Caries Research

Symposium Report

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The Prevalence of Dental Caries in Europe 1990–1995

ORCA Saturday Afternoon Symposium 1995

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Key Words
Caries prevalence · DMFT · dmft

Abstract
Caries prevalence data from recent studies in all European countries showed a general trend towards a further decline for children and adolescents. However, in several countries with already low caries prevalence in primary teeth, there was no further decrease. Regarding the permanent dentition, further reductions were observed in the 12-year age group, these being even more evident at the ages of 15–19 years. In some Central and Eastern European countries, caries prevalence in children and adolescents was still high. Few data were available on young adults, but the benefits of prevention are becoming manifest. The available data on the use of toothbrushes, fluorides and other pertinent items provided few clues as to the causes of the decline in caries prevalence.

Program of the Symposium

14.00–14.05	V. Vrbic, Ljubljana, I. J. Møller, WHO-Copenhagen: Introduction
14.05–16.00	Reports from the various countries, presented by the authors
16.00–16.25	Questions and discussions, round table and audience, moderators T. M. Marthaler, I. J. Møller: Has the lowest attainable level been reached in some countries? Which additional data may be needed regarding the reasons for the changes?
16.25–16.40	Conclusions and summary, T. M. Marthaler, I. J. Møller, D. M. O'Mullane, V. Vrbic: Epidemiological problems 1996–2000

In 1990, European epidemiology of dental caries was the topic of an ORCA symposium for the first time. As the ensuing report of the symposium [Marthaler, 1990a] met with great interest, the topic was chosen again. The contributors to the 1990 symposium agreed to another effort to gather as much data as possible.

Since the 1990 ORCA symposium held in Ljubljana in 1990, many changes have taken place in Europe which are likely to influence the oral-health status in various European countries. Important political, social, economic and commercial changes have occurred in Central and Eastern Europe. For instance, in 1990 there were 34 independent states in Europe, whereas today there are 53. The 19 new states which have emerged are now struggling to establish new infrastructures, not only in the field of health but also in many other administrative areas. The unemployment, inflation, decline in family income and privatization of the dental profession observed in several of these countries may be a threat to the proper utilization of oral-health services, and the first victims will most likely be the children. The discontinuation of water fluoridation schemes in some of these countries may adversely affect dental health, while increasing availablility of tested fluoride-containing products for oral care might have positive effects.

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Table 1. Caries in the primary teeth, dmft, ages 5–7

Country, city or region	Age	1982–1988					1988–1992				
		year	Av. dmft	0 dmft %	n	remarks	year	Av. dmft	0 dmft %	n	remarks
Albania, Tirana	6						1989	3.4			
Andorra	6										
Austria							1988	4.7		5,710	
Vorarlberg							1988	4.8	83	237	
Belarus											
Belgium, Flanders							1989–1991	1.7	60	3,534	
Czech Republic	5	1987	2.7	31	549						
	6		3.4		378						
Denmark	5	1988	1.3	63		NS	1991	1.4	63		NS
Finland	5	1985	2.1	48		NS	1988	1.6	54		NS
France	6	1987	3.5		1,272	RA					
	7	1987	3.7		1,943						
France (USFBD)	6	1987	3.2			dft	1990	2.7			dft
Germany, East	5–6	1980–1984	2.2	36	16,242		1985–1989	2.5	33.2	22,963	
West Germany, 5 States	6	1982–1988	3.5	33	1,739						
Greece	7	1985	4.4			NP					
Athens	5	1984	2.7	42	162						
	6	1982	3.3	35	108						
Hungary	7	1985	5.7	9	895	NP					
Iceland, Reykjavik	4	1988	2.9	40			1989	2.4			
(1986, all Iceland)	6	1986	4.6			NS	1989	3.5			
Ireland, East. Health Board	5	1984	1.3	57	139	FL, RA					
West. Health Board	5	1984	2.2	47	77	NFL, RA					
	5	1984	1.5	59	85	FL, RA					
Italy, Milan area											
Venice region											
Lithuania	5–6	1983	4.9	18	700			4.4	20.1		
Netherlands	5	1982–1984	1.8	59	304		1989	1.5	60	218	
Norway	5	1988		58		NR	1991	1.4	63		NR
Poland	5–6	1987	5.5								
Portugal	6	1984	5.2	17	647	NP	1990	4.2	24	714	NP
Romania	6	1986	4.4				1992	5.6	14	729	NP
Serbia, Kosovo, Gnjilane	6						1989	1.4		257	
Priština + Mitrovica	6						1989	6.6		60	
Slovak Republic	5	1987	2.7								
	6		3.4								
Slovenia	6	1987	5.2	13	207	NP					
Spain	6–7	1985	3.6		1,087	NP					
Sweden	5	1988	70.0			NRIN	1991		70		NRIN
	6	1985		45		NRIN	1991		59		NRIN
Switzerland							1988	2.2	47	550	RA
Canton of Zurich	7	1984	1.8	63	261		1988	1.5	66	304	
United Kingdom	5	1983	2.1	48	804	RA					
England and Wales	5	1983	1.6	52	719	RA					
Scotland	5	1983	3.9	25	319	RA					
Northern Ireland	5	1983	4.5	22	198	RA					
USA	5	1986–1987	1.7	58	1,852	dft, RA	1988–1991	1.7	61	554	RA
	6	1986–1987	1.8	54	3,089	dft, RA		1.8	53	309	RA

RA = Random sample in the specified country or region; NS = national sample, data extracted from national register; NP = National Oral Health Pathfinder Survey; FL = lifetime residents of fluoridated-water communities; NFL = lifetime residents of communities with low-fluo-

1991–1995				
year	Av. dmft	0 dmft %	n	remarks
1994	8.5			
1991	2.1	35	66	RA
1993	2.4	57	300	
1993–1994	7.4	15	350	
1993	2.7	39	591	
1994	1.3	63		NS
1991	1.4	60		NS
1991	2.5		1,512	RA
1991	2.7		1,877	
1993	1.7		1,331	dft
1991–1994	2.5	36	5,115	
1994	2.6	42	8,077	6 to 7 year, dft
1994	1.5	58	318	
1991	2.4	45	111	
1991	3.7	30	898	6-year, NP
1993	0.9	70	2,340	FL, RA
1992	2.1	42	85	NFL, RA
1992	1.0	68	301	FL, RA
1994	1.4	64	590	
1994	1.7	56	405	
1993–1994	4.4	16	945	
1992–1993	1.7	55	340	
1993	1.4	64		NR
1991	5.5	10		
1993	5.4	6		
1995	4.4	17	886	
1994	1.6		140	
1994	7.9		60	
1993	3.9	30	274	NP
1994	1.0	62	453	NP
1993		74		NRIN
1994		64		NRIN
1992	1.6	65	281	
1993	2.0	54	1,691	RA
1993	1.6	57	1,476	RA
1993	3.0	42	381	RA
1993	3.0	37	209	RA

ride water; NR = national register of school or public dental services; In = incomplete.

Materials and Methods

Caries experience as expressed in dmf and DMF counts includes lesions that have reached the cavity level, thus excluding small changes such as white spots or discolored fissures.

In view of the many countries with low caries levels in permanent teeth, often below 2.0 DMFT at 12 years of age, average DMFTs at the age of 6 or 7 were not collected because they were unreliable.

This report is based on variable types of sources. Data representative of the entire population are only obtained through random sampling, which has been increasingly used. In some countries, notably Denmark, national statistics are available for the whole country (e.g. based on the standardized recording system of the Danish Municipal Dental Service). National Oral Health Pathfinder Surveys are based on samples selected to cover the various possible conditions throughout a country.

The annotated references, ordered according to countries, provide the sources of and further information related to the data presented in the tables.

Overview of the Results According to Age

Caries in the Primary Dentition, Ages 5–7

The available data are compiled in table 1. Figure 1 shows that the average dmft obtained in the surveys 1991–1995 ranged between 0.9 and 8.5. Besides Spain with 1.0 dmft obtained in the Pathfinder survey of 1994, the lowest national average was 1.3, in Denmark. National averages below 2.0 were also reported for Finland, the Netherlands and Norway. Table 1 shows that in several cities or regions there were similar low averages, with the Eastern Health Board of the Irish Republic (comprising the capital, Dublin) providing the lowest average of 0.9 dmft. Averages of 2.0 and less were associated with more than 50% of the children showing a dmft of 0.

Figure 2 illustrates the changes in those countries or regions where the second-last average dmft was below 2.0. Generally, the averages remained stable or decreased slightly, the latest ones ranging between 1.3 and 1.6. However, in the 5-year-old children in the Irish Eastern Health Board data, the average dmft decreased from 1.3 in 1984 to 0.9 in 1993.

Caries in the Permanent Teeth, Age 12

The majority of the countries had DMFT averages below 3.0, and 7 averages, from Northwestern Europe and the USA, were below 2.0 (table 2, fig. 3). On the other hand, 12-year-olds in 9 countries had more than 3.0 DMFT, i.e. they have not yet reached the WHO goal for the year 2000. Figure 4 shows the decline which occurred in countries or regions where the second-last survey had resulted in an average below 3.0 DMFT. With the exception of Denmark

(stable at 1.3 DMFT), caries prevalence in the permanent teeth of 12-year-old children continued to decline.

