COMMENTARY

Fluoridation and Social Equity

Brian A. Burt, BDS, MPH, PhD

Abstract

The overall reduction in caries prevalence and severity in the United States over recent decades is largely due to widespread exposure to fluoride, most notably from the fluoridation of drinking waters. Despite this overall reduction, however, caries distribution today remains skewed, with the poor and deprived carrying a disproportionate share of the disease burden. Dental caries, like many other diseases, is directly related to low socioeconomic status (SES). In some communities, however, caries experience has now diminished to the point where the need for continuing water fluoridation is being questioned. This paper argues that water fluoridation is still needed because it is the most effective and practical method of reducing the SES-based disparities in the burden of dental caries. There is no practical alternative to water fluoridation for reducing these disparities in the United States. For example, a school dental service, like those in many other high-income countries, would require the allocation of substantial public resources, and as such is not likely to occur soon. But studies in the United States, Britain, Australia, and New Zealand have demonstrated that fluoridation not only reduces the overall prevalence and severity of caries, but also reduces the disparities between SES groups. Water fluoridation has been named as one of the 10 major public health achievements of the 20th century by the Centers for Disease Control and Prevention, and promoting it is a Healthy People objective for the year 2010. Within the social context of the United States, water fluoridation is probably the most significant step we can take toward reducing the disparities in dental caries. It therefore should remain as a public health priority. [J Public Health Dent 2002;62(4):195-200]

Key Words: dental caries, fluoride, fluoridation, socioeconomic status, public health policy.

Controlled water fluoridation began in the United States in 1945, a time when dental caries was a serious public health problem. By 1992, some 56 percent of Americans were receiving fluoridated drinking water (http://www.cdc.gov / nccdphp / oh / flfact.htm), and that proportion has not changed much in more recent years. Since 1945, however, other sources of fluoride exposure have grown. Fluoride toothpaste got a substantial share of the toothpaste market by the mid-1970s and now dominates that market, and fluoride gels and mouthrinses have been applied or prescribed by dentists since the 1950s. Fluoride varnish, long used in Europe and Canada, became available in the United States in 1994, and some fluoride is also found in processed food and drink (1-4). When all sources of fluoride are considered, virtually all Americans now have daily exposure to fluoride.

Over this period of increasing exposure to fluoride in the United States, the prevalence and severity of dental caries in children has declined substantially. The mean number of teeth affected by caries in children aged 6–18 years in the early 1970s was 4.44; this had dropped to 1.90 by the early 1990s (5). Nonetheless, this welcome reduction in caries severity has not been shared equally by children of all socioeconomic status (SES) levels. Caries distribution has become skewed, with many upper-SES children being free, or almost so, of the disease, and with the bulk of the disease burden now found among the more socially deprived (6).

The principal reason for this substantial decline in caries is likely to be populationwide exposure to fluoride in all its forms (7), with a major impact in the United States considered to come from water fluoridation. Indeed, the Centers for Disease Control and Prevention (CDC) has ranked water fluoridation among the top 10 public health achievements of the 20th century for its role in reducing the dimensions of the caries problem (8). Nevertheless, the total benefits from water fluoridation may be underestimated because of the widespread diffusion of fluoride throughout American society (9). Promoting water fluoridation is also a Healthy People 2010 objective for the nation (http://www.health.gov/healthypeople/document/html/volume2/21oral.htm).

Despite this level of public recognition, many efforts to fluoridate local community water supplies still run into stubborn opposition. Public acceptance of fluoridation may not be as strong as it was simply because dental caries is less obvious than it used to be—a touch of irony when much of the reason for that fact can be attributed to fluoride. Parents of today's children are often themselves virtually caries free, and their honest questions about whether fluoridation is still necessary are not uncommon during fluoridation campaigns.

This paper presents a case for why water fluoridation is still needed in the United States, and why it should be retained as the cornerstone of caries control in public health. The argument is that fluoridation moves us toward achieving social equity in oral health, and is a practical and relatively inexpensive method of doing so. This pa-

Send correspondence to Dr. Burt, University of Michigan School of Public Health, Room 3006, 109 Observatory Street, Ann Arbor, MI 48109-2029. E-mail: bburt@umich.edu. Reprints will not be available. Some of the material in this paper was presented at the symposium "Dental Cavities: a New Look at an Old Problem," during the annual meeting of the American Association for the Advancement of Science in Boston, MA, February 16, 2002. Manuscript received: 12/7/01; returned to author for revision: 2/13/01; final version accepted for publication: 5/6/02.

per first examines the impact SES has on the health status of populations, and then how fluoridation can reduce that impact.

