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Dental caries rates in primary teeth in 2002, and caries surveillance trends 1981-2002, in a South African city.

P. Cleaton-Jones, S. Williams, C. Green and P. Fatti.

Dental Research Institute of the University of the Witwatersrand, Johannesburg, South Africa.

Objective To determine trends in the prevalence and severity of dental caries in 2- to 5-year-old children. ***Basic research design*** Repeated cross-sectional surveys in 1981, 1983, 1985, 1987, 1989, 1991, 1994, 1997 and 2002. ***Clinical setting*** Nursery schools in Germiston, South Africa. ***Participants*** Dental caries was diagnosed by calibrated examiners using WHO criteria in 7,185 2- to 5-year-old children whose parents had given informed consent. ***Main outcome measures*** Caries prevalence (%), caries experience (dmft). ***Results*** Both caries prevalence and experience showed statistically significant ($p<0.001$) fluctuations between study years from 1981 to 2002. A worry is an increase in rates between 1997 and 2002. ***Conclusion*** There is a suggestion of a cyclical pattern to the caries rates observed.

Key words: caries prevalence, dental caries, dental epidemiology, dmft, surveillance

Introduction

Dental caries trends in countries are usually shown through cross-sectional national or local dental surveys at wide intervals (Pitts *et al.,* 2004, 2003; van Wyk and van Wyk, 2004; Wang *et al.*, 2002) or over shorter periods (Pieper and Schulte, 2004). Other methods may be accumulation of results of multiple surveys into a national (Beltran-Aguilar *et al.,* 2003) or an international data base (WHO, 2005) as well as systematic reviews of published information (Bönecker and Cleaton-Jones, 2003). True surveillance studies of dental caries through repeated surveys in the same areas at shortish intervals over long periods by the same examiners are rare.

In 2000 we published results from a surveillance study in the primary dentition of South African children between 1981 and 1997. This showed a secular trend of decreasing caries prevalence and dmft score over the study period. The current paper deals with results from the final survey year, 2002, and with trends over the 22-year-long surveillance study.

Materials and methods

With approval by the University's Human Research Ethics Committee (Medical), the study was begun in 1981 in Germiston, an industrial city situated some 14 km east of Johannesburg, South Africa's largest city, at an altitude of some 6,000 feet (1,800m), with a population of approximately 200,000, with a fluoride water concentration of 0.2ppm, and without a city-wide caries prevention programme. Nursery school children were chosen as the study population because a true random sample of children in the community was not possible. Regarding bias in the sample; in South Africa there are no free child-minding services; crèches or nursery schools are all private even if there is some state subsidy. Fees vary from school to school, but are generally low enough to encourage both parents to work. The exact proportion of children aged between two and five years, in the nursery school catchment areas, who attend the schools has never been documented but nursery school staff estimate that the number is between 50% and 75%.

All 2- to 5-year-old children in the nursery schools whose parents gave informed consent were examined. Surveys were repeated every two years from 1981 until 1991, then in 1994, 1997 and 2002. In 1981 there were 15 nursery schools spread across the city that participated, these had reduced to 11 by the 2002 survey due to one closure and three amalgamations but the 11 still served the same areas as the original 15. The estimated response rate varied from year to year being affected by absence from school or no informed consent available from a parent or guardian on the survey day. The approximate total number of children potentially available for examination per survey year ranged between 1,000 and 1,300 with response rates of 1981 72%, 1983 67%, 1985 58%, 1987 77%, 1989 53%, 1991 72%, 1994 78%, 1997 56% and 2002 48%.

In the 2002 survey two dentists (SDW, PC-J) who had examined the children at every survey year were joined by an additional dentist (CG) - something that had also happened in 1987 and 1991 with two other colleagues, respectively. The calibration of all dentists for all the surveys was with WHO caries diagnostic criteria applied to all surfaces of 200 extracted anterior and posterior permanent teeth, with varying severity of caries, arranged anatomically in plaster blocks. Diagnosis per surface was recorded as sound or unsound surfaces on two occasions at least three days apart after which kappa scores were calculated. For the 2002 survey kappa scores were 0.76 (CJ), 0.78 (SW), 0.72 (CG) (WHO, 1997); a McNemar

Correspondence to: Prof P Cleaton-Jones, Dental Research Institute, University of the Witwatersrand, Johannesburg, Private Bag 3, Wits, 2050 South Africa. E-mail: peter.cleaton-jones@wits.ac.za

test showed no significant bias in diagnosis. During the field survey 49/460 children (11%) were re-examined to check diagnostic repeatability. Because of low numbers of children seen at individual nursery schools repeatability was checked only between examiners (kappa = 0.81). An examiner seeing the same child would easily remember the diagnosis which would introduce unacceptable bias.