Thirty-one pairs of averages regarding dmft and DMFT were available for either countries, regions or cities. Only the latest data were used, resulting in overall averages of 2.83 dmft and 2.67 DMFT, at the ages of 5 (6 and 7 years in a few cases) and 12 years, respectively. The correlation coefficient of 0.85 was highly significant ($p < 0.001$). Nevertheless, figure 5 illustrates that there are considerable deviations from a perfect relation.

Caries in the 15–35 Age Group

Only a few countries had data available for this age range (table 3). Recent averages from Denmark, Finland, the USA and Switzerland ranged between 2.2 and 3.1 for 15 year olds. In the 8 countries or areas where surveys had been repeated, caries prevalence declined (fig. 6). Figure 7 presents the results pertaining to ages around 18 years. The lowest DMFT values were 4.5 and 5.3 as reported from the Netherlands and Finland, respectively.

Caries in the 35–44 Age Group

The recent and comparable older data are compiled in table 4. The average DMFT after 1988 varied between 13.4 and 20.8. In the latest statistics, the DT was usually the smallest and the FT the largest component of the DMFT. This indicates higher levels of restorative care. Apparently, the respective situation had improved during the last decade, and the average FT had even increased in several cases. The total DMFT did not change materially in repeated surveys.

Sugar Disappearance, Toothbrush and Toothpaste Usage and Fluoride in Various Forms

Sugar disappearance (based on data on production, imports and exports, often equated with consumption) was in a relatively narrow range, mostly between 30 and 45 kg per capita and year (table 5). Toothbrush and dentifrice usage differed strongly between countries. In most Western European countries, 90% or more of the dentifrices were fluoridated in the nineties. Fluoride added to water or salt is confined to a few countries but reaches some 40 millions (table 6). Some forms of fluorides are used in almost all countries. Coverage, however, varies widely. Only small groups consume water naturally containing more than 0.7 ppm fluoride.

Questions and Discussion at the Symposium

Several points were raised from the floor and also conveyed to the chairman in written form after the symposium due to the limited time left for discussion.

For frequency distributions, the mere presentation of averages was considered insufficient. When the average DMFT or dmft is below 2.0, for example, the frequency distributions are known to be very skew. To some extent, this was taken into account by presenting the percentages of subjects with a dmft or DMFT of 0, as far as available. In the countries with the lowest caries prevalence in children between 1991 and 1995, around half of the children were indeed caries-free regarding both the dmft and the DMFT count at the ages of 5–7 and 12, respectively.

Regarding the reliability of the data, variations in the diagnostic levels of dental caries affect the results. For the National Oral Health Pathfinder Surveys, the majority of the national epidemiological teams were calibrated by I. J. Møller of the WHO, Copenhagen, Denmark. In Scandinavian countries, it is customarily the treating school dentist who decides whether a surface is in need of conservative treatment and is accordingly to be scored as d or D and subsequently filled. Lower caries activity and minimal intervention techniques may have influenced treatment decisions accordingly, reducing the number of filled units. Sealants are another factor which may influence or sometimes hinder caries diagnosis in pits and fissures. While some variation in diagnostic standards must be supposed and is inevitable in this type of international compilation, the consistency of the results suggests that diagnostic standards were reasonably homogeneous.

A close look should be given to the D, F and M components, with a special view to dentists' interventions.

Factors which may be responsible for a decline or a lack of decline are very difficult to identify. Relevant data as frequently assembled and presented in respective reports and as presented at this symposium may be insufficient.

In collaboration with the International Dental Federation, the WHO formulated six oral health goals to be achieved by the year 2000 [FDI-WHO, 1982]. The most important of these goals is, in fact, goal 6, which states that 'a data-based system for monitoring changes in oral health should be established in each Member State'. This goal was set not only for the year 2000 but also as an intermediate target to be achieved as soon as possible. The symposium shows that considerably more data are available now than in 1990. Nevertheless, this progress is due only in part to 'data-based systems' since many of the recent studies were apparently done as single projects. Follow-up surveys, which are

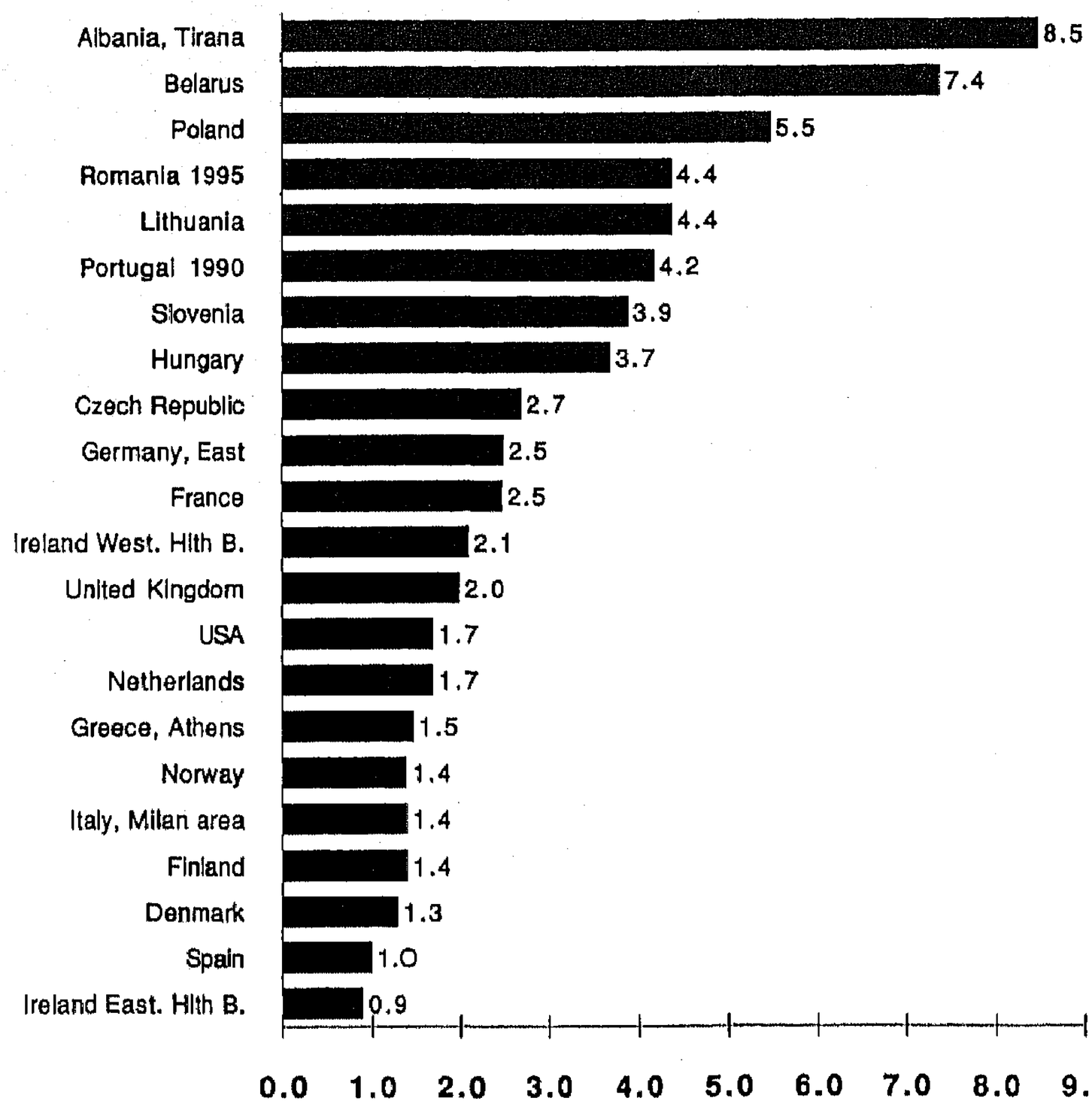

Fig. 1. Caries prevalence in Europe: average dmft at the age of 5–7 (1991–1995 if not indicated otherwise).

indispensable for monitoring, may not be assured in all cases.

Of the remaining five oral-health-related goals, No. 2, 'the global average will be no more than 3 DMF teeth at 12 years of age', is the one with the greatest amount of data available. The data presented during this symposium and those available in the European Data Base of the WHO indicate that of the 53 countries in the European region, only for 2 countries (Azerbaijan and Monaco) are no data availabe; 31 countries (62%) have achieved the goal of no more than 3 DMFT at age 12, and 19 countries (38%) have not yet succeeded [WHO, 1995].

Since less than 5 years remain until the year 2000, the WHO Regional Office for Europe is in the process of formulating European goals for oral health by the year 2020. In a few months' time these goals will be sent to the individual European ministries of health, national dental associations and selected experts for comments and amendments.

The information contained in the WHO European Statistical Data Base for Health for All is available on a diskette. At present, it comprises 181 health indicators, of which 3 are related to oral health. Once the oral-health goals for the year 2020 are made official, the corresponding indicators will be included in this list. Eventually, all health data for Europe as collected by the WHO will be available on the Internet system [WHO-EURO, 1994, 1995]. The data presented here may be compared with those available from the Global Oral Data Bank of the WHO. However, agreement with the latter data is no safeguard, because they are often based on the same studies and may sometimes have the same shortcomings.

