International Dental Journal (2008) **58**, 61-70

Dental therapists: a global perspective

David A. Nash, Jay W. Friedman, Thomas B. Kardos, Rosemary L. Kardos, Eli Schwarz, Julie Satur, Darren G. Berg, Jaafar Nasruddin, Elifuraha G. Mumghamba, Elizabeth S. Davenport and Ron Nagel
Kentucky, USA

In 1921, New Zealand began training school dental nurses, subsequently deploying them throughout the country in school-based clinics providing basic dental care for children. The concept of training dental nurses, later to be designated dental therapists, was adopted by other countries as a means of improving access to care, particularly for children. This paper profiles six countries that utilise dental therapists, with a description of the training that therapists receive in these countries, and the context in which they practice. Based on available demographic information, it also updates the number of dental therapists practising globally, as well as the countries in which they practice. In several countries, dental therapy is now being integrated with dental hygiene in training and practice to create a new type of professional complementary to a dentist. Increasingly, dental therapists are permitted to treat adults as well as children. The paper also describes the status of a current initiative to introduce dental therapy to the United States. It concludes by suggesting that dental therapists can become valued members of the dental team throughout the world, helping to improve access to care and reducing existing disparities in oral health.

Key words: Dental therapist, school dental nurse, global dental workforce

Dental caries and periodontal disease, the most prevalent oral diseases, are ubiquitous, preventable, generally progressive, and without effective treatment result in edentulism. Most nations are faced with a shortage of dentists. The introduction of dental therapists to the workforce, then called school dental nurses, began in New Zealand in 1921 following the discovery during World War I of the poor oral health of potential inductees into military service[1]. School dental nurses were trained in a curriculum of two academic years to provide basic preventive and restorative dental care for children in a School Dental Service, with general oversight by district dental officers. New Zealand's effectiveness in utilising school dental nurses/therapists has been well-documented[2-5]. By 1978, a number of countries had developed and deployed dental nurses to improve access to care[6]. Since the 1980s, dental nurses have generally been referred to as dental therapists. More recently the trend has been to integrate dental therapists and dental hygienists as oral health therapists.

The Netherlands serves as an example of how countries are coming to realise the importance of adding dental therapists to the workforce. Dental therapists had not previously been a component of the Dutch oral health care delivery system. Recently, Holland adopted a combined curriculum, expanding dental hygiene to include dental therapy to develop an oral health therapist, and is now enrolling 300 a year in its training programmes[7,8]. At the same time, the number of dentists educated is being reduced by 20%. The Dutch rationale is that in the future significant aspects of basic preventive and restorative care will be provided by these oral health therapists, with dentists performing more complex procedures and treating medically compromised patients. The new Dutch policy is intended to reduce costs and improve access to care.

This paper profiles the utilisation of dental therapists in six representative countries to illustrate the diversity of approaches to developing and deploying dental therapists. It also summarises the recent attempt to introduce dental therapists in the United States. It concludes by suggesting that access to basic dental care will not be available to a major segment of the world's population without the utilisation of dental therapists in the workforce.

Table 1 provides a listing of the countries that have been identified from the literature, various websites, and