All the surveys were done at each nursery school in good natural light using the WHO caries diagnostic criteria applicable at the time; for the 2002 survey this was the 1997 criteria using plane mirrors (WHO, 1997). The observations were stored in a single computer data set and analysed with SAS for Windows (Version 9.1, SAS Institute Inc, Cary: NC, USA) and Prism 4 for Windows (Version 4.02, GraphPad Inc, San Diego, CA, USA). The dmft scores for each child were calculated with teeth lost to trauma or exfoliation excluded from the calculation. Caries prevalence was defined as the number of children with a dmft score >0. For each child with dmft >0 the percentages of dt/dmft, mt/dmft, and ft/dmft were determined followed by calculation of the mean percent of each.

A linear logistic analysis was used for the analysis of caries prevalence as the dependent variable (dmft = 0, dmft > 0) and age and survey year as independent variables. Regarding the dmft score, a two-way ANOVA using the general linear model procedure was used with dmft as dependent variable and the same two independent variables. The dmft distribution was the typical dmft pattern - highly skewed with mostly low scores and smaller numbers of high scores so had to be log-transformed. When the dmft of children with dmft>0 were analysed the transformation was log(dmft); when the scores of all children were examined the transformation was log(dmft+0.00001) to accommodate zero scores; the value 0.00001 was found to produce a low skewness (0.077). Plots were made for percentage caries prevalence and mean dmft against survey year.

The statistical analysis was done in two phases. In the first, the effects of age, gender and race of each child studied in 2002 was examined. In the second phase, the previously published results for caries prevalence and experience for years 1981 to 1997 (Cleaton-Jones *et al*., 2000) were pooled with the current survey results to enable examination of trends over the 22-year-long surveillance period in the full sample of 7,185 children (48% boys and 52% girls). For all analyses the critical level for statistical significance was set at $P<0.05$.

Results

In the 2002 study sample (n=342, 51% boys, 49% girls, 33% black), age had a statistically significant effect on both caries prevalence and experience ($p<0.001$) but gender and race effects were not statistically significant so, as in previous years, results for gender and race were pooled. Results for the 2002 survey are shown in Table 1. Regarding prevalence, caries was present in about a third of 2- and 3-year-olds rising to almost half at age 4 and two-thirds by age 5. Mean dmft values were low, the main component being untreated caries emphasised by the mean dt/dmft% results in children with dental caries. Filled teeth were uncommon and extracted teeth even less frequent.

Regarding the full data set of 7,185 children**,** in Figure 1 the caries prevalences in each survey year are plotted for the four study age groups. The increase in prevalence from age two to five years is clear. There is a cyclical variation with peaks at 1981, 1989 and 2002 and troughs in 1985 and 1997. In our previous paper (Cleaton-Jones *et al.,* 2000) we described a downward secular trend for caries prevalence between 1981 and 1997; the 2002 data display an increase in prevalence between 1997 and 2002 in all four age groupings. Log-linear analysis showed strong effects for age and for year of study ($p<0.0001$) but no statistically significant interaction between age and year.

When mean dmft scores for all children were plotted, a similar, but less marked, fluctuation than for prevalence was seen (Figure 2). Both age and year of study had strongly significant effects ($p<0.0001$); their interaction was not significant. Secular trends between 1981 and 2002 are slightly downward followed by an upward direction to 2002 more prominent for 2- and 5-year-olds. Mean dmft scores trends for children with dmft>0 show a complex pattern (Figure 3). Between 1981 and 1997 trends were relatively static for all ages but by 2002 among 2- and 5-year-olds the trend was upward, and downward for 3- and 4-year-olds. Age had a highly significant effect ($p<0.0001$), the effect of year of study

Table 1. Numbers of children studied, numbers [%] with dental caries (dmft>0), and mean dmft and component scores (sd) by age group for the 2002 survey. The mean percent component of dmft is for children with dmft>0.

