between 1997–1998 and 2003–2004 (Fig. 1). In this district, in addition to the reduction in the average number of untreated decayed teeth, there have been substantial decreases in the average number of extracted teeth.

The proportion of 5-year-olds with no experience of obvious tooth decay increased from 10% to 32% (P = 0·006, OR = 0·30 for $d_3$mft > 0) between 1997–1998 and 2003–2004 (Fig. 3). Redistribution of the relative frequency of individuals' $d_3$mft scores occurred. Between 1997–1998 and 2003–2004, a decreasing proportion of the 5-year-old population experienced caries in four or more teeth (P < 0·001).

The proportion of children with missing teeth caused by extraction (mt > 0) decreased from 42%

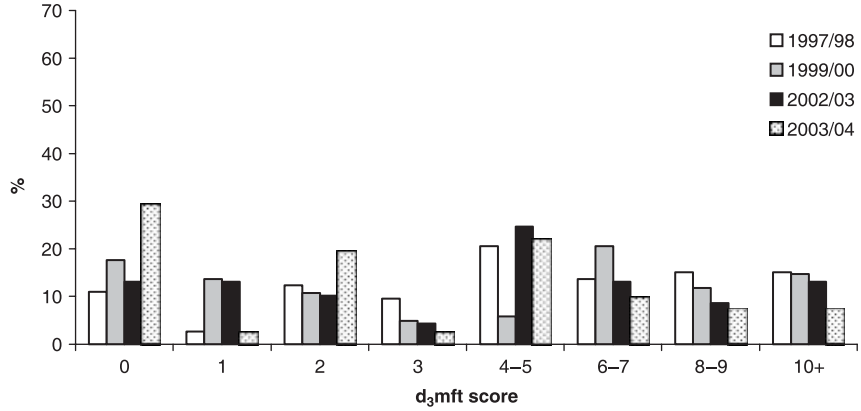

Fig. 2. Relative frequency distribution of $d_3$mft scores of a random sample of 5-year-old residents in pilot community 1 from 1997–1998 to 2003–2004 (Scottish Health Boards' Dental Epidemiological Programme and National Dental Inspection Programme data).

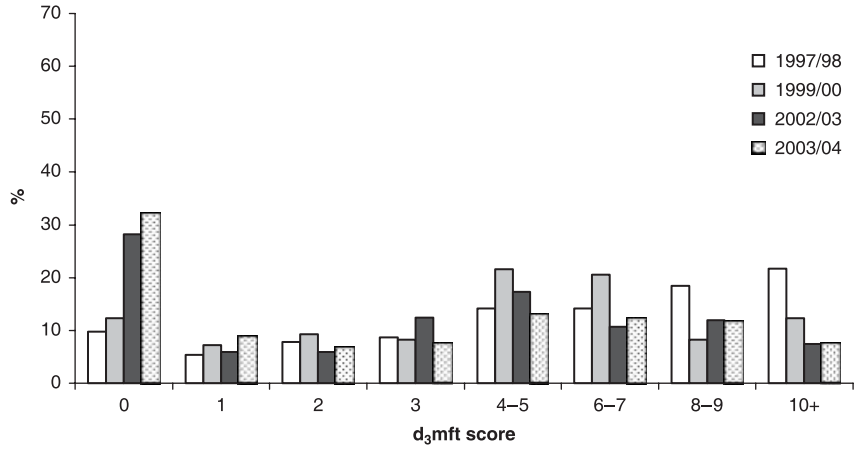

Fig. 3. Relative frequency distribution of $d_3$mft scores of a random sample of 5-year-old residents in pilot community 2 from 1997–1998 to 2003–2004 (Scottish Health Boards' Dental Epidemiological Programme and National Dental Inspection Programme data).

to 18%. The proportion of children with untreated decayed teeth (dt > 0) decreased from 84% to 60%.