Developments since the 1990 ORCA Symposium

Caries Prevalence

Figure 2 supports the hypothesis that levels of primary-tooth caries tend to stabilize at approximately 1.3–1.6 dmft. A distinctly lower average, 0.9 dmft, was observed 1993 in the 5-year-olds of the data from the Eastern Health Board of

Table 2. Caries, DMFT, at age 12 years

Country, city or region	1983–1988					1988–1992					
	Year	Av. dmft	0 dmft %	n	remarks	year	Av. dmft	0 dmft %	n	remarks	trend
Albania, Tirana	1983	5.9				1989	3.4				down
Andorra											
Austria	1984	3.8				1988	4.3	16	288		up
Vorarlberg						1988	4.1	8	228		
Belarus						1992	3.3				
Belgium, Flanders						1989–1991	2.7	25	4,162		
Croatia, Zagreb	1985	6.2	6	128		1988	3.4	10	76		down
Czech Republic						1987	3.3				
Denmark	1988	1.6			NR	1991	1.3	49		NR	stable
Estonia						1992	4.1				
Finland	1988	2.0			Lj90						
France	1987	4.2		1,905	RA						
France (USFBD)	1987	4.2				1990	3.0				down
Germany, East						1989	3.8	18	18,290		
Germany, West						1989	4.1		452	RA	
Greece	1985	4.3			NP						
Athens	1982	3.8	13	82		1988	2.4	25	684		down
Hungary	1985	5.0	8	893	NP						
Iceland; Reykjavik	1988	4.1			Lj90	1990	3.3				down
Ireland, East. Health Board	1984	2.2	15	128	FL, RA						
West. Health Board	1984	3.0	18	110	NFL, RA						
	1984	2.3	27	79	FL, RA						
Italy, Milan area											
Venice region											
Lazio (Rome area)											
Latvia											
Lithuania	1986	3.6	14			1992	3.9				
Moldavia											
Netherlands	1985	1,7			Lj90	1989	1.1	56	340		down
Norway	1988	2.7			NR	1990	2.4	32		NR	down
Poland	1985	4.4									
Portugal	1984	3.7	15	643	NP	1990	3.2	22	705	NP	down
Romania	1986	3.1			NP	1992	4.0	9	660	cities	
Russia, Moscow	1985	3.2				1992	3.7				
Serbia, Kosovo, Gnjilane						1989	4.8		230		
Priština + Mitrovica						1989	7.2		60		
Slovak Republic						1987	4.1				
Slovenia	1987	5.1	6	405	NP						
Spain	1985	4.2		1,021	NP						
Sweden	1988	2.4			NRIN	1990	2.0	40		NRIN	
Switzerland						1988	2.0	38	550	RA	
Canton of Zurich	1984	2.2		542		1988	1.6		453		down
Ukraine	1984	3.7									
United Kingdom	1983	3.1	19	1,165	RA						
England and Wales	1983	2.9	21	1,036	RA						
Scotland	1983	4.5	10	525	RA						
Northern Ireland	1983	4.8	6	239	RA						
USA	1986–1987	1.8	42	3,187	RA	1988–1991	1.4	50	176	RA	down

RA = Random sample in the specified country or region; NS = national sample, data extracted from national register; NR = national register of school or public dental services; Lj90 = data from ORCA symposium, Ljubljana, 1990 [Marthaler, 1990a]; In = incomplete; NP = National Oral Health

1991–1995					
year	Av. dmft	0 dmft %	n	remarks	trend
1994	2.2	17			down
1991	2.5	32	63	RA	
1994	3.0		491	NS	down
1993	1.8	26	307		down
1994	3.8				up
1991	2.6	21	96		down
1993	2.7	23	593		down
1994	1.3	48		NR	stable
1991	1.2	30		NR	down
1991	2.6		1,921	RA	down
1993	2.1		1,331		down
1992	2.5	24	7,732	RA	down
1993–1994	2.6		>9,000	IN	down
1991	1.9	35	54		down
1991	4.3	10	898	NP	down
1993	2.3	22			down
1993	1.4	42	2,552	FL, RA	down
1992	2.1	44	102	NFL, RA	down
1992	1.6	48	278	FL, RA	down
1994	2.6	31	531		
1994	2.2	35	306		
1995	1.8	43	1,426		
1992	7.7				
1994	3.8	12	1,026		?
1992	2.3				
1992–1993	0.9	60	341		down
1993	2.1	36		NR	down?
1991	5.1		1,100		up
				NP	
1995	3.4	20	900	NP	down
1994	3.7				
1994	2.0			FL	
1994	3.3			NFL	
1994	2.9		131		down
1994	7.8		60		up
1993	2.6	31	401	NP	down
1994	2.3	32	502	NP	down
1994	1.5	48	NRIN		down
1992	1.1		399		down
1992	4.4				
1993	1.4	48	1,502	RA	down
1993	1.2	50	1,293	RA	down
1993	2.0	39	316	RA	down
1993	3.0	24	216	RA	down

Pathfinder Survey; FL = lifetime residents of water-fluoridated communities; NFL = lifetime residents of communities with low-fluoride water.

the Irish Republic; those children had been consuming fluoridated water from birth as early as 1984, when the average dmft was still 2.2. The low dmft average of only 1.0 (and 62% with 0 dmft) as obtained for Spain from the National oral Health Pathfinder Survey of 1994 is encouraging but may need confirmation.

At the 'bottom' dmft average of 1.3, approximately 60% have 0 dmft. That means that the remaining 40% of the children still affected by caries (dmft > 0) have an average of 3.5 dmft. This illustrates that in those children at kindergarten age who are affected by caries, decay remains an important problem and often requires lengthy treatment. Accordingly, dentists still need to be trained in pedodontic conservative treatment. This is also necessary with a view to migrant children whose number is increasing. They often have high caries levels and their neglected dentitions are usually in need of complex restorative care [Williams, 1996].

At the age of 12 years, declines of DMFT averages to 1.0 or below seem to be attainable. This is particularly borne out by the averages from England and Wales as well as Finland (both 1.2 DMFT) and from regional surveys in the Netherlands and the Canton of Zurich in Switzerland, where averages as low as 0.8–1.1 DMFT have been determined. Several non-European, English-speaking countries have also attained levels below 1.6 [Naylor, 1994; WHO, 1995].

Regarding Spain and Portugal, table 2 documents a substantial decline of DMFT averages in 12-year-old children. The decline in Spain appears to be more pronounced than in neighboring Portugal. Both countries joined the European Union (i.e. the common market at that time) in January 1986, which greatly increased the availability of, and marketing for, modern fluoridated dentifrices. Spain had its second survey in 1994, 8 years after joining the European Union in 1986, while the second survey in Portugal was done already in 1990. For the Spanish children, fluoridated dentifrices had thus been available for a period twice as long as for Portuguese children, and this may in part explain the smaller reduction of caries prevalence in the latter country.

Incomplete but substantial data from Western Germany indicate a fairly rapid decline of dental caries in children of 5 states. While for 1989, a national sample from Western Germany resulted in 4.1 DMFT in 12-year-old children [Micheelis and Bauch, 1993, average extrapolated from 13- to 14-year-old children], the averages from 5 states surveyed between September 1993 and December 1994 ranged between 2.4 and 2.6 [Pieper, 1995].

In Eastern Germany, caries prevention has been practised since the fifties. Until 1990, reductions of DMF levels in the range of 50–70% were documented for cities with water fluoridation, while a general decline in children could