Socioeconomic Status and Health

Substantial differences in mortality and health status between people in the higher and lower SES strata have been documented in a number of countries, using a number of different outcomes (10,11). Given the individualistic philosophy that characterizes the United States, it is likely that these disparities are more pronounced in that nation than in other countries with more egalitarian traditions (12,13). In any event, the data show with remarkable consistency that people of higher SES enjoy better health than those of lower SES, and this observation has endured well over time (14-17). This finding is not dependent on how health status is measured, for it has been documented when health status was expressed in terms of overall mortality, heart disease, diabetes, or even subjective perceptions of ill-health (18-22). While there are numerous individual behavioral determinants involved in this profile (e.g., smoking, alcohol abuse, quality of diet, regular exercise), there is also evidence that social determinants (i.e., risk factors that apply to the whole community rather than to specific individuals) play a key role. These social determinants include the quality of housing, extent of community services, availability of transportation, prospects for employment, crime levels, access to parks, open space, and suitable recreational facilities.

Poor social circumstances are linked to disease by way of material, psychosocial, and behavioral pathways. Social and environmental disadvantages can lead directly to poor health behavior and the subsequent biological disturbances that lead directly to ill health. The argument therefore holds that excessive social stresses in themselves can negatively affect health (23). As one example, the gap in both mortality rates and cardiovascular disease levels between western European countries and those that were formerly part of the Soviet bloc were accentuated sharply following the breakup of the Soviet Union in 1991. This phenomenon has been attributed to the high degree of social stress that accompanied the breakup (24). Another example is seen in the causative link between sustained economic hardship over a long period of time and poor general health (25).

Socioeconomic Status and Oral Health

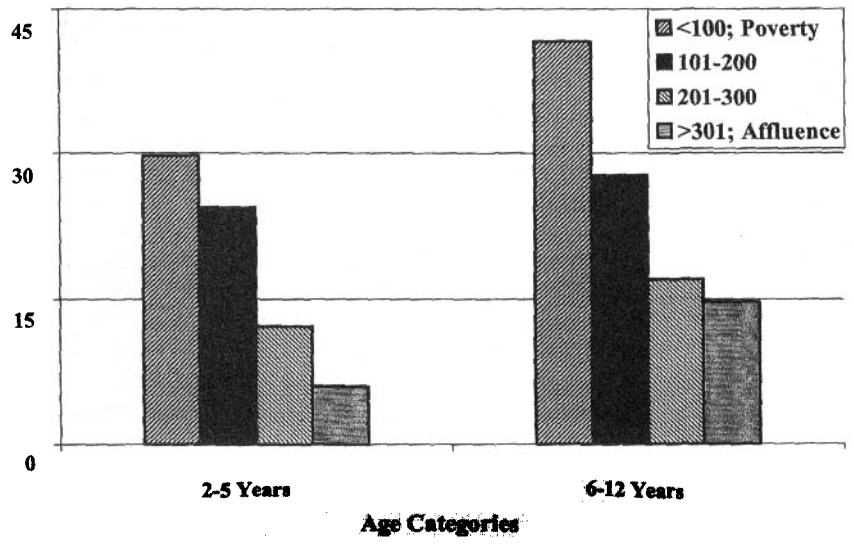
Dental research in this area has not progressed to the extent seen in medical research, but there are indications that similar relations exist between social determinants and oral health. Ample recent British data show marked disparities between higher and lower social classes in terms of oral health and use of dental services (26-31). Locker's elegant review describes the reasons why social deprivation is a risk factor for poor oral health status (32), and these turn out to be very similar to those described above for mortality and general health measures.

It is therefore not surprising that oral health disparities between SES levels are clearly evident in American society today. Figure 1, using data from the Third National Health and Nutrition Examination Survey (NHANES III), shows that lower-SES children had a higher prevalence of caries in the primary dentition than did those in higher levels. A survey of second grade children in New York State found similar distributions (33), as did a statewide survey of schoolchildren in Tennessee (34).