0020-6539/08/02061-10
doi:10.1922/IDJ_1819-Nash10

Table 1 Oral health workforce in countries utilizing dental therapists, 2007

Country	Dentists	Population(A)	Population per Dentist	Dental Therapists	Dental Hygienists	Source(B)	Year
Anguilla	2	11,400	5,700	3		1	2000
Australia	8,991	20,155,000	2,242	1,242	577	1, 8	2007
Bahamas	76	727,000	4,250	1	10	5	2004
Bahrain(C)	64	9,755,000	11,359	18	18	3	1993
Barbados	67	277,000	4,134	10	8	1	2006
Belize	35	286,000	8,171	2		1	2006
Benin	54	8,439,000	156,278	8	8	5	2004
Botswana	14	1,765,000	126,071	4		3	1992
Burkina Faso	50	13,228,000	264,560	70		5	2000
Cambodia(E)	335	14,071,000	42,000	88		3	2003
Canada	16,899	32,268,000	1,909	300	14,525	1, 4	2007
Cook Islands	10	18,000	1800	See Note G		1, 3	2001-07
Costa Rica	1,560	4,327,000	2,774	31		2	2000
Estonia	1,076	1,330,000	1,236	20	13	7	2003
Ethiopia	52	77,431,000	1,489,058	32		2	2000
Fiji	32	848,000	26,500	54		1, 3	2004-07
Gabon	42	1,384,000	32,952	55		2	2000
Gambia	18	1,517,000	84,277	1	1	5	2000
Great Britain	32,682	59,800,000	1,830	691(F)	4,722	1, 6, 7	2000-07
Grenada	16	103,000	6,437	5		2	2000
Guyana	34	767,200	38,360	47	2	1	2006
Hong Kong	1,714	6,940,432	4,049	301	60	5	2004
Ireland	1,800	4,148,000	2,304	453	241	6	2000-03
Jamaica	264	2,700,000	10,227	150	10	1	2006
Jordan	982	5,703,000	5,808	120	60	2	2000
Kiribati	2	99,000	49,500	2		2	2000
Lao PDR	367	5,924,000	16,142	11	11	4	1999
Latvia	1,732	2,307,000	1,332	87	177	5	2004
Malaysia	2,550	26,127,700	10,246	2,090		1, 8	2007
Mali	47	13,518,000	287,617	50		2, 3	2000
Marshall Islands	4	60,000	15,000	See Note G		1, 3	2004-07
Mozambique(D)	2	19,792,000	9,896,000	21		3	1996
Myanmar (Burma)(C)	970	50,519,000	52,081	2	2	3	1991
Nepal	100	27,133,000	271,330	7	2	2	2000
Netherlands	8,000	16,408,000	2,051	300	2,000	1	2006
New Zealand	1,836	4,028,000	2,194	660	237	1, 5	2007
Nigeria	2,850	131,530,000	46,151	1,100	400	5	2004
Palau-Belau	2	20,500	10,250	3		1	2006
Paraguay	3,254	6,158,000	1,892	908		1	2006
Seychelles	14	81,000	5,786	28		6	2004
Singapore	987	4,326,000	4,383	183		4	2001
South Africa	4,563	47,432,000	10,395	411	1,000	1	2006
Sri Lanka	1,353	20,743,000	15,331	425		5	2004
Suriname	35	449,000	12,829	70	3	1	2006
Swaziland	11	1,032,000	93,818	2	40	2	2000
Switzerland	4,250	7,300,000	1,717	250	1,400	7	2002
Tanzania	110	38,200,000	347,273	150		1, 3	1985-07
Thailand	6,200	64,233,000	10,360	3,000	70	1, 2	2000
Togo	40	6,145,000	153,625	7		2	2000
Trinidad & Tobago	266	1,305,000	4,906	45		1	2006
U.S.- DT Alaska only	173,500	298,213,000	1,719	11	112,000	1	2007
Viet Nam	1,800	84,238,000	46,799	800		3, 6	2000
Zimbabwe	191	13,010,000	68,115	112	3	5	2004
Total:	281,905	1,158,332,232	4,108	14,441	137,600	----	----

A. Updated to 2006
B. Source
1. Personal communication with public health professionals in respective countries
2. Zillén PA & Mindak M. World Dental Demographics, Internat Dent J, 2000; 50: 194-197.
3 WHO/CAPP (WHO Oral Health Country/Area Profile Programme)
4. Governmental agency referenced in WHO/CAPP.
5. Dental association referenced in WHO/CAPP.
6. Publication in dental journal.
7. EU Manual of Dental Practice, 2004
8. Government Report
C. Estimated at 50% of combined Dental Therapist/Dental Hygienist figure listed in WHO/CAPP.
D. Estimated at 50% of combined Dental Therapist/Dental Assistant figure listed in WHO/CAPP.
E. 88 Assistant Dentists trained in ART + 300 Traditional Dentists not counted.
F. Includes 363 combined Dental Therapist/Dental Hygienist.
G. Dental therapists are deployed in these countries, but an accurate number not available.

personal communication with dental health professionals as employing dental therapists. Currently, 53 countries utilise dental therapists, with over 14,000 existing world-wide. As the table indicates, the utilisation occurs in both developed economies and developing countries; and in countries with both high and low dentist to population ratios.

It should be noted that China has an estimated 25,000 'assistant dentists' who practice independently in rural areas and function in a capacity that could be considered analogous to dental therapists, according to Chinese dental educators[9,10]. However, they are not included in the data as this report focuses on the dental nurse/therapist movement that began in New Zealand.

Profiles of dental therapy in six nations

Table 2 summarises information on the six countries profiled including their population, history of dental therapy, dental therapist/population ratio, dentist/population ratio, dental therapy training programmes, and dental therapist's scope of practice. In many countries, dental therapists provide a full range of preventive services, prepare and place amalgam and composite restorations and preformed stainless steel crowns; perform pulpal therapy, such as pulpotomies; and provide basic periodontal therapy (scaling). Dental therapists in less developed countries, with Tanzania being an example, may be limited to atraumatic restorative treatment (ART) and extractions. In some countries care is provided only to children and in others to children and adults. There is variation among countries and within countries regarding the environment in which dental therapists may practice and the degree of supervision required by a dentist.

New Zealand

As early as the 1890s, the poor state of oral health in the country was recognised. A compulsory School Dental Service (SDS) was proposed in recognition that oral health is vital to general health, early clinical intervention would minimise loss of teeth, and there should be a focus on prevention[1]. However, it was not until 1923 that the pioneering SDS was established, with small clinics on elementary school grounds staffed by 30 school dental nurses under the general (indirect) supervision of district public health dentists. Initially dental nurses were trained to do dental prophylaxis, oral health and dietary instruction, intra-coronal restorations and to extract primary teeth. Now called dental therapists, they provide a full-range of preventive and restorative services, including placement of preformed stainless steel crowns, as well as pulpal therapy on primary teeth

Currently, over 97 % of children under age 13 and 56% of preschoolers participate in the SDS Service, with the virtual elimination of permanent tooth loss[11]. At the end of a school year there is essentially no untreated dental caries in children enrolled in the SDS [3]. Adolescents, ages 13-18, are also provided with government-financed dental care by private dentists.