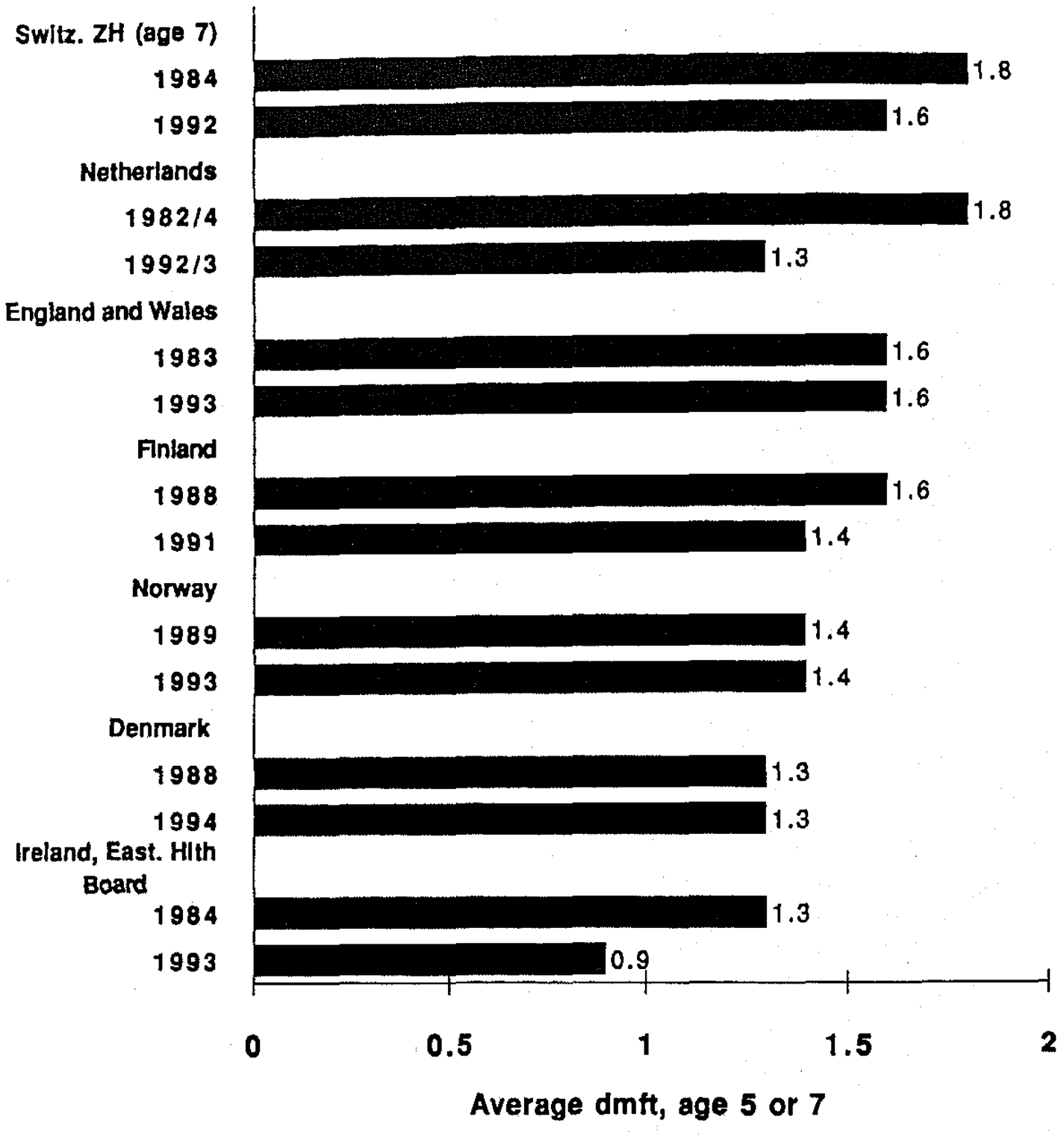

Fig. 2. Caries prevalence in Europe: recent changes in countries where the second-last average dmft was below 2.0.

not be ascertained on the then national (East German) level. Regarding the latest developments, the decline from 3.8 DMFT in 1989 to 2.5 in 1994 is considerable [Künzel, 1996].

A strong decline of caries prevalence is well documented for France. Italy is now the only large, populous Western continental country for which a decline remains to be demonstrated.

Regarding ages 15–19, 9 countries indicated a reduction of caries prevalence. Slovenian adolescents at 15 years of age had 10.2 DMFT in 1987 but only 5.6 in 1992, the latter average being the highest (fig. 6) of those few available; adolescents aged 18 had 8.8 DMFT in 1993, the highest average of the few countries which reported on this age group, but it was lower by 32% when compared to 12.9 DMFT in 1987 (fig. 7). Rapid reductions in these age groups are also obvious for France, the Netherlands and Switzerland.

In the age span 14–20, carious lesions become frequent on approximal surfaces and substantial underrecording might occur in the absence of radiography or fiber-optic transillumination. The examination technique used in the Canton of Zurich included radiographs, and the reduction of the number of lesions confined to the enamel or with penetration into the dentine was substantial. Excluding radiolucencies limited to the enamel, the approximal DFS was 2.07 in 1984 but only 0.52 in 1992 [Marthaler et al., 1994].

There were even less data available for age groups between 20 and 35. Most remarkable are the averages of 6.3 and 9.4 DMFT, respectively, pertaining to the ages 18–24 and 25–34 in the USA between 1988 and 1989. Since the DMFT counts did not include the third molars, they are not directly comparable to the European statistics (it was often not stated whether the DMFT counts in young adults were based on 28 or 32 teeth; for ages up to 20 years, 28 teeth may be supposed to have been counted, and 32 for the higher ages). Nevertheless, they illustrate the long-term benefits of prevention, which are expected to increase in the future. Obviously, future research should focus more on the 15- and 18-year age groups and young adults in order to provide more information on the midterm benefits of prevention.

Samples from Norwegian adults aged 35 years illustrate the benefits in adults to be expected after approximately two decades of prevention of dental caries in children (table 7).

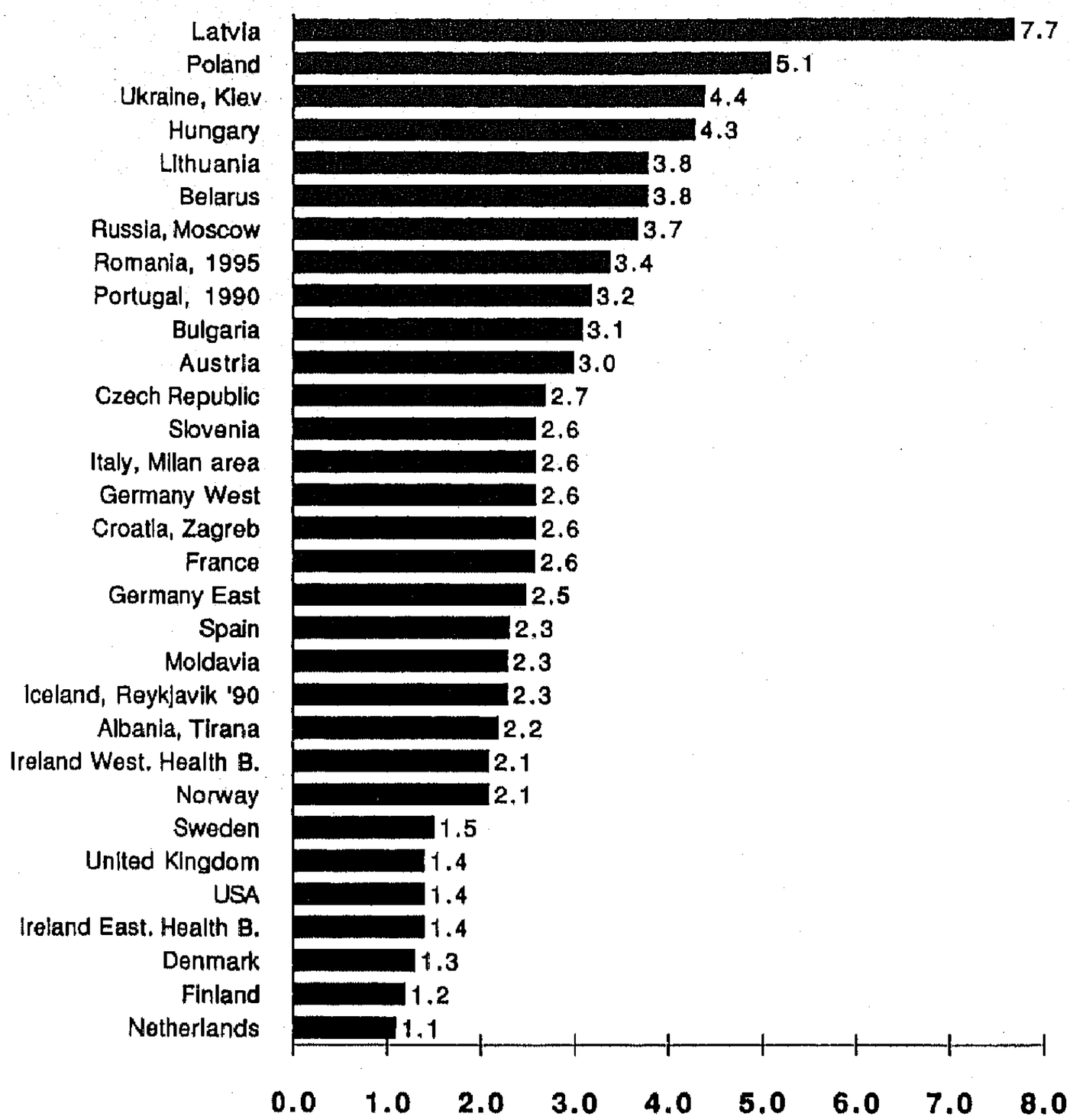

Fig. 3. Caries prevalence in Europe: average DMFT at the age of 12 years (1991–1994 if not indicated otherwise).