Closing the SES Disparities Gap

Reducing the oral health disparities between SES levels is a more complicated issue than simply providing services, for even when dental services are readily available and free of charge, they tend to be underused by lower-SES people (35). Even in those countries with extensive publicly funded social services, where high-quality health care is readily available at no charge to the recipient, oral health disparities between social classes are still apparent. One example is from Sweden, a nation where an extensive system of social services has been constructed for the specific purpose of promoting an egalitarian society. Excellent school dental services are in place as part of that system; even so, some unexpected disparities between SES levels in oral health and use of dental services were disclosed in a national survey (36). Similar SES disparities in caries experience have been reported from Finland, where equal access to health care is also a social value (37). These SES disparities in Europe appear to be less extensive than those seen in the US, but European society for the most part is ethnically and culturally less diverse. It is noteworthy, however, that disparities in caries experience based on SES and

FIGURE 1
Prevalence of Dental Caries in US Children Aged 2–5 Years and 6–14 Years, by Percent of Federal Poverty Level (Ref. 6).



ethnicity are being recorded in Europe as a result of the extensive immigration from eastern Europe during the 1990s (38,39).

School dental services of the type found in Scandinavia and some other countries have excellent facilities and staff, and they ensure that all schoolchildren receive close dental attention at least once each year. School-based dental services of this kind have never been part of the way health care is provided in the United States, and the expense of running such services, even where there is political will to implement them, do not encourage their development. Other prevention-based approaches thus need to be devised if the disparities gap is to be reduced in the United States, and the first obvious step is to fluoridate drinking water wherever feasible. Fluoridation is a true public health procedure in that it reaches all members of the community who receive municipal water, thus ensuring a good level of fluoride exposure for everyone.

Fluoridation and Socioeconomic Status

Thus the issue becomes whether water fluoridation, by itself, will reduce the SES disparities in oral health. The evidence, on balance, suggests that it will reduce them, though not remove them completely. Data from Britain (40-44), Australia (45,46) and New Zealand (47,48) show that when caries experience is measured against SES level and the presence or absence of water fluoridation, the disparities by SES level are reduced in the area with water fluoridation. Figure 2, using data from northern England (49), gives a graphic example of this relationship. It demonstrates that both SES and water fluoridation are strong influences on caries experience, although the caries disparity between the SES levels is reduced more in the fluoridated area than in the nonfluoridated area.

SES is a complex issue, so it is not surprising that studies from Britain, Finland, and New Zealand found, in regression analysis, no interaction between social class and water fluoridation (31,50,51). It is possible that these results were confounded by high levels of restorative dental treatment (in Finland and New Zealand), or by relationships being more difficult to discern at low population levels of caries (31). Another study from New Zealand concluded that social class was a stronger correlate of children's oral health than was community fluoridation, though this result was confounded by widespread exposure to fluoride other than from drinking water. The use of treatment statistics to measure oral health in this study was also questionable (52).

An assessment of whether fluoridation reduces the social class gradient (i.e., the disparity in caries experience between higher and lower SES groups) was one objective of the systematic review of water fluoridation's effects carried out by the Centre for Reviews and Dissemination at the University of York, Britain (53). This review is probably the most rigorous scrutiny of existing knowledge about fluoridation yet carried out. It has been criticized by both proponents and opponents of fluoridation, mainly because the stringent inclusion and exclusion criteria for published reports led to many papers being omitted from consideration. However, adherence to strict inclusion/exclusion criteria for scientific papers is an integral part of any systematic review summing up the evidence base for an issue. Most of the 15 papers (not all of them published) included for the fluoridation/social gradient issue presented data for 5-year-old children. The review found no difference in the social gradient between children from fluoridated or nonfluoridated areas when caries was measured only as prevalence; however, a favorable social gradient reduction in fluoridated areas was seen with severity measures (mean dmf, def, df indexes scores). Data for ages other than 5 years were too limited to permit conclusions.