	Age			
	2 years	*3 years*	*4 years*	*5 years*
n	64	78	76	124
dmft>0	23 [36%]	27 [35%]	35 [46%]	74 [59%]
dmft	1.5 (2.3)	1.6 (2.9)	2.0 (2.9)	3.4 (3.7)
dt	1.0 (0.3)	1.2 (2.5)	1.5 (2.7)	2.4 (3.3)
mt	<0.1 (0.3)	0.1 (0.7)	0.1 (0.5)	0.3 (1.3)
ft	0	0.3 (1.2)	0.4 (1.4)	0.7 (1.8)
dt/dmft %	99.0 (4.6)	85.8 (34.8)	72.9 (43.9)	71.5 (40.0)
mt/dmft %	1.0 (4.6)	3.8 (14.0)	6.2 (23.6)	8.6 (20.7)
ft/dmft %	0	10.4 (27.1)	21.0 (39.7)	19.9 (34.1)

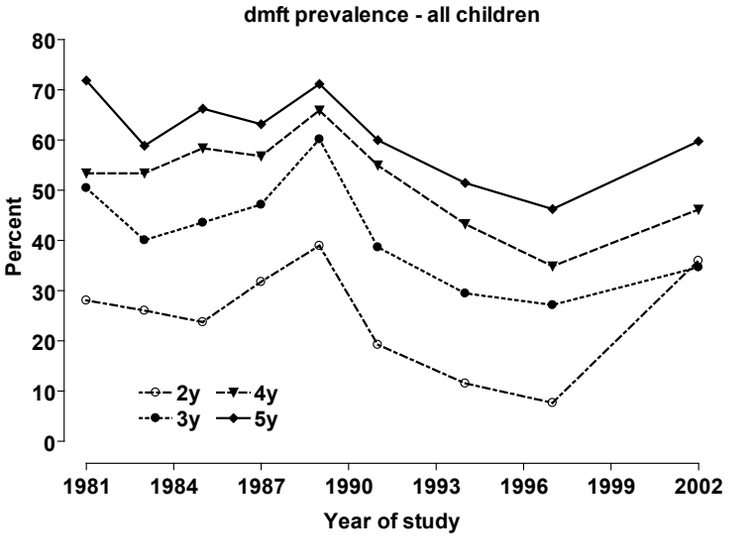

Figure 1. *Trends for percent prevalence of caries (dmft>0) by age and year of study.*

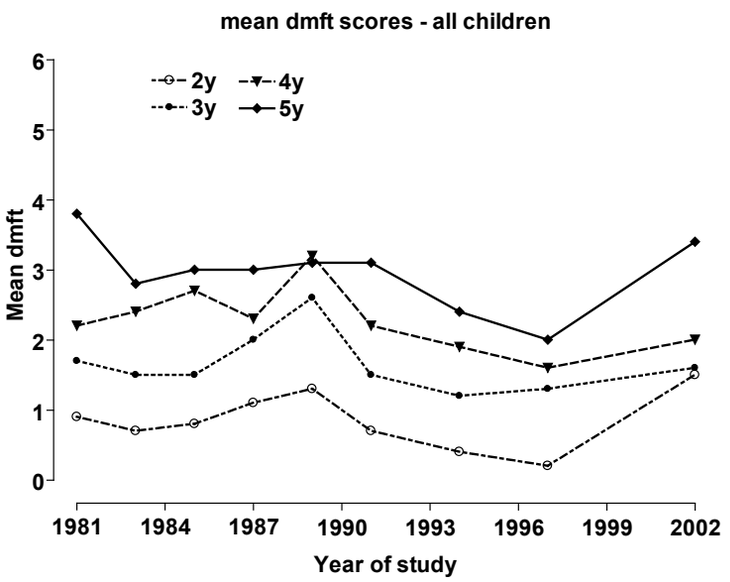

Figure 2. *Trends for mean dmft scores for all children by age and year of study.*

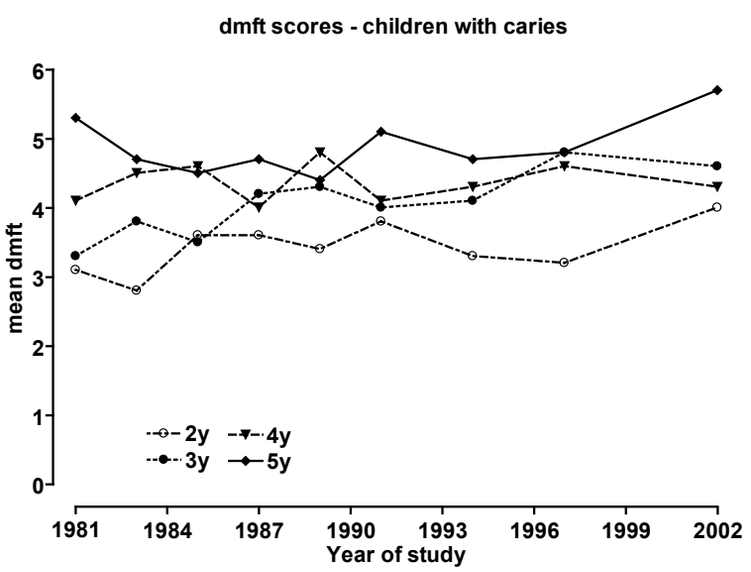

Figure 3. *Trends for mean dmft scores for children with dmft>0 by age and year of study.*

was weakly significant (p=0.03) while their interaction was not significant.