Glasgow's DepCat 7 communities: 1997–1998 to 2003–2004

The mean $d_3$mft values for Glasgow's 5-year-olds residing in DepCat 7 communities, before and after the introduction of OHATs from 2000, are illustrated in Fig. 4. No statistically significant improvement in dental health indices occurred prior to the introduction of OHATs (i.e. in the nonintervention phase). However, following extension of community-based oral health promotion activities via the introduction of OHATs, a reduction in mean $d_3$mft from 4·9 (95%CI = 4·6–5·3) in 1997–1998 to 4·1 (95%CI = 3·7–4·4) in 2003–2004 was recorded (Fig. 4).

Over the same time interval, an increase from 20% to 32% ($P < 0{\cdot}001$, OR = 0·35 for $d_3$mft > 0) in the proportion of 5-year-olds with no experience of obvious caries was observed (Fig. 5), and the overall redistribution of relative frequency of individuals' $d_3$mft scores improved significantly ($P < 0{\cdot}001$).

The proportion of 5-year-old with experience of extracted teeth decreased from 35% to 22% ($P < 0{\cdot}0001$) and with untreated decay from 75% to 58% ($P < 0{\cdot}0001$) over the period. No increase in the proportion of children who had received restorative care was recorded.

Glasgow caries trends: 1997–1998 to 2003–2004

In the period prior to the introduction of OHATs in 2000, there was no evidence of any statistically significant improvement in the dental health indices of the 5-year-old population across the whole of Glasgow (Figs 4 & 6). However, following the introduction of community programmes targeted at the most vulnerable DepCat 7 communities' residents, who constitute 32% of Glasgow's 5-year-old population, a downward trend in mean $d_3$mft values from 3·7 (95%CI = 3·5–3·9) to 3·1 (95%CI = 2·9–3·2) was observed in the mean for all of Glasgow's 5-year-old population.

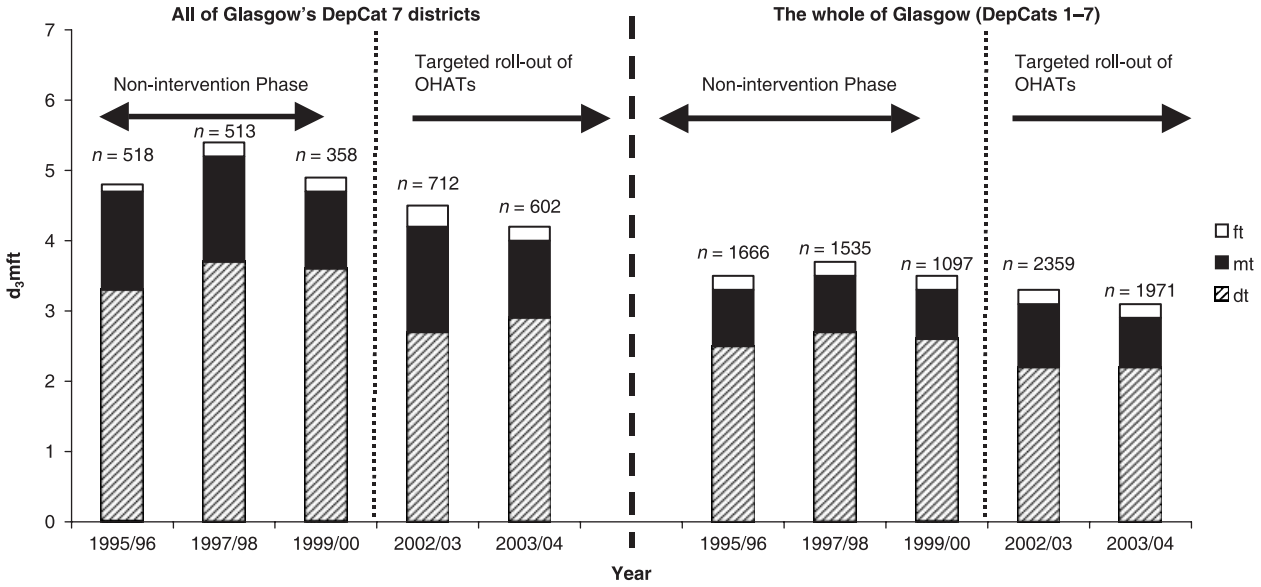

Fig. 4. Mean $d_3$mft scores of random samples of 5-year-old residents in DepCat 7 community districts and the whole of Glasgow from 1995–1996 to 2003–2004 (Scottish Health Boards' Dental Epidemiological Programme and National Dental Inspection Programme data).