Fewer data exist from the United States (compared to British data) to assess how water fluoridation affects SES disparities in caries, but those that do exist are compelling. In a Louisiana study of Medicaid-eligible children aged 1–5 years, the Medicaid-eligible children in communities without fluoridated water were three times more likely than those from fluoridated communities to receive dental treatment in a hospital operating room, and the cost of dental treatment per eligible child was approximately twice as high (54). This finding, which reflects caries severity, is consistent with the results of the York review, stated above. Figure 3 shows data from fluoridated Newburgh and non-

FIGURE 2
Caries Experience by Social Class Among British 5-year-olds in Fluoridated and Nonfluoridated Areas: County Durham (Ref. 49)

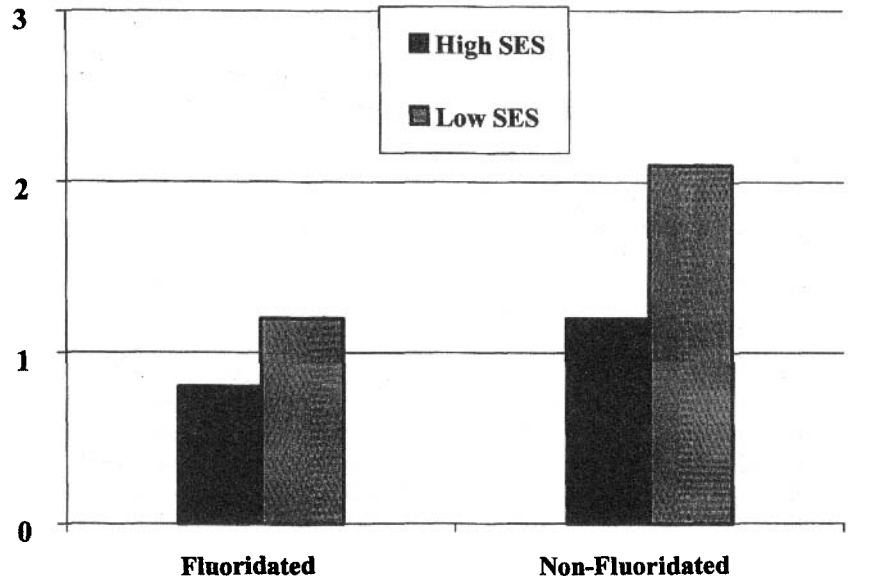
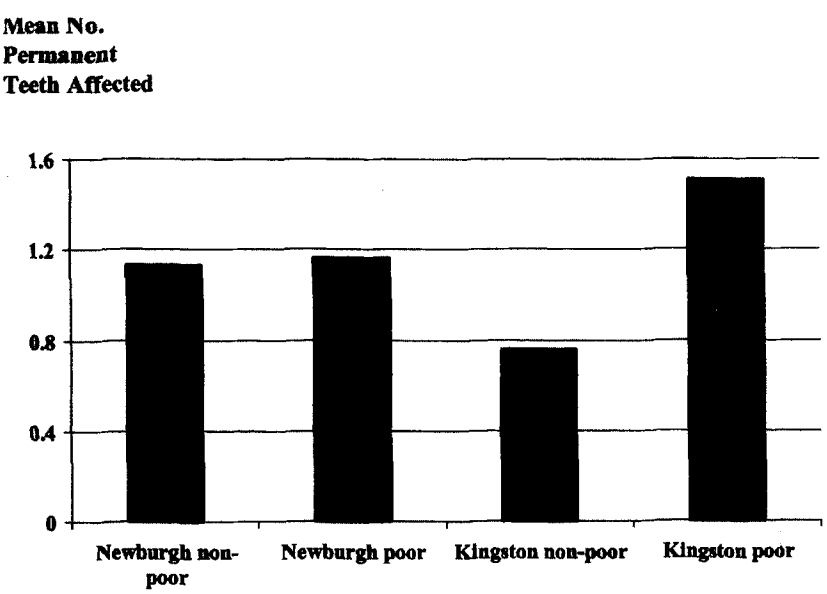


FIGURE 3
Caries Experience, Expressed as Covariate-adjusted Mean DMF Surfaces per Child, in 7–14-year-old Children in Newburgh and Kingston, NY, by Poverty Status ("Poor" defined as children participating in the free school lunch program) (Ref. 55)



fluoridated Kingston, New York, after 50 years of fluoridation in Newburgh (55). The overall mean age-standardized DMFS values were slightly lower in Kingston, which reflects the higher SES status in that city. However, when the data are split by poverty status, Figure 3 shows that the difference between SES levels in Newburgh was very small, while there was still a noticeable disparity between the SES groups in nonfluoridated Kingston.