Until recently, oral health care by dental therapists was limited to children through the SDS. Legislation and registration/licensure now permits them to provide care for adults, following completion of additional training. They can also now work in private dental practices and may also practice independently, but only with a consultative agreement with a dentist[12].

Originally trained in three regional dental therapy schools, training of dental therapists was transferred to New Zealand's national School of Dentistry at the University of Otago in 1999. In 2006, the curriculum for dental therapy and dental hygiene merged into a three academic-year programme, with resultant credentialing in both scopes of practice rather than what had previously been two separate training programmes. An additional dental therapy programme was established in Auckland in 2002 that has also made the transition to a joint therapy/hygiene curriculum.

Most dental therapists remain salaried employees within the SDS with a small number in private practice. There are now 660 registered dental therapists, down from a high of 1,350 in the 1970s; a full time equivalency of approximately 510 therapists caring for the country's 850,000 children. New Zealand has 1,836 dentists and 237 dental hygienists serving a population of just over 4 million[13]. With the introduction of fluoridation in the 1950s, and the subsequent decline in dental caries, the need for a full time dental therapist in each elementary school decreased and many were assigned to multiple school clinics. However, with an increasing population and workforce attrition due to retirement, a shortage in the number of required dental therapists has recently been predicted by the Ministry of Health[14].

The quality of care provided by dental therapists in New Zealand has been documented in a number of reports[2,15-17]. The extraordinarily high rate of participation, nearly 100% of elementary school students, can only be achieved and maintained by providing access to care on school grounds. The dental therapists have been highly valued by the public for more than 80 years[18].

Australia

A SDS staffed by dentists began in Australia in 1915. During subsequent decades, school dentists were able to care for only a small percentage (25%) of the children[19]. Despite widespread dental disease and the shortage of dentists, strong opposition from the dental profession prevented adoption of the school dental nurse until 1964, when a number of New Zealand dental nurses, who had been working as dental assistants, were assigned restorative dentistry roles in the SDS[20,21]. The success of the New Zealand SDS, in particular the high participation rate and social acceptance by the population, led to the

Table 2 History, training and scope of practice of dental therapists (DT) in six selected countries.