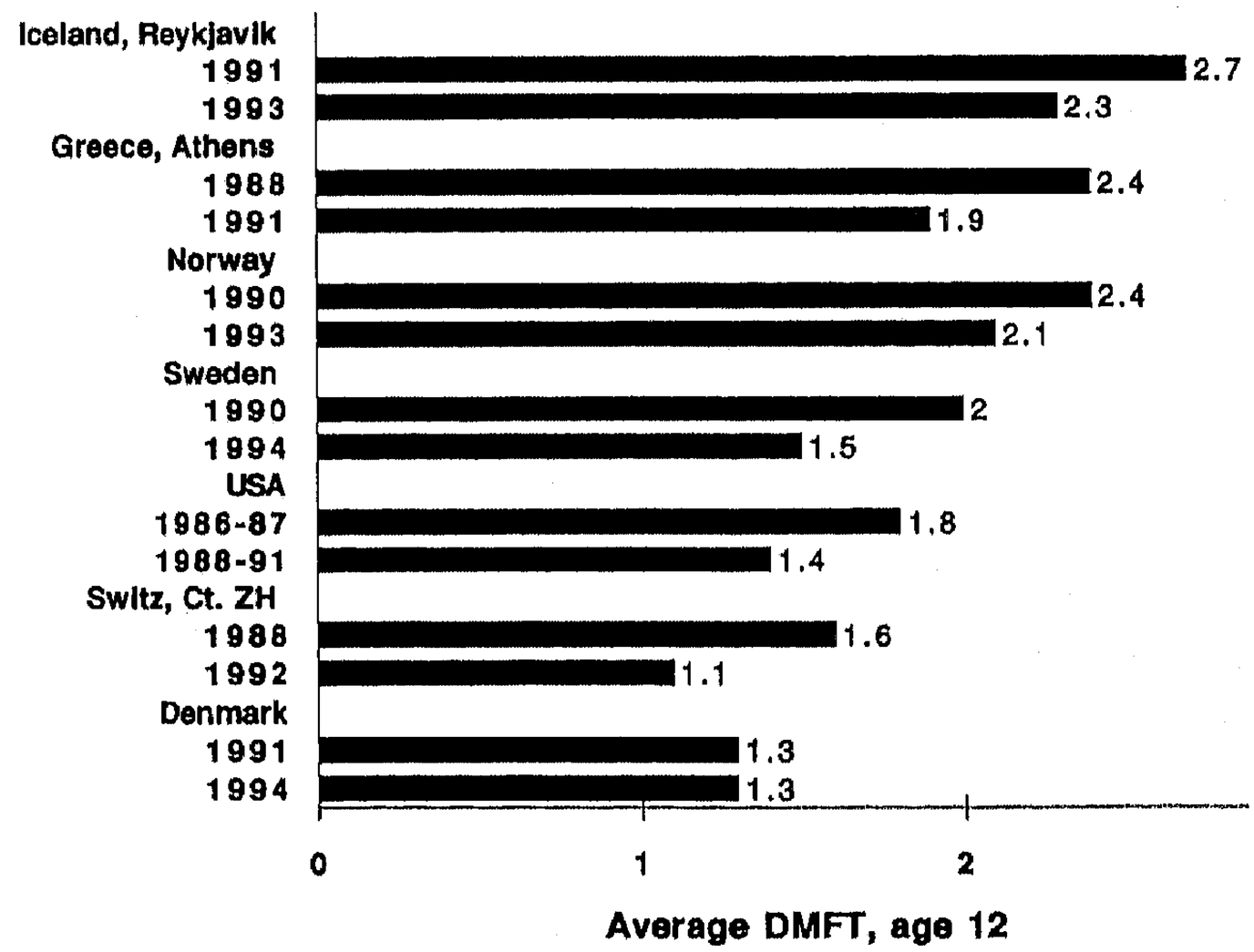

Fig. 4. Caries prevalence in Europe: recent changes in countries where the second-last average DMFT was below 3.0.

Table 3. Caries DMFT, at ages 15–34

Country, city or region	Age	1978–1984					1985–1991				
		year	Av. dmft	0 dmft %	n	remarks	year	Av. dmft	0 dmft %	n	remarks
Belarus	15										
Czech Republic	20–24						1987	10.3		738	
	25-29						1987	12.4		781	
Denmark	15						1991	3.2	25		NR
Finland	15										
	18										
	20										
France	15						1987	6.9		1,931	RA
Germany, East	15	1987–1991	5.6	10	7,198		1985	5.8	7	12,333	
East Berlin	19–20						1988	10.3	1	487	
Germany, West, recruits	21										
Greece, Epirus	15	1984	7.7	4	135	RA					
	17	1984	8.9	7	150	RA					
Iceland, Reykjavik	15						1990	6.1			
Ireland, Republic of	20						1990	8.3	0	38	
	20–24							9.5	0	158	
	25–29							13.6	0	153	
	16–24							7.6		101	NFL, RA
	16–24							7.2		227	FL, RA
	25–34							16.9		90	NFL, RA
	25–34							13.8		121	FL, RA
Lithuania	15	1983	6.4	5			1986	6.2	1		
Netherlands	15–19						1986	6.6		530	
	20–24							11.3		372	
	25–29							15.9		419	
4 cities	17						1987	6.8		454	
	23							12.7		362	
Tiel + Culemborg	15	1981–1982	8.2	2	589		1987–1988	5.2	18	538	
Norway	18						1990	7.4	7		
Romania	18										
Slovenia	15						1987	10.2	1	203	NP
	18						1987	12.9	0	192	NP
Sweden	19						1990	6.3			NR
Switzerland	20–24						1988	10.1		70	RA
	25–29						1988	13.1		66	RA
Canton of Zurich	15	1984	4.8	20	286		1988	3.9	23	228	
United Kingdom	16–24	1978	14.9		646	RA	1988	10.8		706	RA
England and Wales	16–24	1978	14.4		567	RA	1988	10.4		622	RA
Scotland	16–24	1978	17.0		211	RA	1988	13.4		252	RA
Northern Ireland	16–24	1978	16.6		198	RA	1988	14.2		120	RA
USA	15						1986	3.7	22	2,794	RA
	12–17						1986	3.4	27		RA
	18–24						1985–1986	8.2	7	1,940	RA
	25–34						1985–1986	10.5	4	3,945	RA

NR = National register of school or public dental services; NS = national sample, data extracted from national register; RA = random sample in the specified country or region; NFL = lifetime residents of communities with low-fluoride water; FL = lifetime residents of water-fluoridated communities; NP = National Oral Health Pathfinder Survey.

1991–1995				
year	Av. dmft	0 dmft %	n	remarks
1993	7.9			
1994	2.8	29		NR
1991	3.1	23		NS
1991	5.3	11		NS
1991	7.8	6		NS
1991	4.9		1,549	RA
1993	4.6	12	6,877	
1993	13.5		120	
1993	5.1	14		
1993	5.6	2	1,010	
1993	4.5		522	
	8.5		429	
1993	6.9	10		NR
1995	6.9	6	785	
1993	5.6	5	280	NP
1993	8.8	2	199	NP
1994	5.2	13		NR
1992	2.2	44	147	
1991	2.6	35	183	RA
1991	2.8	33		RA
1988–1991	6.3	12	792	RA
1988–1991	9.4	4	1,193	RA

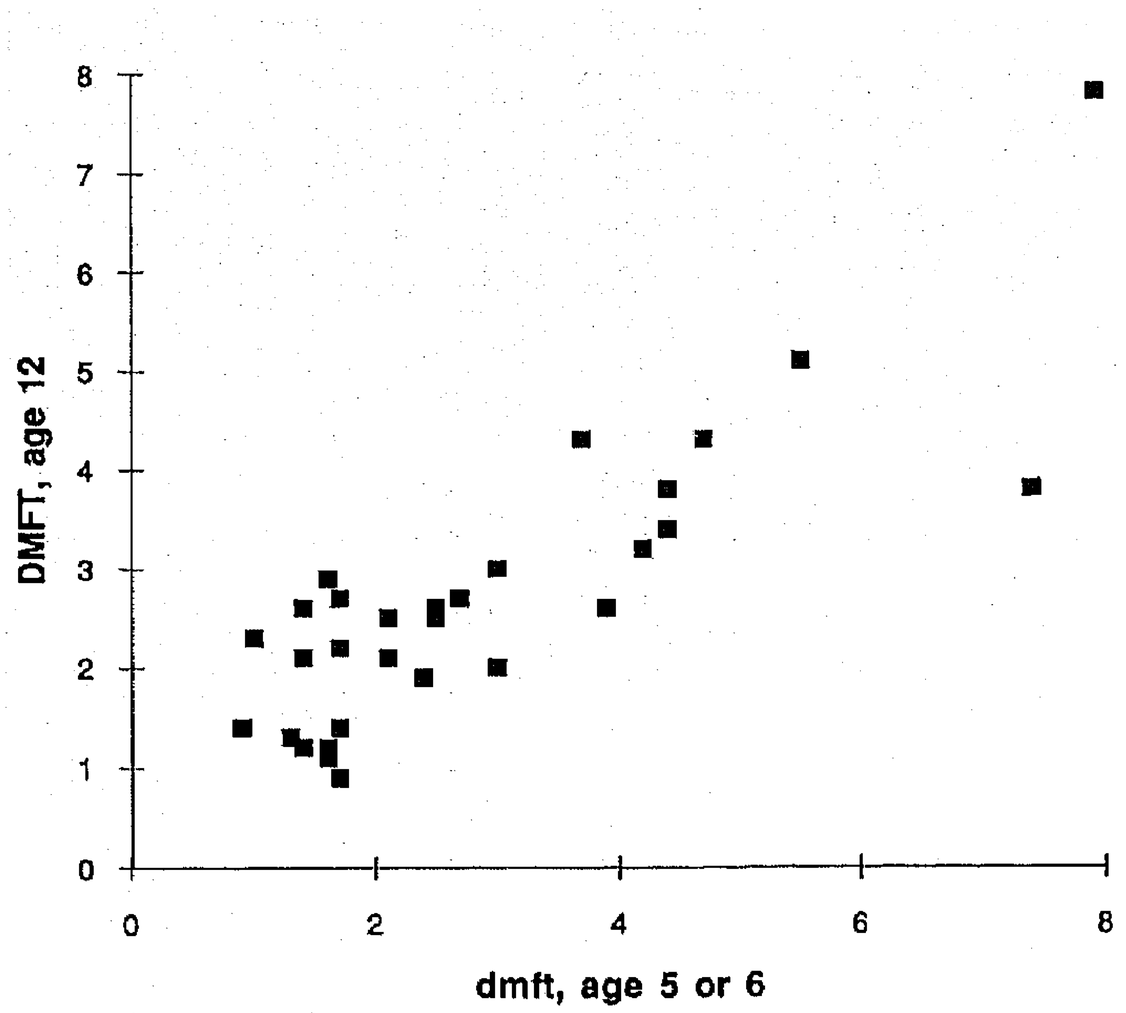

Fig. 5. Scattergram showing the correlation between the average dmft at the ages of 5–7 and the average DMFT at the age of 12, latest available data from countries, regions or cities. $r^2 = 0.717$, $r = 0.847$.