Some use the issue of childhood immunizations as an analogy to water fluoridation. The major infectious diseases of the 19th century are rarely seen in the United States today, so do we need to continue with childhood immunizations? Obviously we do, because immunizations are a prime reason these diseases are rarely seen, and laxity with immunization will lead to their resurgence. The parallel argument is that exposure to fluoride is the main reason for lower caries levels, and water fluoridation is the prime exposure to fluoride for millions of Americans.

Data from Wisconsin (56), Germany (57), and Scotland (58) showed a resurgence of caries following defluoridation. But these three cases are from several decades ago, when drinking water was virtually the only source of fluoride exposure; thus, with defluoridation the increased caries incidence was to be expected. More recent examples from Germany (59), as well as from Cuba (60), Canada (61), and Finland (62,63), show a different pattern. In those cases, caries incidence did not rise after defluoridation, and in fact continued to fall in some instances. However, in all of these communities the children all were well exposed to other sources of fluoride, e.g., from toothpaste, mouthrinse, or professionally applied varnish. In Cuba, for example, a program of biweekly fluoride rinsing commenced when water fluoridation ceased, and children aged 2–5 years received 1–2 applications of fluoride varnish annually. In Finland, the comprehensive school dental service ensured that children received regular applications of fluoride varnish and made good use of fluoride toothpaste. The Canadian children, in British Columbia, were generally from an affluent area where caries levels were low and use of fluoride toothpaste and dental services was high.

The most interesting data come from Germany, where sweeping social changes took place following German reunification in 1990. Sugar consumption dropped, despite the greater availability of sugar-rich foods, as more sugar substitutes were consumed (64). The previous state-run health care system was restructured for private practice, so the school dental service and community prevention services were ended. This included water fluoridation, which previously had been established in 35 towns and reached 18 percent of the East German population. Some changes favored better oral health: fluoride toothpaste, which had 15 percent of the toothpaste market prior to 1990, rose to 88 percent market share by 1993–95, and fluoridated salt became available in 1992. The dental treatment level increased significantly, despite the ending of the school dental service, and this resulted in widespread application of fissure sealants. By 1995, more than 40 percent of children in the former East Germany had sealants, with an average of 3.6 sealed teeth per child (64).

Between the 1980s and 1993–95, the mean DMFT for 12-year-old children in the former East Germany dropped from 3.8 to 2.5. Given the tumultuous changes that took place over a short period of time, interpretation of these events would have been easier had there been a control city that retained fluoridation and also received the additional preventive services. In Ireland, as an example, with widespread fluoridation it was shown that caries levels were reduced in both fluoridated and nonfluoridated communities after the introduction of fluoride toothpaste, but the drop was greater in the fluoridated communities (65). The substantial drop in DMF scores in Germany over a short period of time is intriguing, and leads to questions about the direct effect of major social change on dental caries.

All of this suggests that what is important in caries control is regular fluoride exposure, especially maintaining ambient fluoride levels within the oral cavity (66). Relative to those in higher SES levels, people in lower SES strata do not visit the dentist as often and do not brush their teeth as often (67-69). This means they are likely to have less exposure to fluoride from professional applications and from toothpaste than do people in higher SES strata, which essentially leaves fluoridated water as the only practical method of bringing fluoride exposure to the whole population.

These data collectively suggest that both SES and water fluoridation are determinants of caries status. Whether one of these factors is more important than the other, while an interesting and complex research issue, is irrelevant in terms of social policy. The concern of dental public health workers is to reduce caries as far as possible in their communities of interest. Little can be done about changing SES, but public health workers can strive to institute water fluoridation where it is needed and to maintain it where it already exists. The bulk of the evidence cited above indicates that fluoridation has the effect of reducing the dental caries disparities between the different SES strata, and that is an important enough reason to keep water fluoridation as a public health priority in the United States.