Discussion

This study has shown two things in the primary teeth of nursery school children living in a low fluoride area without organised prevention. Firstly, caries prevalence and experience has varied over the 22 years suggestive of a cyclical pattern. Secondly, the belief that the caries rate decline begun in 1989 would continue to decrease after 1997 has not been supported since there was been a rise for all ages in 2002.

In trying to understand the changes seen one would naturally look at whether the data may be trusted - dental examiners and / or diagnostic method could influence this. Regarding dental examiners, the two principal investigators participated in every survey and were re-calibrated for each survey. When, in three survey years, there was one additional examiner, that dentist went through the same calibration and was cross-checked with the principal investigators. Dental caries diagnosis from 1981 through 1994 used WHO criteria with mirror and probe; the surveys in 1997 and 2002 used mirror only as then recommended by WHO (1997) so it might be argued that this could influence the caries rates in those survey years. A field study in one of the nursery schools compared diagnostic methods in the same children, under surveillance conditions common to all the study years, and showed no statistically significant differences in caries rates between mirror alone and mirror plus probe (Cleaton-Jones *et al.,* 2001). The diagnoses over the full surveillance period are therefore comparable.

What about study area? This remained constant and, although their numbers reduced, the schools remaining in the study still drain the same catchment areas. Another change has been a reduction in numbers attending nursery schools due to the opening of pre-primary classes in primary schools. Parents are making more use of these to ensure that their children gain access to chosen primary schools. Internal drop-out during the studies was low, not more than five children per study year. This we believe is because we never wear white coats; we examine older children first and let the waiting children see that the examination is fun. Teachers are always present for reassurance and if desired hold a nervous child for examination.

Has the racial composition in the nursery schools changed? Certainly; since the elimination of apartheid with the first democratically elected government in South Africa in 1994 the racial composition in schools, including nursery schools has altered to represent more closely the multiracial composition of the South African population. Analysis of the 1997 and 2002 data which contained sufficient children of different races, showed no statistically significant effect of race on either caries prevalence or experience.

Are the caries rates representative of the child population of the area? This cannot be answered with certainty. Firstly, only 50-75% of children resident in the surveillance area are estimated to attend nursery schools and since fees must be paid at the schools bias towards better-off families cannot be eliminated. Then, the response rates of those attending the schools are not what one would like. Ethically however one may not examine any children without permission from a parent or guardian, a necessity that has been reinforced by the inclusion in the Bill of Rights of the South African Constitution (1996) of a requirement to obtain informed consent from all who participate in medical research.

The response rate in the 2002 survey is the lowest of the survey series. An anecdotal reason for this, based on discussions with teachers in each school, is that parents are less involved in their children's schooling mainly though increased economic survival pressures. Fear of spread of the HIV virus during an examination is also a factor given the high prevalence of the condition in Africa.

Comparison to caries trends, over a prolonged period, in the primary dentition of children living in a developing country is not possible because such studies do not appear in the published dental literature. The only published long-term caries surveillance study found was done among 12-year-old school children living in the fluoridated city of Bauru, Brazil between 1976 and 2001 (da Silva Bastos *et al*., 2005). This showed a significant reduction in caries rates ascribed to the introduction of city fluoridation in 1975.

In the discussion of the results in a South African national oral health survey 1999-2002 it was mentioned that caries was worse in the primary than in the permanent dentition (van Wyk *et al.,* 2004; van Wyk and van Wyk, 2004). These authors said that between 1982 and 2002 there had been a gradual reduction in DMFT levels in 12-year-old children but did not comment on primary caries changes.

Examination of the fluctuation in caries rates in nursery school children seen over 22 years in the same communities leads us to speculate that dental caries may have a cyclic pattern much as is seen with other human pathogens (Dowell, 2001) but a great deal more research is needed to establish if this is true. What is clear is that the trends observed are complex.

Surveillance of disease rates is important but, as this study has shown, is hard to do over many years due to changing social circumstances that alter participation and even methods of analysis. A practical suggestion is for public health authorities to calibrate their dental staff for field surveys according to WHO methods and to accept that inclusion of surveillance sites at intervals of say three years would aid in service planning, will increase international knowledge and provide intellectual satisfaction for staff. It should not be left to interested individuals on an ad hoc basis.

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