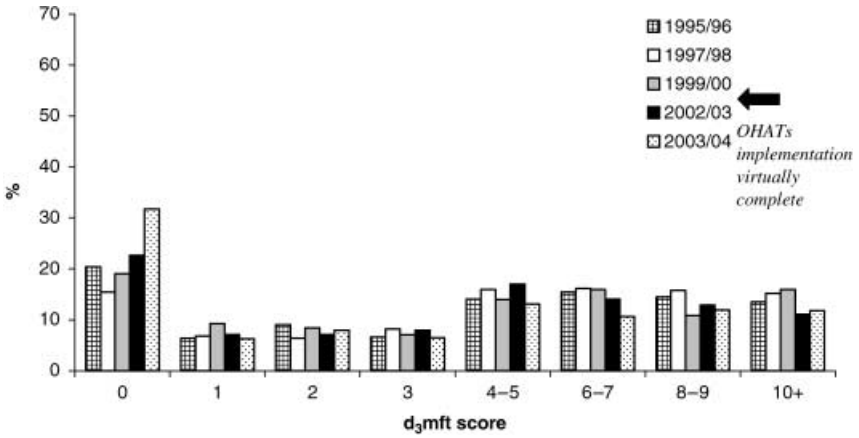

Fig. 5. Relative frequency distribution of $d_3$mft scores of a random sample of 5-year-old residents in Glasgow's DepCat 7 community districts from 1995–1996 to 2003–2004 (Scottish Health Boards' Dental Epidemiological Programme and National Dental Inspection Programme data).

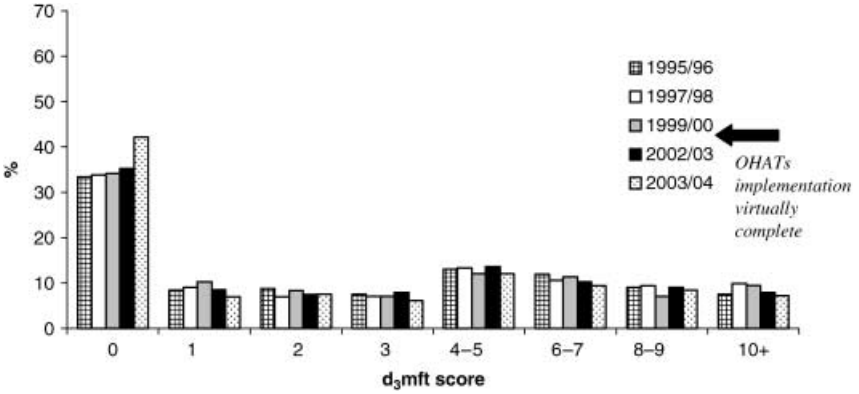

Fig. 6. Relative frequency distribution of $d_3$mft scores of a random sample of 5-year-old residents in all Glasgow districts (DepCat 1–7) from 1995–1996 to 2003–2004 (Scottish Health Boards' Dental Epidemiological Programme and National Dental Inspection Programme data).

Table 2. Age-adjusted odds ratio (OR) with 95% confidence intervals (95% CI) for $d_3mft > 0$ and Wilcoxon values for the relative frequency distribution of the d_3mft scores of 5-year-old residents in Glasgow and component DepCat* 1–7 communities in 2003–04 relative to 1997–1998.

		OR for $d_3mft > 0$ for 2003–2004 relative to 1997–1998 and probability (adjusted for age)		Wilcoxon value for relative frequency distribution of dmft score and probability (adjusted for age)	
Community	Size of random samples	OR (95%CI)	*P*-value	*W*-value	*P*-value
All Glasgow†	3506	0·66 (0·57–0·77)	< 0·0001‡	24·63	< 0·001‡
All DepCat 7	1115	0·35 (0·26–0·47)	< 0·001	38·8	< 0·001
All DepCat 6	677	1·03 (0·74–1·43)	0·88	0·00	1·0
All DepCat 5	236	0·65 (0·37–1·13)	0·125	0·47	0·49
All DepCat 4	474	0·98 (0·67–1·45)	0·94	0·03	0·86
All DepCat 3	354	0·62 (0·39–0·98)	0·040	1·28	0·26
All DepCat 2	391	0·66 (0·42–1·05)	0·08	2·77	0·1
All DepCat 1	259	0·70 (0·40–1·12)	0·20	0·51	0·48