References

1. Clovis J, Hargreaves JA. Fluoride intake from beverage consumption. Community Dent Oral Epidemiol 1988;16:11-15.
2. Heilman JR, Kiritsy MC, Levy SM, Wefel JS. Assessing fluoride levels of carbonated soft drinks. J Am Dent Assoc 1999; 130:1593-9.
3. Burt BA. The changing patterns of systemic fluoride intake. J Dent Res 1992;71: 1228-35.
4. Kiritsy MC, Levy SM, Warren JJ, Guha-Chowdhury N, Heilman JR, Marshall T. Assessing fluoride concentrations of juices and juice-flavored drinks. J Am Dent Assoc 1996;127:895-902.
5. Brown LJ, Wall TP, Lazar V. Trends in untreated caries in primary teeth of children 2 to 10 years old. J Am Dental Assoc 2000;131:93-100.
6. Vargas CM, Crall JJ, Schneider DA. Sociodemographic distribution of pediatric dental caries: NHANES III, 1988-1994. J Am Dent Assoc 1998;129:1229-38.
7. Burt BA. The future of the caries decline. J Public Health Dentistry 1985;45:261-9.
8. US Public Health Service, Centers for Disease Control and Prevention. Ten great public health achievements: United States 1900-1999. Morbid Mortal Week Rep MMWR 1999;48:241-3.
9. Griffin SO, Gooch BF, Lockwood SA, Tomar SL. Quantifying the diffused benefit from water fluoridation in the United States. Community Dent Oral Epidemiol 2001;29:120-9.
10. Kaplan GA. People and places: contrasting perspectives on the association between social class and health. Int J Health Services 1996;26:507-19.
11. Brunner EJ. Socioeconomic determinants of health: stress and the biology of inequality. Br Med J 1997;314:1472-6.
12. Kunst AE, Mackenbach JP. The size of mortality differences associated with educational level in nine industrialized countries. Am J Public Health 1994;84: 932-7.
13. Ross NA, Wolfson MC, Dunn JR, Berthelot JM, Kaplan GA, Lynch JW. Relation between income inequality and mortality in Canada and in the United States: cross-sectional assessment using census data and vital statistics. Br Med J 2000; 320:898-902.
14. Haan MN, Kaplan GA, Syme SL. Socioeconomic status and health: old observations and new thoughts. In: Bunker JP, Gomby DS, Kehrer BH, eds. Pathways to health: the role of social factors. Menlo Park, CA: Henry J Kaiser Family Foundation, 1989:76-135.
15. Kaplan GA, Haan MN, Syme SL, Minkler M, Winkelby M. Socioeconomic status and health. In: Amler RW, Dull HB, eds. Closing the gap: the burden of unnecessary illness. New York: Oxford University Press, 1987:125-9.
16. Marmot MG, Kogenivas M, Elston MA. Social/economic status and disease. Ann Rev Public Health 1987;8:111-35.
17. Syme SL, Berkman LF. Social class, susceptibility, and sickness. Am J Epidemiol 1976;104:1-8.
18. Blane D. Social determinants of health—socioeconomic status, social class, and ethnicity [editorial]. Am J Public Health 1995;85:903-5.
19. Goodman E. The role of socioeconomic status gradients in explaining differences in US adolescents' health. Am J Public Health 1999;89:1522-8.
20. Kaplan GA, Pamuk ER, Lynch JW, Cohen RD, Balfour JL. Inequality in income and mortality in the United States: analysis of mortality and potential pathways Br Med J 1996;312:999-1003.
21. Link BG, Phelan JC. Understanding sociodemographic differences in health—the role of fundamental social causes [editorial]. Am J Public Health 1996;86: 471-2.
22. Pappas G. Elucidating the relationships between race, socioeconomic status, and health [editorial]. Am J Public Health 1994;84:892-3.
23. Brunner E, Marmot MG. Social organization, stress, and health. In: Marmot M, Wilkinson RG, eds. Social determinants of health. New York: Oxford University Press, 1999:17-43.