	New Zealand	Australia	Canada	Malaysia	Tanzania	Great Britain
Population	4,028,000	20,155,000	32,268,000	26,127,700	38,200,000	59,800,000
Brief History	Pioneered training 29 School Dental Nurses (now called Dental Therapists) in 1920. By 1970 there were 3 DT schools and over 1300 DTs in School Dental Service for pre- and primary school children, with 95% utilization. Training transferred to dental school in 1999 and was combined in 2007 with dental hygiene in a 3 year program. Now only 660 DTs are registered, almost all in public school clinics for children and adolescents up to age 19. DT's can treat adults with additional training as part of teams in conjunction with dentists. Dental Therapists can practice independently with consultative supervision of a dentist, but very few do. A shortage in the number of Dental Therapists is predicted by the Ministry of Health.	Initiated in 1966 by employment of New Zealand trained DTs. In 1966-7, the states of Tasmania and South Australia established training schools. There are now 7 university schools training DTs. By 1979, 280 DTs graduated annually; currently approximately 200 graduate each year. Although most states permit DTs to work in private dental practices and to treat adults, with prescriptive authority required in two states, the large majority (87%) work in the School Dental Service that provides most of children's dental care. A combined dental therapy/dental hygiene degree in Oral Health Therapy is now offered.	Initiated in 1972, two-thirds of DTs (202) are located in the province of Saskatchewan, with 100 DTs spread across other parts of Canada. Dental Therapists work in government programs, prevention programs in public health, community clinics, training institutions, First Nations organizations and private dental clinics as clinicians, health educators, and administrators. Since elimination of the school-based program in 1987, more than half of the DTs in Saskatchewan practice alongside dentists in private practice. Primary orthodontic services may be added to their scope of practice with additional training.	Still called Dental Nurses, the program was started in 1949. Malaysia has trained over 2000 DTs, including students from 19 other countries. All Dental Nurses in Malaysia are females and assigned to the Preschool, Primary and Secondary School Dental Service, providing comprehensive treatment to 90% of children up to age 17. They are not permitted to work in private practice. Most Dental Nurses stay in government service until compulsory retirement at age 55.	In 1955, specially trained dental assistants performed functions similar to current Dental Therapists. The first Dental Therapist training school was established in 1981, a second in 1983, each with 12 students. Although trained to provide more comprehensive treatment, Dental Therapists in Tanzania provide mostly emergency extractions for all ages, due to the extreme shortage of dentists. Other functions include oral health education and ART. Atypically, the ratio of male to female Dental Therapists is 2:1.	Training of Dental Therapists began in 1960 and has since expanded to 15 programs attached to Dental Teaching Hospitals. Dental Care Professionals (DCP) is a recent designation for dental auxiliaries including Dental Therapists, dental hygienists, orthodontic therapists and clinical prosthetists. Most of the training programs now offer a Dental Therapist diploma or a combined dental therapist/dental hygienist B.Sc. in Oral Health Sciences. Dental Therapists are employed in all sectors of dentistry.
DTs/Population /Eligibles (Est.)	660 DTs = 1:61,861 1:1288 Eligibles to Age 18	1,236 DTs = 1:16,307 1:4707 Eligibles to Age 18	300 DTs = 1:110,887 1:1000 Eligibles(Saskatch.-Age 19)	2090 DTs = 1:12,501 1:4784 Eligibles to Age 17	150 DTs = 1:254,667	691DTs = 1:86,541
Dentists/population	1836 Dentists = 1:2194	8,991 Dentists = 1:2242	16,899 Dentists = 1:1909	2,550 Dentists = 1:10,246	110 Dentists = 1:347,273	32,682 Dentists = 1:1830
DT Training Programs	In Years: 2-diploma, 3-degree No. Graduated/yr: 45 ☒ In Dental School ☐ In Dental Therapist School ☒ In University Setting	In Years: 3-degree No. Graduated/yr: 200 ☒ In Dental School ☐ In Dental Therapist School ☒ In University Setting	In Years: 2-diploma No. Graduated/yr: 15-20 ☐ In Dental School ☒ In Dental Therapist School ☐ In University Setting	In Years: 3-diploma No. Graduated/yr: 160 ☐ In Dental School ☒ In Dental Therapist School ☐ In University Setting	In Years: 3-diploma No. Graduated/yr: 24 ☐ In Dental School ☒ In Dental Therapist School ☐ In University Setting	In Yrs: 2¼ -diploma, 3-degree No. Graduated/yr: 215 ☒ In Dental School ☒ In Dental Therapist School ☐ In University Setting
DT Scope of Practice	☒ Exams ☒ X-rays ☒ Diagnosis ☒ Prophylaxis ☒ Coronal Scaling ☐ Root Planing ☒ Topical Fluoride ☒ Sealants ☒ Infiltration Anesthesia ☒ Nerve Block Anesthesia ☒ Amalgam filling ☒ Composite filling ☐ ART ☒ Preformed SS Crown ☒ Pulp therapy (deciduous) ☒ Extraction (deciduous) ☐ Extraction (permanent) ☐ Orthodontics ☒ Children ☒ Adolescents ☒ Adults	☒ Exams ☒ X-rays ☒ Diagnosis ☒ Prophylaxis ☒ Coronal Scaling ☐ Root Planing ☒ Topical Fluoride ☒ Sealants ☒ Infiltration Anesthesia ☒ Nerve Block Anesthesia ☒ Amalgam filling ☒ Composite filling ☒ ART ☒ Preformed SS Crown ☒ Pulp therapy (deciduous) ☒ Extraction (deciduous) ☐ Extraction (permanent) ☒ Orthodontics ☒ Children ☒ Adolescents ☒ Adults	☒ Exams ☒ X-rays ☒ Diagnosis ☒ Prophylaxis ☒ Coronal Scaling ☒ Root Planing ☒ Topical Fluoride ☒ Sealants ☒ Infiltration Anesthesia ☒ Nerve Block Anesthesia ☒ Amalgam filling ☒ Composite filling ☒ ART ☒ Preformed SS Crown ☒ Pulp therapy (deciduous) ☒ Extraction (deciduous) ☒ Extraction (permanent) ☒ Orthodontics ☒ Children ☒ Adolescents ☒ Adults	☒ Exams ☒ X-rays ☒ Diagnosis ☒ Prophylaxis ☒ Coronal Scaling ☐ Root Planing ☒ Topical Fluoride ☒ Sealants ☒ Infiltration Anesthesia ☒ Nerve Block Anesthesia ☒ Amalgam filling ☒ Composite filling ☒ ART ☐ Preformed SS Crown ☒ Pulp therapy (deciduous) ☒ Extraction (deciduous) ☒ Extraction (permanent) ☐ Orthodontics ☒ Children ☐ Adults	☒ Exams ☒ X-rays ☒ Diagnosis ☒ Prophylaxis ☒ Coronal Scaling ☐ Root Planing ☒ Topical Fluoride ☐ Sealants ☒ Infiltration Anesthesia ☒ Nerve Block Anesthesia ☒ Amalgam filling ☐ Composite filling ☒ ART ☐ Preformed SS Crown ☐ Pulp therapy (deciduous) ☒ Extraction (deciduous) ☒ Extraction permanent) ☐ Orthodontics ☒ Children ☒ Adolescents ☒ Adults	☒ Exams ☒ X-rays ☐ Diagnosis ☒ Prophylaxis ☒ Coronal Scaling ☐ Root Planing ☒ Topical Fluoride ☒ Sealants ☒ Infiltration Anesthesia ☒ Nerve Block Anesthesia ☒ Amalgam filling ☒ Composite filling ☐ ART ☒ Preformed SS Crown ☒ Pulp therapy (deciduous) ☒ Extraction (deciduous) ☐ Extraction (permanent) ☐ Orthodontics ☒ Children ☒ Adolescents ☒ Adults
Place of Practice	☒ Government Agency ☒ Non-government Practice	☒ Government Agency ☒ Non-government Practice	☒ Government Agency ☒ Non-government Practice	☒ Government Agency ☐ Non-government Practice	☒ Government Agency ☒ Non-government Practice	☒ Government Agency ☒ Non-government Practice

final approval of school dental nurses practicing in Australia in 1965[22]. The National Health and Medical Research Council recommended that the course of training should be as short as possible in order to maintain the cost-effectiveness of the dental nurse while ensuring competence. Dental nurses were also to be female, and to have their employment restricted to the government service[22].