*DepCat is a measure of relative deprivation: (DepCat 7) most deprived; and (DepCat 1) relatively most advantaged.
†DepCats 1–7 inclusive.
‡Also adjusted for DepCat.

An increase in the proportion of infants with no obvious tooth decay from 34% to 42% ($P < 0·0001$) became apparent in Glasgow's 5-year-old population between 1997–1998 and 2003–2004 (Fig. 6).

The proportion of Glasgow infants with $dt > 0$ has decreased from 63% to 50% ($P < 0·0001$) and the proportion with $mt > 0$ has reduced from 21% to 16% ($P < 0·001$). However, there has been no change in the proportion (12%) with filled teeth ($ft > 0$), nor in the mean number of restored teeth ($ft = 0·2$) over the interval.

Data in Fig. 6 from representative samples of the whole of Glasgow's 5-year-old population demonstrate a 'left shift' in the distribution of individual d_3mft scores similar to that observed in the two pilot districts and in the DepCat 7 communities. This has become evident only since the OHATs' extension ($P < 0·001$).

Data from all Glasgow's DepCat 1–6 districts (i.e. those types of districts not targeted by the intervention programme) represent 'proxy' control populations. Although the change in the odds ratio (OR) for d_3mft just reached significance in relatively affluent DepCat 3 districts, the concomitant Wilcoxon value for change in relative frequency distribution of dmft score in DepCat 3 communities over the interval was not significant. The data in Table 2 show appropriately adjusted ORs for $d_3mft > 0$, and Wilcoxon values for the whole of Glasgow and for each separate SES category over the study interval. While respective 2003–2004 versus 1997–1998 ORs for $d_3mft > 0$ in DepCat 7 communities and the whole of Glasgow are 0·35 (95%CI = 0·26–0·47, $P < 0·001$) and 0·66 (95%CI = 0·57–0·77, $P < 0·0001$). During this interval, no consistent pattern of change in OR and concomitant Wilcoxon value was in evidence in any of the nontargeted districts.

Discussion

The direction and magnitude of change in all communities directly subjected to the OHAT programme interventions is universally favourable. The results indicate a consistent pattern of improvement in the dental health indices of 5-year-old children in Glasgow at the pilot district, DepCat 7 and area levels. Whilst such improvements have been observed in DepCat 7 districts, no consistent pattern of significant improvements in 5-year-olds' dental health was detected in any of Glasgow's respective DepCat 1–6 communities, i.e. districts not subjected to community interventions. Furthermore, there was no indication of any background trend towards improvement in infants' dental health indices in Glasgow over more than a decade preceding introduction of OHATs [1]. There is a temporal association between the introduction of community-based dental health promotion activities within designated areas and the reported oral health gains. Targeting programme interventions at the

tertile of Glasgow's 5-year-old population living in the least-advantaged SES circumstances (DepCat7) has had a significant impact on the whole-area statistics for this age group.

Conventional etiquette for the reporting of caries epidemiological trends has relied on age-specific mean $d_3$mft and percentage with $d_3$mft = 0. Inclusion of the data illustrating changes in the relative frequency distributions of individual $d_3$mft scores has the advantage of demonstrating whether only those individuals who would otherwise have been at marginal risk of developing caries have benefited from the interventions, or whether the programme was able to produce beneficial change in even the most vulnerable subgroups within socioeconomically deprived communities.