24. Bobak M, Marmot M. East-West mortality divide and its potential explanations: proposed research agenda. Br Med J 1996;312:421-5.
25. Lynch JW, Kaplan GA, Shema SJ. Cumulative impact of sustained economic hardship on physical, cognitive, psychological, and social functioning. New Engl J Med 1997;337:1889-95.
26. Carmichael CL, French AD, Rugg-Gunn AJ, Furness JA. The relationship between social class and caries experience in 5-year-old children in Newcastle and Northumberland after 12 years' fluoridation. Community Dent Health 1984;1:47-54.
27. Gratrix D, Holloway PJ. Factors of deprivation associated with dental caries in young children. Community Dent Health 1994;11:66-70.
28. Jones CM, Woods K, Taylor GO. Social deprivation and tooth decay in Scottish schoolchildren. Health Bull 1997;55:11-15.
29. Sweeney PC, Nugent Z, Pitts NB. Deprivation and dental caries status of 5-year-old children in Scotland. Community Dent Oral Epidemiol 1999;27:152-9.
30. Tickle M, Moulding G, Milsom K, Blinkhorn A. Dental caries, contact with dental services and deprivation in young children: their relationship at a small area level. Br Dent J 2000;189:376-9.
31. Ellwood RP, O'Mullane DM. The association between area deprivation and dental caries in groups with and without fluoride in their drinking water. Community Dent Health 1995;12:18-22.
32. Locker D. Deprivation and oral health: a review. Community Dent Oral Epidemiol 2000;28:161-9.
33. Kumar JV, Green EL, Coluccio C, Davenport R. Oral health status of second grade school children in upstate New York. NY S Dent J 2001;67:26-31.
34. Gillcrist JA, Brumley DE, Blackford JU. Community socioeconomic status and children's dental health. J Am Dent Assoc 2001;132:216-22.
35. Ismail AI, Sohn W. The impact of universal access to dental care on disparities in caries experience in children. J Am Dent Assoc 2001;132:295-303.
36. Hjern A, Grindefjord M, Sundberg H, Rosen M. Social inequality in oral health and use of dental care in Sweden. Community Dent Oral Epidemiol 2001;29: 167-74.
37. Milen A. Role of social class in caries occurrence in primary teeth. Int J Epidemiol 1987;16:252-6.
38. Menghini G, Steiner M, Marthaler TM. [The dental status of schoolchildren from abroad in Canton Zurich 1992 to 1994. English summary]. Schweiz Monatsschrift Zahnmed 1995;105:1529-33.
39. Kallestål C, Wall S. Socioeconomic effect on caries. Incidence data among Swedish 12–14-year-olds. Community Dent Oral Epidemiol 2002;30:108-14.
40. Carmichael CL, Rugg-Gunn AJ, Ferrell RS. The relationship between fluoridation, social class and caries experience in 5-year-old children in Newcastle and Northumberland in 1987. Br Dent J 1989; 167:57-61.
41. Jones CM, Worthington H. Water fluoridation, poverty and tooth decay in 12-year-old children. J Dentistry 2000;28: 389-93.
42. Riley JC, Lennon MA, Ellwood RP. The effect of water fluoridation and social inequalities on dental caries in 5-year-old children. Int J Epidemiol 1999;28:300-5.
43. Evans DJ, Rugg-Gunn AJ, Tabari ED, Butler T. The effect of fluoridation and social class on caries experience in 5-year-old Newcastle children in 1994 compared with results over the previous 18 years. Community Dent Health 1996;13: 5-10.
44. Murray JJ, Breckon JA, Reynolds PJ, Tabari ED, Nunn JH. The effect of residence and social class on dental caries experience in 15-16-year-old children living in three towns (natural fluoride, adjusted fluoride and low fluoride) in the northeast of England. Br Dent J 1991;171: 319-22.
45. Brown L, Mulqueen T, Storey ED. The effect of fluoride consumption and social