Prior to 2000, dental therapists were taught largely in non-university schools in a programme of two academic years. However, all programmes are now university-based with a three academic-year curricula at the Universities of Adelaide, Melbourne, Sydney, Queensland, Western Australia, La Trobe and Griffith. These schools offer courses that graduate a single practitioner with both traditional dental therapy and dental hygiene skills. This new practitioner is designated an oral health therapist. However, for both registration/licensure and practice, graduates must designate the application of their skills as either a dental therapist or a dental hygienist, or both; as there is currently no registration/licensure specifically for an oral health therapist. Registration/licensure and practice restrictions vary from state to state.

Dental therapists have been permitted to practice in the private sector in Western Australia since 1977, providing services with the prescription of a dentist to patients of all ages. With the exception of New South Wales, dental therapists now are permitted to work in private dental practices, preschool and community health programmes, and hospital clinics, although 87% still work in the SDS[23]. In 2003, there were an estimated 1,560 registered dental therapists, with 1,242 engaged in practice[23]. In some states, dental therapists can treat adults up to age 25, but generally are restricted to age 18. The overwhelming majority of dental care for children in Australia is provided by dental therapists[24].

Comparing teeth restored by Australian school dental therapists and dentists, Roder found that 2.6% of the restorations placed by dentists were defective, in contrast to 1.8% of those by dental therapists[25,26]. In 1974, he reported that diagnosis and treatment planning decisions between dental therapists and dentists were comparable[27]. This finding was corroborated in a study conducted by the Western Australia Health Department in which it was found that radiographic interpretation and treatment decisions were similar between dentists and dental therapists[28].

Inequalities in oral health and access to dental care are still widespread[29]. Government policy recommendations emphasise the need to develop a sufficient workforce that includes a strong component of associated oral health team members, such as oral health therapists. It is anticipated there will be a continuation and expansion of oral health therapists throughout Australia[30,31].

Canada

In 1963, the Yukon School Dental Care Experiment employed a New Zealand trained dental nurse living in the community to teach prevention, provide fluoride treatments, and refer children in need of dental care to dentists. The demand for service grew quickly and the project expanded to permit the dental nurse to provide simple restorations and extractions of primary teeth as delegated in writing by a dentist.

Lacking sufficient dentists to care for the general population, much less the native Indian (First Nations) and Inuit (Eskimo) populations, and recognising the success of school dental nurses in New Zealand and Australia, a programme to train dental nurses was established at Fort Smith, Northwest Territories in 1972 under the guidance of the Faculty of Dentistry of the University of Toronto[32,33].

Also in 1972, the province of Saskatchewan began training school dental nurses at Wascana Institute of Applied Arts and Sciences in Regina to provide services to children under the Saskatchewan Dental Plan[34]. By the mid-1980s the Saskatchewan Dental Plan employed over 150 school dental therapists. Over 90% of children were enrolled and over 90% of all enrolled children were examined and treated on a yearly basis[35]. Despite this broad acceptance and public support, the school-based programme and the dental therapist training programme at Wascana were eliminated in 1987 due to pressure from private sector dentists and in order to focus on funding for training dental hygienists rather than dental therapists. At that time there were 246 licensed dental therapists practising in Saskatchewan[36]. The school-based programme was transferred to private dental practice, where it continued to be publicly funded on a fee-for-service basis. The high rates of enrolment and completion rates of the school-based programme were never duplicated in the private practice setting and the entire programme was eliminated in 1992.

In 1976, the province of Manitoba developed the Manitoba Children's Dental Program, which was also school-based. The province contracted with Wascana Institute of Arts and Science in Saskatchewan to train school dental therapists for the programme. Due to opposition of Manitoba dentists, the programme was initially limited to rural areas. In 1978, dental therapists in Manitoba also began to be employed in private offices and by Health Canada in First Nations communities. Continued opposition of private practice dentists resulted in the school-based programme being eliminated in 1993 and transferred to private practice.

In 1984, the training programme for dental therapists moved from Fort Smith to Prince Albert, Saskatchewan, due to an inadequate supply of patients in the Fort Smith area. Today, the National School of Dental Therapy at Prince Albert, a component of First Nations University, is the only training programme for dental therapists in Canada. It admits 20 students/year to its two academic-year curriculum with the goal of preparing dental therapists to care for First Nations and Inuit populations on First Nations reserves and in the Northern Territories[33].