Although it has not been possible to assign a deprivation category to caries data preceding 1995–1996, there is no indication in the prior decade of any secular trend towards improvements in the dental health of Glasgow's infants in advance of this programme. Biennial SHBDEP surveys from 1987–1988 to 1991–1992 reported mean $d_3$mft values for 5-year-olds in Glasgow to be 3·17, 3·33 and 3·22 [22–24]. During this period, conventional approaches to reduce dental caries incidence and prevalence in Glasgow were based on dental health education in nurseries, schools and clinical dental settings. These previous approaches, which rested responsibility with individuals to protect their own and their families dental health, were singularly unsuccessful in population groups who probably did not have the requisite 'health literacy' or 'economic freedom' to act effectively [25], or access to fluoride products [26]. These earlier approaches did not take into account either the very early age of onset of childhood caries in the most 'at risk' deprived population groups, or the fact that they were least likely to attend asymptomatically at dental practice [11,17–19]. It has been postulated that dental health professionals can only help people to adopt behaviours conducive to their good oral health after forming an appreciation of their specific barriers to access and acceptance of dental advice and care [27]. The data presented in this paper indicate that this programme has succeeded in overcoming the previously described barriers relating to infants' parents/carers [27].

It is beyond the scope of this paper to report the full process or the respective priority for adoption of work strands in each of the 15 individual LHCCs, since this was locally determined by OHATs and local communities. Although experience suggests that obstacles to good dental health are similar across all of Glasgow's deprived districts, socioeconomic infrastructure, availability of personnel, health service configuration, identification of local 'champions' and the speed of their recruitment to the cause varied. Nevertheless, it has been possible to ensure that all of the core themes, i.e. tackling poor diet, lack of fluoride dentifrice and infrequent contact with dental health professionals are topics which continue to be addressed locally.

Decreases of 35% and 40% in mean $d_3$mft scores were recorded in pilot districts 1 and 2, respectively, over the 6 years of the consecutive programmes. These reductions amounted to negative increments in mean $d_3$mft of 1·9 and 2·4 tooth units, recorded after 6 years of the programme, i.e. the rates of improvement in mean $d_3$mft scores in successive 5-year-old cohorts within respective pilot districts were −0·32 and −0·4 teeth per annum. Over the interval, proportions of 5-year-olds with $d_3$mft = 0 increased by 167% and 229%, i.e. at a rate of 28% and 38% per annum. The mean $d_3$mft score of 5-year-olds living in DepCat 7 communities decreased by 0·26 teeth, while the incidence of 5-year-olds with $d_3$mft = 0 increased at a rate of 17% per annum.

In susceptible populations, dental caries tends to follow a chronic disease pattern. Therefore, it is necessary to maximize dental health gains in the youngest-possible age groups if caries incidence and prevalence are to be minimized in older infants.

An earlier Glasgow-based programme delivered by dental staff in a health centre setting provided a 'package' of preventive dental care aimed at inner city infants aged 0–2 years at recruitment [28]. This preventive regimen involved the use of parent education, daily oral fluoride supplements, regular applications of fluoridated acid phosphate gel at an intended frequency of twice monthly and fissure sealing of buccal teeth on their eruption. Reported results when subjects (n = 73) reached 4–6 years of age indicate an annual incremental change in mean $d_3$mft scores ranging from −0·6 to −0·8 teeth, compared to control cohorts, depending on exact age at recruitment, and a 77% improvement overall in the proportion with dmft = 0. Whilst this approach was undoubtedly effective in bringing about reductions in caries incidence and prevalence in programme-attending infants, it is uncertain that it could be generalized to populations of the most deprived individuals because of the barriers to dental attendance

and acceptance of dental care and advice described within contemporary clinical service models [11–14].

Future plans for OHATs include the creation of children's integrated clinical care pathways aligned to OHATs. It is postulated that combining the community-based OHATs approach with a clinical prevention 'package' will have additive/synergistic impact.

A previous UK study has suggested that children from more deprived backgrounds are more likely to have had extractions than their more affluent peers, irrespective of their caries experience [29], but in Glasgow, careful thought is now being given to developing the clinical components of the envisaged care pathways to ensure that corresponding NHS payment and incentive systems are sufficiently sensitive to promote good dental health outcomes.