According to the fillings placed by the school dental services, caries activity started to decrease fairly distinctly in 1971 [Rølla and Øgard, 1987]. In adults, the number of DS and MS showed noteworthy reductions until 1984, but little change otherwise. By 1993, the DMFT (based on 28 teeth) had decreased by 28% and the DMFT by 40%. The DS and MS components were reduced to fairly low averages. It is obvious that the decline of caries prevalence in children which prompted the 'First International Conference on the Declining Prevalence of Dental Caries' [Glass, 1982] is slow to become manifest in the DMFT of adults in the 35–44 age group, in keeping with the scant European data (table 4).

Reasons for the Decline

Until 1970, there was a fairly strong relation between sugar consumption (sometimes also referred to as supply and disappearance) and caries experience. Based on the DMFT level at the age of 12 years, the coefficient of determination reached 50% [Sreebny, 1982]. Later studies from industrialized countries showed that this relation may be effaced due to preventive efforts [Marthaler, 1990b]. This was illustrated by the analyses of Woodward and Walker [1994], whose study was based on more recent data. The relation between sugar consumption and DMF levels was still sig-

Table 4. Caries, D-, M-, and FT at age 35–44 (base 32 teeth)

Country, city or region	1978–1987									
	year of study	teeth present	DT	FT	Sound teeth	MT	DMFT	Edentulous %	n	remarks
Belarus										
Croatia	1986	23.4[1]	1.5	5.5	16.4	8.6	15.6		160	NP
Zagreb										
Czech Republic	1987	25.7[1]	2.0	9.4	14.3	6.3	17.7		2,533	
Finland (age 35)										
France, Rhône/Alpes										
Germany, West										
Germany, East										
Greece, Athens										
Ireland, Republic of										
Netherlands	1985	21.1					18.3	11	473	
Dentate	1985	23.0	2.2[2]	10.6[2]	10.2	4.6[2]	17.4		418	
Norway, Oslo (age 35)	1984						18.8			
Slovenia	1987	22.5	2.6	9.2	10.7	8.7	20.5		406	NP
United Kingdom	1978		1.8[2]	8.9[2]		9.2[2]	19.9	13	589	RA
England and Wales	1978		1.8[2]	8.6[2]		8.8[2]	19.2	12	528	RA
Scotland	1978		2.1[2]	8.7[2]		11.8[2]	22.6	27	144	RA
Northern Ireland	1978		1.4[2]	9.1[2]		11.1[2]	21.6	17		RA
USA (only 28 teeth)	1985–1986	23.8	0.6	10.6	12.6	3.1	14.3	3	2,623	RA
USA (age 45–54)		20.0	0.6	10.6	8.8	5.7	16.9	9	2,897	RA

NP = National Oral Health Pathfinder Survey; NS = national sample, data extracted from national register; RA = random sample in the specified country or region; NFL = lifetime residents of communities with low-fluoride water; FL = lifetime residents of water-fluoridated communities.

nificant for developing countries, but the coefficient of determination reached only 26%. The limited value of such studies was discussed by Nadanovsky [1994]. National figures for sugar disappearance are not easy to collect, as obvious from the paper of Woodward and Walker [1994] and particularly from the detailed analysis of sugar consumption by Gibney et al. [1995].

It has often been stated that it is not the amount of sugar consumed but the way the sugar is eaten, particularly the frequency of its consumption and perhaps its stickiness, which determine the level of caries prevalence. This is essentially based on well-established knowledge regarding carbohydrate fermentation in the microbial dental plaque. Detailed investigations into the way in which sugar is consumed, as well as how often and how long it stays in the oral cavity are of great interest. However, such studies are expensive and difficult to conduct. Moreover, due to large-scale marketing strategies of powerful manufacturers and to new technological possibilities of creating new kinds of sweets, products offered to the consumer tend to change fairly rapidly. It is thus understandable, although regrettable, that only few studies taking these various factors into account are available.

On the other hand, fluoride dentifrices are accepted by almost all researchers to be the most important factor of the decline of caries prevalence in industrialized countries. Raw dentifrice supply (or disappearance) data may also be of limited value. Children may use toothpaste and toothbrush on average more frequently than middle-aged or elderly adults where dental health education is common, but this aspect has not been studied systematically. Recent studies showed that the way in which teeth are brushed, particularly whether users rinse their mouth vigorously or just spit out after brushing, affects the protection provided by fluoride. Chesters et al. [1992] and Duckworth et al. [1991, 1992] have, under varying experimental conditions, provided respective evidence. The systematic studies by Sjögren [1995] have conclusively demonstrated that some habits and details of dentifrice use may have a very strong influence on the cariostatic effectiveness of fluorides in dentifrices.

1988–1994									
year of study	teeth present	DT	FT	Sound teeth	MT	DMFT	Eden-tulous %	n	remarks
1993	27.8[1]	3.2	8.2	16.4	4.2	15.6	0		
1994	28.2[1]	4.1	8.2	15.9	3.8	16.1		108	
1991						20.1			NS
1994	29.0[1]	1.2	10.4	17.4	3.0	14.6	0	1,000	
1989	28.4[1]	2.0	11.1	15.3	3.6	16.7	1	451	RA
1992	25.1	1.0	8.0	16.1	4.4	13.4	1	364	RA
1988	26.4[1]	2.2	6.8	17.4	5.6	14.6			
1990	19.0	1.8	4.6	12.6	12.6	19.0	6		NFL,RA
1990	22.5	0.6	9.0	12.9	9.3	18.9	2		FL,RA
1993	31.0[1]	0.7	13.1	17.2	1.0	14.8			
1993	24.0	1.7	10.5	11.8	6.8	19.0		256	NP
1988		1.0[2]	11.0[2]		6.9[2]	18.9	7	618	RA
1988		1.0[2]	11.1[2]		6.6[2]	18.7	3	550	RA
1988		1.0[2]	10.7[2]		9.1[2]	20.8	7	216	RA
1988		0.9[2]	10.6[2]		9.8[2]	21.3	5	84	RA
1988–1991	23.5	0.7	9.1	13.7	3.3	13.1	3	1,066	RA
	19.7	0.6	10.2	8.9	5.6	16.4	11	675	RA

[1] Figure obtained for 32 MT (US data, 28 teeth).

[2] Dentate subjects only.

Improvements of the level of oral hygiene have been a factor also. However, the many studies on oral hygiene and caries provide no basis for reliable assessments of the cariostatic efficacy in entire populations. Improvements in oral hygiene may result in more frequent toothbrushing, and this enhances the protective effect of the fluoride present in almost all dentifrices.

Tables 5 and 6 do not seem to provide clues as to which factors may have caused the reductions seen in most countries. Except for sugar disappearance, there are strong variations regarding almost all items, but no single item seems to correlate well with changes in caries prevalence. The data were not sufficiently complete to allow multivariate statistical analysis. While such data are of limited relevance in the present context, they should be made available routinely for general reasons and policy-making.

The existence of comprehensive pedodontic care systems and, within these, treatment of primary teeth may also be a factor. Children who are recalled frequently for visits to the dentist, particularly in school dental clinics, may benefit from positive influences from the personnel, which by various mechanisms may translate into low caries activity.

Nadanovsky and Sheiham [1995] used dental variables and broad socioeconomic factors to investigate relations with the decline in 18 countries in the 1970s and early 1980s. Broad socioeconomic variables explained up to 65% of the variation among declines, expressed in compound annual reductions. While this approach provided noteworthy results and merits further study, it did not identify clues regarding biological mechanisms of the cariostatic effects. However, this study and an earlier one [Nadanovsky and Sheiham, 1994] demonstrated beyond doubt that biological factors acting on caries are strongly correlated with social variables. Both papers showed that usage of fluoride was associated with lower caries prevalence.

Three European reports document an increase of caries prevalence. Stephen et al. [1987] studied primary caries in the Scottish town of Wick, where the water was defluoridated in 1979. In that year, the 5- to 6-year-old children had 2.63