At present there are approximately 300 dental therapists practising in Canada; 202 practise in the province of Saskatchewan; 37 positions exist in the three northern territories with about 55 dental therapists being distributed throughout the rest of Canada with the exception of the provinces of Ontario and Quebec[37,38]. There is a vacancy rate exceeding 50% in dental therapy positions in remote communities in the Nunavut and Northwest territories[39]. This is due in part to the social and economic disincentives of practising in isolated communities without professional collegial support. There are a number of dental therapists also employed in private practice in Manitoba. However, because they are not regulated it is not possible to determine the actual numbers of dental therapists in practice there.

In Saskatchewan, dental therapists have been a self-regulating profession for more than 30 years. They must be licensed by the Saskatchewan Dental Therapists Association, and they may practise in all settings as long as they are employed by, or have established a formal referral or consultation process with a dentist. In 2007, 118 of the 202 dental therapists practising in Saskatchewan were practising alongside dentists, hygienists, and assistants in the private sector, including in satellite clinics in smaller rural and First Nations communities, providing care on a fee for service basis[37]. These satellite clinics serve communities that otherwise would not have access to care. About 40 dental therapists are employed by Health Canada or First Nations bands or tribal councils in Saskatchewan.

Outside Saskatchewan, dental therapists are either employed directly by the First Nations and Inuit Health Branch of Health Canada (Canada's Ministry of Health), or by the three northern territorial governments providing oral health services to Inuit and First Nations people. In other provinces, therapists are limited to practising on First Nations/Crown Land and must be directly employed by the federal government or by special agreement. In most regions, dental therapists can examine, diagnose, and develop or modify treatment plans; however, some regions require that initial and some periodic examinations be carried out by dentists. Dental therapists in all regions are able to provide urgent care for patients to alleviate an emergency, without the requirement of a treatment plan by a dentist.

In a 1976 blind-folded study, Ambrose, Hord, and Simpson evaluated restorations placed by Saskatchewan dental therapists. They found the quality of amalgam restorations by dental therapists was better, on average, than those by dentists, and the stainless steel crowns placed were comparable in quality[40]. In1988, Health and Welfare Canada contracted with two past presidents of the Canadian Dental Association to assess the technical quality of dental therapists and dentists using the rating guide developed by Ryge and Synder[41]. The results indicated that the restorations placed by dental therapists were equal to those placed by federal dentists[42]. On further statistical analysis of these same data, Trueblood concluded: "the quality of restorations placed by dental therapists was equal to but more often better than that of those placed by dentists"[43]. The cost-effectiveness of Health Canada utilising dental therapists in providing dental care has also been documented[44].

Malaysia

When Malaysia became an independent country in 1957, the population of seven million was faced with an acute shortage in the dental workforce, a high caries prevalence, described as 'appalling,' and a young population, with more than 50% of the population under age 18[45]. There were approximately 20 dentists in government service, with another 50 in private practice who were concentrated in urban areas[46]. There was no school of dentistry.

The Malayan School for Dental Nurses was established in June, 1949. Patterned after the New Zealand model and located in Penang, it was the first training programme for dental nurses outside of New Zealand. Dental nurse continues to be the accepted nomenclature in Malaysia where they are all females and they are not permitted to practice in the private sector[47]. The School initially trained 50-70 dental nurses each year, and since its founding it has graduated more than 2,000 from Malaysia, and 19 from other countries who have either been sponsored by the WHO or their respective governments[45,48].

It was not until 1976 that the first class of 30 dentists graduated from the newly established School of Dentistry at the University of Malaya in Kuala Lumpur. With two new dental schools opened in 2000, approximately 180 dentists are now graduating annually. This still does not produce enough dentists to achieve the government targeted dentist to population ratio of 1:4,000[48]. Students are sent to other countries for training, and dentists are recruited from other countries. In 2006, the government approved the establishment of five additional dental schools.

The present dentist/population ratio varies from 1:8,779 in urban areas to 1:25,108 in remote states[49]. More dentists will not affect the overall pattern of dental care for school children, almost all of which is provided by dental nurses in government service. Malaysian dentists treat children primarily on referral by dental nurses when required care is beyond their competency and scope of practice. Essentially all of a dentist's practice is devoted to treating adults. Economic incentives are resulting in public sector dentists migrating into private practice. In 1970, the majority of dentists (60%) worked in government programmes, but by 2004 the majority (56%) were in private practice[48]. In an attempt to reverse this trend, in 2003 the government made national service for three years compulsory for all new dental graduates. Nonetheless, dental nurses will continue to be the primary provider of oral health care for Malaysia's children.

The Malaysian government supports free oral health care for the three million children in l7,583 elementary schools, and the two million children in 2,111 secondary schools through its network of 1,969 public dental clinics[49]. The public health service is empowered by law to provide dental examinations and treatment to all enrolled school children. However, treatment requires written consent from parents or guardians.

Practising dental nurses now number 2,090. Implementation of the systematic, incremental dental care system based in the schools, and operated by dental nurses since 1985, has resulted in a sharp decline of decayed teeth and a corresponding increase in restored teeth[48]. The programme has been so successful that by 2003 the school dental programme reached 96% of elementary and 67% of secondary school children. Only a few parents decline treatment by the dental nurses, primarily because they have private dentists. Of those given care, 97% of elementary and 91% of secondary school children were rendered orally fit. The major contributing factor to this increase was in the coverage of elementary schools, which rose from 37% in 1984 to 90% in 2003[49]. This could not have been achieved except through the utilisation of dental nurses. The services by dental nurses are provided in school dental clinics, mobile dental clinics, and by dental teams using portable dental equipment. The goal is to render all school children orally healthy before they leave the school system. Recently, dental nurses have begun caring for pre-school children as well.