In this programme, the proportion of 5-year-old children with extracted teeth decreased by 33% and 57% in pilot communities 1 and 2, respectively, and this trend was also evident at a city-wide level following extension of the interventions. Perhaps disappointingly, however, there was no evidence of increased restorative dental treatment in any of the targeted 5-year-old Glasgow populations. Such increases, if they had arisen, might have been plausible explanations for the reduction in untreated caries.

The data in Table 2 indicate that convincing statistically significant improvements in ORs for $d_3mft > 0$ have been confined to only the most socioeconomically deprived districts, all of which were targeted in the community-based intervention programme. The nonintervention districts across DepCat 1–6 have acted as quasi-control populations. Although the magnitude of change and the proportion of the Glasgow population resident in DepCat 7 districts has been sufficient to impact on all-Glasgow 5-year-old dental health statistics, there is no consistent evidence of any secular trend toward improvement in dental health across the whole of Glasgow either prior to the programme, or in nonintervention communities during or since OHAT programme roll-out.

Therefore, it is entirely reasonable to conclude that the reductions in mean d_3mft and increased proportions of children with no obvious caries experience in intervention districts are attributable to primary dental caries prevention behaviours when practiced on a day-to-day basis in homes and community settings. The OHATs' prime responsibilities at locality level are to develop pragmatic, culturally appropriate and acceptable ways for people to improve their day-to-day nutritional practice by enabling the community to decrease their previous reliance on frequent exposures to dietary sugars, and to increase exposure to topical fluoride via widespread use of free fluoride dentifrice distributions. These approaches accord with the evidence-based consensus expressed in the scientific literature [15] on caries prevention. The benefits which have accrued to the populations are attributable to the twinned approach that combined risk reduction with dental health protection. This combined approach was necessary because of uncertainty about whether any individual intervention programme could be effective in Glasgow. Having learned that it is possible to have a beneficial impact on the dental health statistics of infants resident in the poorest communities, future research will investigate individual components from this approach and suitable programmes for more affluent districts' infants who continue to experience unacceptable caries burdens.

The observed improvements in dental health indices are a result of real improvement in dental health and are not an artefact of clinical service provision. However, there remains a considerable burden of dental disease still to be overcome in Glasgow's children.

Multifaceted ecological programmes are based on environmental, behavioural and policy changes, taking into account relationships at the individual, interpersonal, organizational, community and societal levels. It is probable that it was these very features which were advantageous to this programme when compared to traditional structured programmes or 'clinical trial' type interventions. Although perceptions of lack of conventional experimental design/control (e.g. compared to randomized controlled trials) persist in posing theoretical barriers for some researchers, an increasing number of authors have described the need for comprehensive, multifaceted 'Ottawa Charter' intervention programmes [16,30,31], comprising of 'diversity by design'. International consensus is developing regarding appropriate evaluation methods for community programmes [32–35]. In many general-health promotion programmes, temporal distance from interventions to health outcomes creates evaluation difficulties, and it is for this reason that matrix-models of evaluation have been advocated [35]. However, routine caries datasets of 5-year-olds provide a comparatively early opportunity to assess

dental health outcomes at population levels. The World Health Organization recommends that 'routine (caries) data should be used to the maximum' [36].

The OHATs programme did not begin in all DepCat 7 districts before 2000, only in the two pilot areas. The area-wide extension of the programme to encompass all of Glasgow's DepCat 7 communities via phased implementation of OHATs was substantially complete by the end of 2001. Therefore, it is encouraging to observe both the speed and magnitude of reduction in mean $d_3$mft scores and increases in the proportions of infants with no obvious tooth decay at 5 years of age in Glasgow. The most recent data provide evidence that observed rates of improvement in caries indices continue unabated in the pilot districts where the programme has operated longest. There is optimism that sustainable improvement will follow in all targeted districts.

What this paper adds

- This paper provides evidence of positive and reproducible outcomes following targeted community-based oral health promotion activities in SES-challenged communities.

Why this paper is important to paediatric dentists

- Oral health promotion interventions, when delivered in non-clinical settings, can impact positively on the oral health status of infants in communities where attendance for asymptomatic dental care and advice in early childhood is least frequently practiced.
- The earlier in infant life that caries risk factors are ameliorated, the greater the impact on caries incidence for the individual child and caries prevalence at community level.

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