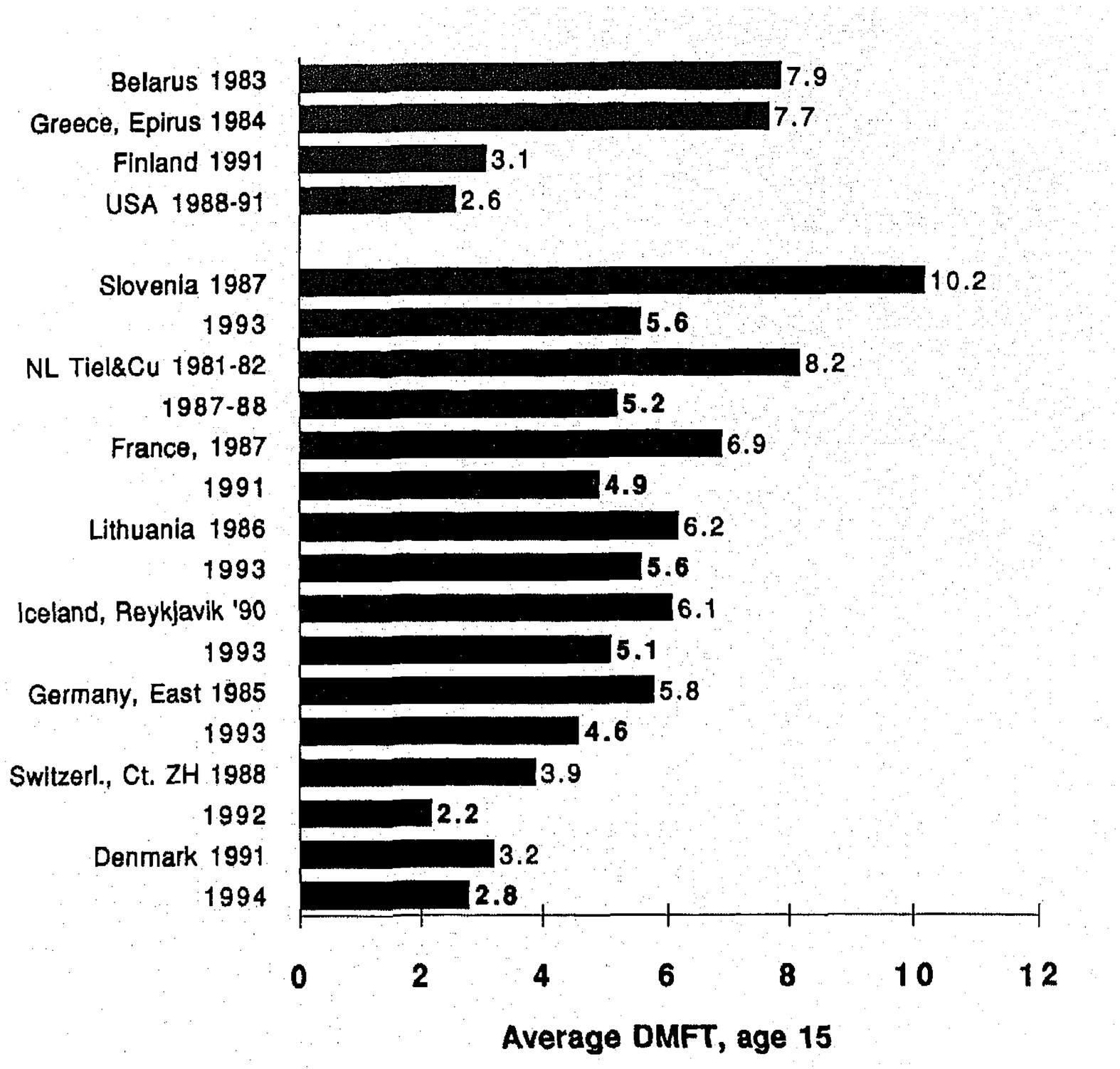

Fig. 6. Caries prevalence in Europe: average DMFT at the age of 15 years and changes as far as data were available.

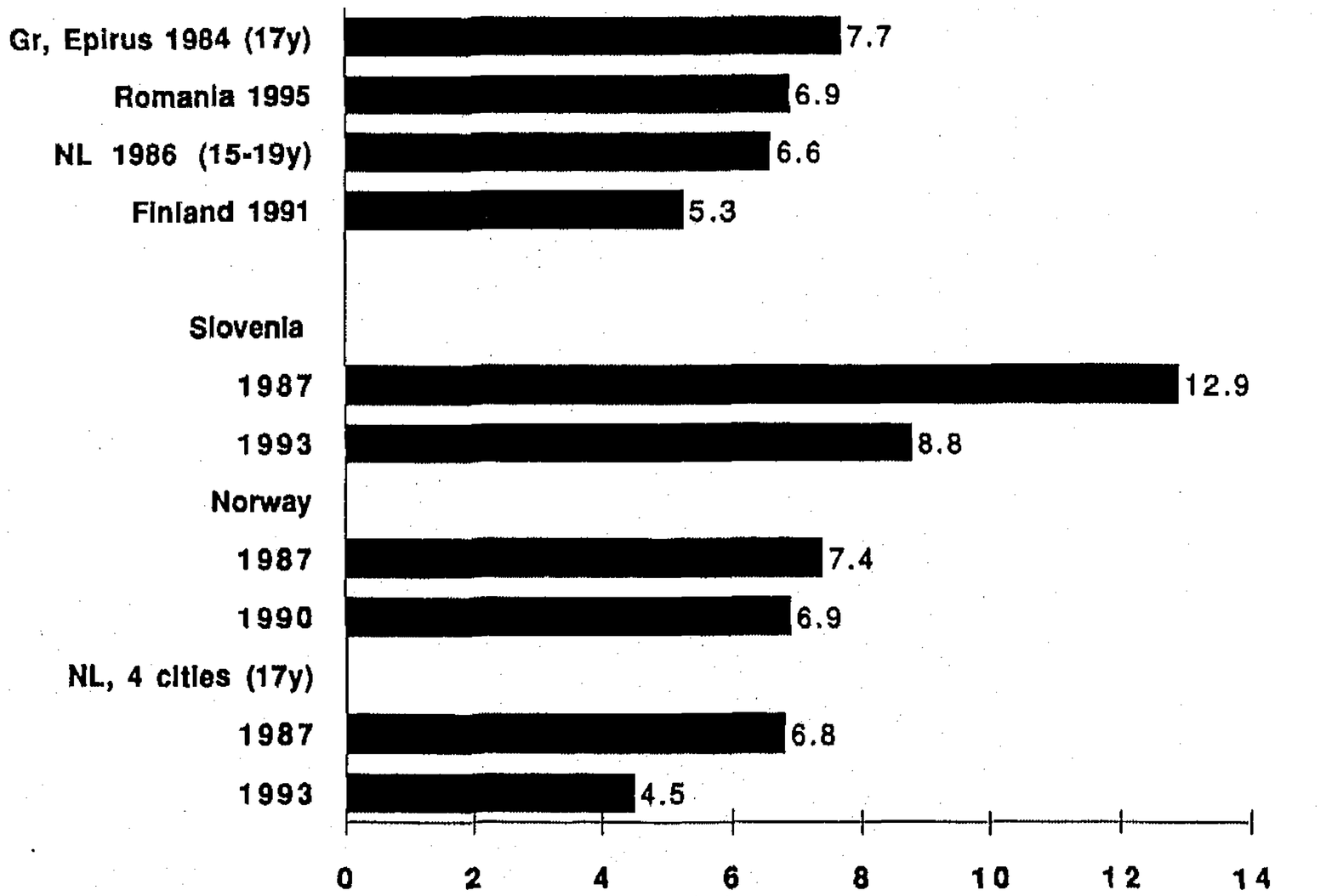

Fig. 7. Caries prevalence in Europe: average DMFT at the age of 18 years and changes as far as data were available.

Table 5. National data on products for oral hygiene and sugar disappearance (consumption, supply), per capita and year

Country	Sugar disappearance, kg				Toothbrush disappearance			Toothpaste disappear., g or ml			Percentage fluoridated		
	1980–1984	1985–1989	1990–1994	A?	1980–1984	1985–1989	1990–1994	1980–1984	1985–1989	1990–1994	1980–1984	1985–1989	1990–1994
Austria	39	35		AW			1.1			350			75
Belgium	39	40				0.7	1.4		178	192	>90	>90	>90
Croatia		17		A	1	1	1	1 tube	1 tube	1 tube	>50	>50	>50
Czech Republic	38	40		A		1			400			40	95
Denmark	42	40	37	AW					130	130		95	95
Finland	42	38	38	AW	0.66	0.71	0.88	155	164	170	98	98	98
France			38	AW			3			210			>90
Germany East	40	41	37	A		1.8	2		385	435		15	90
Germany West	37	35	37	AW		1			435	435		95	95
Hungary	38	34	38	A		1	3		160	270		40	85
Iceland	50	52	55						380	380	>90	>90	>90
Ireland, Republic of	40	38	37			0.7	1		210	270	30	90	95
Italy	31	28	22				1.2			230			95
Netherlands	39	39	39	AW	1.3	1.5	1.7	205	310	400	>90	>90	97
Norway	35	43	42	AW			1.7		185	272	75	92	96
Poland	41	46							250	270		10	70
Portugal	31	30	29		0.4	0.5	0.7	103	148	266			93
Russia	44	47										45	
Slovak Republic	38	40								400			40
Slovenia	HH:18	HH: 19	HH: 16								>70	>80	>80
Spain	31												
Sweden	43	45	43	AW					360	360		80	90
Switzerland	43	43	43	AW	2	2.5	3.1	370	400	420	85	90	>90
United Kingdom	38	37	35	AW		0.9	1.2		400	308	95	95	95

A = Nonacidogenic sweets generally available; AW = widespread use of nonacidogenic sweets; HH = only household.

dmft (7.80 dmfs) while in 1984, after 5 years on low-fluoride water, children of the same age had 3.92 dmft (13.33 dmfs). This increase took place in spite of the fact that almost all dentifrices contained fluoride. Karjalainen et al. [1994] compared two groups, one of which benefitted from the customary fluoride applications by rinsing or supervised toothbrushing, while for the other the measures at school were discontinued. The latter group had a higher caries prevalence after a 3-year observation period. In countries where school programs comprising topical fluoride treatment are halted, an increase of caries prevalence must be suspected. In some Norwegian counties or districts, the former decline reverted to an increase [Haugejorden, 1994]. Such setbacks are not unexpected: In view of the generally high sugar consumption in Europe and the continued presence of cariogenic plaque microorganism, the cariogenic challenge must be assumed to be as strong as ever. Epidemiological monitoring is important to study further, and single out, such situations.

Conclusions and Summary

During preparation of the symposium, attention was focused on certain questions and hypotheses. Some answers are now available:

(1) In certain countries with low caries prevalence in the primary teeth, there seems to be no further decline.

This hypothesis was supported by the results.