The dental profession initially opposed the utilisation of dental nurses, presumably for fear of sub-standard quality of treatment and the possibility of competition. However, there have been no reports of serious injuries or record of litigation or malpractice claims against dental nurses over the 50 years of their existence. Competition with private dentists does not occur as the two treat different segments of society. Dentists are trained primarily to treat adults, while dental nurses constitute the oral health delivery system for children.

Tanzania

Dental therapists in Tanzania date to 1955 when they were known as dental assistants who served as primary providers of dental care in rural areas at the level of a district hospital. Specific training of dental therapists was initiated by the Tanzania-Danish International Development Agency in 1981[50]. Although trained to work for the government in clinics, health centres, and district hospitals, therapists are also able to work in private practices. They are not limited to caring for children and most treat adults due to the pattern of demand for dental services.

Dental therapists train in a three-year programme, at either the Tanga or Mbeya Dental Therapist School. Twelve students are admitted to each school each year. Currently, there are 150 dental therapists practising in Tanzania[51]. After gaining experience in practice, two additional years of training are also available to expand practice skills and profile of practice. The basic three year training programme emphasises oral health promotion, clinical examination, preventive dentistry, atraumatic restorative technique (ART), and simple extractions, whereas the two additional years of training enables individuals to perform restorative care for all carious lesions, extractions including impactions, initial periodontal therapy and fabrication of partial dentures. Historically, society gave priority in training to males; thus, the ratio of male to female dental therapists is approximately 2:1. Current initiatives are attempting to address this gender imbalance.

Tooth extractions comprise most of the dental care because patients fail to seek treatment until dental caries is advanced. Additionally, restorative dental materials are not readily available in government clinics due to their cost. Yet, in countries like Tanzania, with an emerging economy, patient satisfaction can be attained even with therapy such as tooth extraction; and patients are very satisfied with the care they receive from dental therapists[52].

Great Britain

Great Britain initiated training of dental nurses in 1960 at New Cross Hospital. In 1966, the regulatory authority, the General Dental Council (GDC) appointed a group of 28 dentists to assess the quality of dental restorations placed by New Cross 'dental auxiliaries'. They concluded that 91% of the restorations were satisfactory, which was interpreted as an endorsement of their performance[53]. In 1983, the programme was discontinued at New Cross, but was initiated at the London Hospital Medical College (now Barts & The London Queen Mary's School of Medicine and Dentistry) with a small class of eight students. In the 1990s, the number of dental therapists being trained expanded as a result of the Nuffield Inquiry and the GDC's Auxiliary Review Group report[54,55]. The number increased again in 2003 by 150 positions, in recognition that dental therapists have an important role in the delivery of care. Currently over 200 students are accepted each year in 15 programmes, most of which are affiliated or attached to dental schools/dental teaching hospitals. They include: Birmingham Dental Hospital, Bristol Dental Hospital, Cardiff University, Dundee Dental Hospital, Eastman Dental Hospital, Edinburgh Dental Hospital, King's College Dental Hospital, Glasgow Dental Hospital, Greater Manchester School for Professions Complementary to Dentistry, Leeds Dental Institute, Barts & The London St Mary's School of Medicine and Dentistry, Manchester School of Dentistry, Newcastle Dental Hospital, University of Portsmouth School of Professionals Complementary to Dentistry, and Sheffield School of Clinical Dentistry[56].

In the mid-1990s, a combined dental hygiene and dental therapy curriculum was introduced nationally, through dental schools, covering 24 months, later extended to 27 months. Most training programmes now offer the combined programme varying in length from 27 to 36 months (two to three academic years), with the length determined by whether a diploma (certificate) is awarded or a degree - the Bachelor of Science (B.Sc.) in Oral Health. The curriculum is governed and monitored by the GDC and is guided by the document *Developing the Dental Team: Curricula Frameworks for Registerable Qualifications for Professionals Complementary to Dentistr*[57]. Along with other basic dental training and training in traditional dental hygiene skills, the curriculum includes instruction in intra-coronal restorative procedures for primary and permanent teeth, preformed stainless steel crowns for primary teeth, pulp therapy for primary teeth, and extraction of primary teeth.

Currently, 691 dental therapists are practising in a variety of settings and are considered to be full members of the dental team[58]. They treat children and adults and are capable of independent practice, but must practice with a treatment plan developed by a dentist. However, dental therapists have autonomy in implementation of treatment plans, utilising their knowledge to make informed decisions regarding priorities and techniques.

In a 1993 survey of 70 general practitioners, 40% indicated they would employ dental therapists in their practices[59]. A survey in 2003 found that 70% of dentists considered a dental therapist to be a valued member of the dental team, and 54% indicated they could accommodate a dental therapist in their practice. Yet only 16% had ever worked with a therapist. However, 52% indicated they were aware that a dental therapist could provide high quality care[60]. It is anticipated that dentists will be employing more dental therapists in their practices in the future. Despite residual opposition from some of the dental profession and uncertainty regarding the role of dental therapists, the outlook for dental therapy practice in Great Britain continues to improve.