class on dental caries in 8-year-old children. Austral Dent J 1990;35:61-8.
46. Slade GD, Spencer AJ, Davies MJ, Stewart JF. Influence of exposure to fluoridated water on socioeconomic inequalities in children's caries experience. Community Dent Oral Epidemiol 1996;24: 89-100.
47. Wright JC, Bates MN, Cutress T, Lee M. The cost-effectiveness of fluoridating water supplies in New Zealand. ANZ J Public Health 2001;25:170-8.
48. Treasure ET, Dever JG. Relationship of caries with socioeconomic status in 14-year-old children from communities with different fluoride histories. Community Dent Oral Epidemiol 1994;22: 226-30.
49. Provart SJ, Carmichael CL. The relationship between caries, fluoridation and material deprivation in five-year-old children in County Durham. Community Dent Health 1995;12:200-3.
50. Hausen H, Milen A, Heinonen OP, Paunio I. Caries in primary dentition and social class in high and low fluoride areas. Community Dent Oral Epidemiol 1982;10:33-6.
51. Evans RW, Beck DJ, Brown RH, Silva PA. Relationship between fluoridation and socioeconomic status on dental caries experience in 5-year-old New Zealand children. Community Dent Oral Epidemiol 1984;12:5-9.
52. Colquhoun J. Influence of social class and fluoridation on child dental health. Community Dent Oral Epidemiol 1985;13:37-41.
53. McDonagh M, Whiting P, Bradley M, et al. A systematic review of public water fluoridation 2000. University of York NHS Centre for Reviews and Dissemination, Sept 2000. (http://www.york.ac.uk/inst/crd/fluores.htm.)
54. Barsley R, Sutherland J, McFarland L. Water fluoridation and costs of Medicaid treatment for dental decay—Louisiana, 1995-1996. Morbid Mortal Week Rev MMWR 1999;48:753-7.
55. Kumar JV, Swango PA, Lininger LL, Leske GS, Green EL, Haley VB. Changes in dental fluorosis and dental caries in Newburgh and Kingston, New York. Am J Public Health 1998;88:1866-70.
56. Lemke CW, Doherty JM, Arra MC. Controlled fluoridation: the dental effects of discontinuation in Antigo, Wisconsin. J Am Dent Assoc 1970;80:782-6.
57. Künzel W. Effect of an interruption in water fluoridation on the caries prevalence of the primary and secondary dentition. Caries Res 1980;14:304-10.
58. Stephen KW, McCall DR, Tullis JI. Caries prevalence in northern Scotland before, and 5 years after, water defluoridation. Br Dent J 1987;163:324-6.
59. Künzel W, Fischer T, Lorenz R, Bruhmann S. Decline of caries prevalence after the cessation of water fluoridation in the former East Germany. Community Dent Oral Epidemiol 2000;28:382-9.
60. Künzel W, Fischer T. Caries prevalence after cessation of water fluoridation in La Salud, Cuba. Caries Res 2000;34:20-5.
61. Maupome G, Clark DC, Levy SM, Berkowitz J. Patterns of dental caries following the cessation of water fluoridation. Community Dent Oral Epidemiol 2001; 29:37-47.
62. Seppä L, Karkkainen S, Hausen H. Caries frequency in permanent teeth before and after discontinuation of water fluoridation in Kuopio, Finland. Community Dent Oral Epidemiol1998;26:256-62.
63. Seppä L, Karkkainen S, Hausen H. Caries in the primary dentition, after discontinuation of water fluoridation, among children receiving comprehensive dental care. Community Dent Oral Epidemiol 2000;28:281-8.
64. Künzel W. Caries decline in Germany: eine Studie zur Entwicklung der Mundgesundheit. Heidelberg: Huthig, 1997 (English summary pp 310-21).
65. O'Mullane D, Whelton H. Caries prevalence in the Republic of Ireland. Int Dent J 1994;44(Suppl 1):387-91.
66. Featherstone JD. Prevention and reversal of dental caries: role of low level fluoride. Community Dent Oral Epidemiol 1999; 27:31-40.
67. Addy M, Dummer PM, Hunter ML, Kingdon A, Shaw WC. The effect of toothbrushing frequency, toothbrushing hand, sex and social class on the incidence of plaque, gingivitis and pocketing in adolescents: a longitudinal cohort study. Community Dent Health 1990;7: 237-47.
68. Kuusela S, Honkala E, Kannas L, Tynjala J, Wold B. Oral hygiene habits of 11-year-old schoolchildren in 22 European countries and Canada in 1993/1994. J Dent Res 1997;76:1602-9.
69. Thomson WM, Locker D. Dental neglect and dental health among 26-year-olds in the Dunedin Multidisciplinary Health and Development Study. Community Dent Oral Epidemiol 2000;28:414-8.