(2) In some countries, the decrease of caries prevalence of the permanent teeth seems to bottom out in children at school age.

At the age of 12 years, the decline has continued in most countries; for age 15, all available data from repeated studies revealed a decrease, which may generally be expected for countries in which caries prevalence at age 12 has declined during the last decade.

Table 6. Public use of fluorides apart from dentifrices, percentage of population and schoolchildren covered

Country	Fluoride in water (W) or salt (S)			Other fluorides[1]		
	1980–1984	1985–1989	1990–1994	1980–1984	1985–1989	1990–1994
Austria	none	none	none			some B at school
Belgium	none	none	S: begun			T, >20 up to age 5
Croatia	none	none	none		B in city schools	
Czech Republic		W: 30	discontinued			
Denmark	none	none	none	R		mostly discontinued
Finland	none	none	none	R and/or T, 30–40		
France	none	S: begun	S: 40–50			
Germany, East	W: 12	W: 19	discontinued	T in kindergarten, 20, discontinued		
Germany, West	none	none	S: begun		B, 3 to >6	
Hungary	none	none	none		some	
Iceland	none	none	none	R, most schoolchildren		
Ireland, Republic of	W: 65	W: 67	W: 67			
Netherlands	none	none	none	some B or T at school, discontinued		
Norway	none	none	none	T, 20–40		
Poland	W: 1	W: 3	W: 1		T 20 to 10	
Portugal	none	none	none		fissure sealant programs	
Russia		W: 15	discontinued			
Slovak Republic		W: 18	discontinued			
Slovenia	None	none	none	T, discontinued	B, 20 to 60	
Spain	none	none	W: 3		some R	
Sweden	none	none	none			
Switzerland	S: 70	S: 74	S: 78	B, 60 to 70		
United Kingdom	W: 9	W: 12	W: 9			
USA		W: 54	W: 56	some R		

[1] Fluoride tablets (T), rinses (R) and brushing (B) in schools.

Table 7. Average DMF experience in 35-year-old adults from Oslo, Norway, and percent reductions from 1973 to 1993

	DMFT	DMFS	DS	MS	FS
1973	19.9	68	6.5	13.3	48.4
1984	18.8	66	3.3	8.8	54.4
1993	14.4	41	1.5	5.3	34.1
Reduction, %	28	40	77	60	30

From Eriksen et al. [1995].

(3) The reduction of permanent-tooth caries is becoming evident in young adults in those countries where the decrease started in the mid-seventies.

The scant data support this hypothesis but more data are needed for both adolescents and young adults.

(4)There is a need to identify the most important factors contributing to the decline in order to give useful advice to the countries where caries prevalence is still high. Fluorides in dentifrices and their usage are certainly not the only factor.

The data collected by the symposium illustrate that well-coordinated and detailed research into apparently minor details is necessary if single or interrelated factors are to be identified with some certainty.

Acknowledgment

Supported by Procter & Gamble.

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Assembled by W. Künzel.

Krejsa O, Mrklas L: Caries experience of 5- and 12-year-old children in the Czech Republic in 1987 and 1993 (abstract). Caries Res 1995;29:300.

Denmark

Assembled by F. R. von der Fehr

Von der Fehr FR: Caries prevalence in the Nordic countries. Int Dent J 1994;44: 371–378.

Estonia

Assembled by W. Künzel.

Finland

Assembled by F. R. von der Fehr.

Von der Fehr FR: Caries prevalence in the Nordic countries. Int Dent J 1994;44: 371–378.

France

Assembled by T. M. Marthaler. The surveys of 1987 and 1991 were a joint effort of the dental institutes of the universities. The French Union for Oral Health also carried out epidemiological studies independently.

Cahen PM, Obry-Musset AM, Grange D, Frank RM: Caries prevalence in 6- to 15-year-old French children based on the 1987 and 1991 national surveys. J Dent Res 1993;72:1581–1587.

Hescot P, Bourgeois D, Berger M: International Collaborative Study of Oral Health Outcomes. Lyon, Centre National de la Recherche Scientifique, 1995.

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Germany

Assembled by W. Künzel. In 1989, a nationwide survey based on a random sample was conducted in former Western Germany. The 1992 survey in Eastern Germany (the former German Democratic Republic) used the same methodology. In both surveys, 13- to 14-year-old children were examined, and the average DMFT for age 12 was obtained by extrapolation. Since then, the relatively independent states have started to set up their own statistics, focussing on ages 6, 9 and 12.

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Pieper K: Epidemiologische Begleituntersuchungen zur Gruppenprophylaxe 1994. Bonn, Deutsche Arbeitsgemeinschaft für Jugendzahnpflege eV, 1995.

Van Steenkiste M, Peschek B, Vöckler B: Kariesbefall, Kariesmorbidität, Sanierungsgrad und Vorkommen von Versiegelungen bei 12jährigen Schülern in Baden-Württemberg. Oralprophylaxe 1993;15:24–28.

Greece

Assembled by T. M. Marthaler. The data were provided by Th. Athanassouli, Athens.

Athanassouli T, Koletsi-Kounari H, Mamai-Homata H, Panagopoulos H: Oral health status of adult population in Athens, Greece. Community Dent Oral Epidemiol 1990;17:82–84.

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Salapata J, Blinkhorn AS, Attwood D: Dental health of 12-year-old children in Athens. Community Dent Oral Epidemiol 1990;18:80–81.

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Hungary

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Czukor J: WHO epidemiológiai viszgálatok Magyarországon 1985-ben és 1991-ben. Fogorv Sz 1994;87:233–235.

Iceland

Assembled by F. R. von der Fehr.

Von der Fehr FR: Caries prevalence in the Nordic countries. Int Dent J 1994;44: 371–378.

Ireland, Republic of

Assembled by D. M. O'Mullane.

O'Mullane D, Whelton H: Caries prevalence in the Republic of Ireland. Int Dent J 1994;44:387–391.

Italy

Assembled by T. M. Marthaler. Since the data collection for the 1990 ORCA symposium, only local studies seem to have been carried out. L. Strohmenger, Milan, Italy, provided data for the Venice and Lazio regions, and R. Ferro, Cittadella supplied those for the Venice region.

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Latvia

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Lithuania

Assembled by W. Künzel.

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Assembled by W. Künzel.

Netherlands

Assembled by G. J. Truin and K. G. König. Data were from The Hague and Veenendaal (table 1), and The Hague, Midden Holland and Texel (table 2). The age groups 17 and 23 were subjects from 4 cities who were included in the national insurance scheme, which comprises 80% of the population (DMFT provided by H. Kalsbeek). The adult statistics were based on a national random sample.

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Kalsbeek H, Verrips GH, Eijkman MAJ, Kieft JA: Change in caries prevalence in children and young adults of different ethnic origin in the Netherlands between 1987 and 1993. Caries Res 1996;30, in press.

Truin GJ, König KG, Bronkhorst EM: Caries prevalence in Belgium and the Netherlands. Int Dent J 1994;44:379–385.

Norway

Assembled by F. R. von der Fehr.

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Portugal

Assembled by T. M. Marthaler. The data were provided by C. Mejia Almeida, Lisbon, Portugal, one of the examiners in the National Oral Health Pathfinders Survey of 1984 and 1990.

Romania

Assembled by V. Vrbic; data provided in part by M. Rusu.

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Russia

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Kuzmina E, Smirnova T, Vasina S, Shaduntz A, Zimina V: Dental caries prevalence in 12-year-old children living in various districts of Moscow region (abstract). Caries Res 1994;28:211–212.
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Serbia, FR Yugoslavia, Kosovo

Assembled by V. Vrbic; data provided by S. Redzepagic, Pristina.

Slovak Republic

Assembled by W. Künzel.

Takac L, Bellus D, Mitrova E, Frankovic K, Kondratova G, Pseniekova I, Lasova G: Projekt zdravia WHO do roku 2000-sucasna situacia a nase predpoklady v stomatologii. Česk Stomatol 1988;88:5–9.

Slovenia

Assembled by V. Vrbic. Most of the results of the various epidemiological studies have been published.

Premik M: Oral health project and the quality of life of Slovene population. Zdrav Var 1994;33:85–90.
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Spain

Assembled by T.M. Marthaler. The data were provided by E. Cuenca e Sala. National Oral Health Pathfinder Surveys were done in 1985 and 1994.

Sweden

Assembled by F. R. von der Fehr.

Von der Fehr FR: Caries prevalence in the Nordic countries. Int Dent J 1994;44: 371–378.

Switzerland

Assembled by T.M. Marthaler. The national data regarding ages 7 and 12 are based on a nationwide random sample. The adult sample was randomly selected from the patient records of randomly selected dental practices. In the Canton of Zurich, the same 16 communities in various regions of the canton were investigated in all years; the children were selected at random within the 16 communities.

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Ukraine

Assembled by W. Künzel. Surveys were made in the capital, Kiev, and Sotschi.

United Kingdom

Assembled by M. C. Downer.

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United States of America

Assembled by J. Brunelle, the National Institute of Dental Research, NIH. All results are based on random samples obtained on the national scale, but there were differences regarding the sampling frames: 1985–1986, survey of employed adults in the USA; 1986–1987, survey of schoolchildren in the USA, and 1988–1991, a national household survey, the National Health and Nutrition Examination Survey (NHANES III). Examinations were done in mobile examination centers. It must be noted that third molars were not included in the DMFT counts. M designates teeth lost because of disease; for adults this was either caries or periodontal disease, or both.

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