Introducing dental therapists in the United States (Alaska, not the USA as a whole)

In 2000, the Surgeon General of the United States released a report, *Oral Health in America,* documenting deficiencies in access to dental care in the United States, with the resulting disparities in oral health of large segments of the nation's population[61]. As a consequence, there has been renewed interest in the utilisation of dental therapists to address the access and disparities problem[62,63].

Because of the prevalence of dental disease and the chronic shortage of dentists in Alaska, the Alaska Native Tribal Health Consortium, with the support of the Indian Health Service (IHS), in 2003 sent six Alaskans to be trained in dental therapy at the University of Otago, New Zealand's national dental school[64,65]. They returned to Alaska in 2005 to begin practising dental therapy in rural villages, only to be met with a lawsuit by the American Dental Association (ADA) to stop what it considered to be the illegal practice of dentistry[67,68]. The Alaska attorney general's office issued a ruling that dental therapists in the Alaska Tribal health system are not subject to the state dental practice act because they are certified under federal law[68]. An independent assessment of the quality of care provided by the first cohort of Alaskan dental therapists returning from New Zealand concluded that they met every standard of care evaluated and were 'competent providers'[69]. The law suit was settled in 2007, allowing dental therapists to continue to practise in the Alaska tribal system and the ADA agreed to "join forces with programme managers to improve oral health care"[70, 71].

As of 2007, eleven dental therapists who were trained in New Zealand were practising in Alaska.

Currently, training of dental therapists has been initiated in Alaska in a programme developed by the University of Washington School of Medicine's physician assistant programme in cooperation with the Alaska Tribal health system. Major grants from a number of philanthropic foundations supported the development of the programme. Training began in January of 2007, with seven students enrolled in the first year of preclinical training in Anchorage at a new facility developed specifically for the programme. The second year of clinical training will be in existing Tribal clinics in Alaska[72]. The American Association of Public Health Dentistry and the American Public Health Association have endorsed the practice of dental therapists in Alaska[73,74].

Many dentists in the United States, unfamiliar with the development, functioning, and achievements of dental therapists internationally, fear and oppose dental therapists. Ignorance of their role and objection to their use occurred initially in other countries where dental therapists are now accepted and valued[46,75-78]. It is ironic to note that the development of a dental hygienist was met with similar objections in the United States when first introduced in the early 1900s[79]. After an initial period of resistance, American dentists came to understand the valuable role of dental hygienists as integral members of the dental team.

At the current time in the United States, dental therapists are only permitted to practise in the clinics of the Native Alaska Tribal Health Consortium in the state of Alaska.

Conclusion

Since their introduction in New Zealand, dental nurses/therapists have improved access to oral health care in increasing numbers of countries. Multiple studies have documented that dental therapists provide quality care comparable to that of a dentist, within the confines of their scope of practice. Acceptance and satisfaction with the care provided by dental therapists is evidenced

by widespread public participation. Through providing basic, primary care, a dental therapist permits the dentist to devote more time to complex therapy that only a dentist is trained and qualified to provide.

For most countries of the world, there is need for both more dentists and more dental therapists, if the oral health needs of the global population are to be met. For a significant number of individuals throughout the world, access to basic dental care will not be available without the utilisation of dental therapists in the workforce.

Author affiliations

Dr. Nash is the William R. Willard Professor of Dental Education and professor of pediatric dentistry at the College of Dentistry, University of Kentucky, Lexington; Dr. Friedman is a dental consultant and author, Los Angeles, California; Dr. Kardos is professor and Deputy Dean of the University of Otago Faculty of Dentistry, Dunedin, New Zealand; Ms. Kardos is a senior teaching fellow in the Faculty of Dentistry, University of Otago, Dunedin, New Zealand; Dr. Schwarz is professor and Dean of the Faculty of Dentistry, University of Sydney, Sydney, Australia; Dr. Satur is a dental therapist and senior lecturer in oral health therapy at the School of Dental Science, University of Melbourne, Melbourne, Australia; Darren Berg is a Saskatchewan dental therapist, North Battleford, Saskatchewan, Canada; Dr. Nasruddin is professor of community dentistry and Deputy Dean in the Faculty of Dentistry, University of Malaya, Kuala Lumpur, Malaysia; Dr. Mumghamba is a senior lecturer in the department of restorative dentistry, Muhimbili University College of Health Sciences, University of Dar es Salaam, Dar es Salaam, Tanzania; Dr. Elizabeth S. Davenport is a professor of dental education in Barts and The London Queen Mary's School of Medicine and Dentistry in London; and Dr. Nagel an officer in the United States Public Health Service and the dental consultant to the Alaska Native Tribal Health Consortium, Anchorage, Alaska.

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Correspondence to: Dr David A. Nash, College of Dentistry, University of Kentucky, Lexington, Kentucky 40536.0297, USA. Email: danash@email.uky.edu