

The cost-effectiveness of supportive periodontal care: a global perspective

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Abstract

Aim: To evaluate the cost-effectiveness of supportive periodontal care (SPC) provided in generalist and periodontal specialist practices under publicly subsidized or private dental care.

Material and methods: SPC cost data and the costs of replacing teeth were synthesized with estimates of the effectiveness of SPC in preventing attachment and tooth loss and adjusted for differences in clinician's time. Incremental cost-effectiveness ratios were calculated for both outcomes assuming a time horizon of 30 years.

Results: SPC in specialist periodontal practice provides improved outcomes but at higher costs than SPC provided by publicly subsidized or private systems. SPC in specialist periodontal practice is usually more cost-effective than in private dental practice. For private dental practices in Spain, United Kingdom and Australia, specialist SPC is cost-effective at modest values of attachment loss averted. Variation in the threshold arises primarily from clinician's time.

Conclusion: SPC in specialist periodontal practice represents good value for money for patients (publicly subsidized or private) in the United Kingdom and Australia and in Spain if they place relatively modest values on avoiding attachment loss. For patients in Ireland, Germany, Japan and the United State, a higher valuation on avoiding attachment loss is needed to justify SPC in private or specialist practices.

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Supportive periodontal care (SPC) comprises professional therapeutic measures that support patients' own efforts to control periodontal infections and avoid re-infections (Lang et al. 2008). There is a substantial literature that supports the importance of SPC in achieving longterm stability in patients with chronic periodontitis. This stability presents as

Conflict of interest and source of funding statement

The study has no specific source of funding nor was it supported by a grant award. None of the authors or their institutions have any conflict of interests. an absence or a significant reduction in clinical attachment loss and, from the patient's perspective, maintenance of a functional and aesthetic dentition (Nyman et al. 1975, Axelsson & Lindhe 1981, Cortellini et al. 1994, Becker et al. 2001, Serino et al. 2001, Preshaw & Heasman 2005, Eickholtz et al. 2008, Matuliene et al. 2008). The longterm clinical benefit in societal terms, however, will also likely be influenced by the availability of, and access to care, and by ensuring that care provision results in the best use of the available resources.

SPC can be delivered by periodontal specialists or by dentists working with

either private or publicly subsidized patients, and the efficiency of SPC can be addressed through an economic evaluation. In a previous, UK-based, study of cost-effectiveness, we concluded that SPC delivered in specialist periodontal practice would result in greater periodontal stability and higher tooth survival rates than when SPC is delivered in general dental services. These benefits, however, were more expensive, with incremental cost-effectiveness ratios (ICERs) of approximately €290 for each extra tooth-year saved and €1500 per 1 mm less attachment loss over a 30-year period (Gaunt et al. 2008). The costs averted from preserving the

dentition did not entirely offset the costs of SPC provided by periodontal specialists after appropriate discounting (Gaunt et al. 2008).

We acknowledged, however, that these data were specific to the UK systems of dental healthcare and concluded that the model and observations might be sensitive to the costs of SPC in different countries. Consequently, the cost-effectiveness of SPC should be evaluated in different countries and oral health systems.

The objective of this study, therefore, is to evaluate the cost-effectiveness of SPC in different countries and to report ICERs for preserving clinical attachment and avoiding tooth loss based on costs for public, private and specialist periodontal health care systems where those data are available.

Methods

Treatment options

Extensive data on the provision of SPC were collected from Australia. Germany, Ireland, Japan, Spain, Sri Lanka, the United Kingdom and the United States. All countries, with the exception of Spain, Ireland and Germany, reported some form of SPC under a state- or an employer-subsidized system, although in the United States and Australia, this system is available only to those on low incomes. Hence, three SPC options were, where possible, evaluated for each country: SPC provided at a general practice under a state-supported system; SPC provided at a general practice in the private sector; and SPC provided at a periodontal specialist periodontal practice (Fig. 1). The lack of specialist periodontists in Sri Lanka and Japan restricted us to a comparison of state-subsidized and private SPC in those countries.

The economic analysis was undertaken from the perspective of the patient and attempted to include all costs falling on the patient as a result of SPC and restorative treatments. The aim was to quantify the benefits of private or specialist SPC to determine which patient values for these outcomes would justify the SPC provisions. We attempted to quantify the full cost to the patient of each SPC option including the opportunity costs of seeking treatment. It was acknowledged that patients typically pay a fraction of the costs of dental care in publicly subsidized systems and the costs falling directly on governments were ignored. In many countries, patients using private dental care will have a dental insurance plan, and patient fees at point of use will be reduced or zero. Apart from Germany, where it is mandatory, we have assumed that patients do not have private dental insurance. We would expect insurance premiums to broadly reflect patient charges.

Realistic treatment options for patients will depend on whether they access publicly funded dental care (Fig. 1). A patient receiving their routine dental care under the publicly subsidized system (scenario A) had three options: SPC under the publicly subsidized system; private provision of SPC at a generalist practice; or SPC at a specialist periodontal practice (where available). Two options were considered for a patient using private regular dental care (scenario B): SPC at their own dental practice or SPC at a specialist periodontal practice. In Germany, SPC is not available under the publicly subsidized system. We considered patients covered by the state insurance (BEMA) system, around 85% of all patients, and patients with private insurance whose copayments fall under the GOZ tariffs. Patients face the same costs for SPC under both systems; only the costs of replacing lost teeth differ.

Effectiveness of SPC

The data available on the long-term outcomes of SPC are limited. Consequently, any comparative analysis requires assumptions over the additional effectiveness of alternative/more intensive treatment. Previous comparative analysis (Gaunt et al. 2008) estimated attachment loss and tooth loss over 30 years using published data (clinical reference data) (Axelsson & Lindhe 1981). Axelsson and Lindhe (1981) report attachment loss and tooth loss for patients receiving either 40 or 120 min. of clinician's time annually. We assumed that the effectiveness of SPC is purely a function of clinician's time and the effectiveness data were adjusted according to the total clinician's time per year for SPC under each dental healthcare system.



Fig. 1. Possible patient scenarios for overall strategies of periodontal care provision. It is assumed that all patients receive their periodontal treatment at a specialist periodontal practice. For long-term care, there are options for receiving supportive periodontal care (SPC) at the patients' own dental practice in the state or private systems or at a specialist periodontal practice. It is assumed that: (i) restorative care for tooth replacement will be from the patients' own dentists; (ii) a patient whose regular dental care is provided in the private sector will not defer to a state care system for long-term SPC (scenario B).

Exponential functions were fitted to the clinical reference data for clinical attachment loss in the first 3 years of SPC; from the fourth year of SPC; and for tooth loss. A third data point was required to specify an exponential function fitting these criteria and we chose to ensure plausible tooth loss and attachment loss for when clinician time is zero, reflecting no SPC provision, although data on outcomes in the absence of SPC are limited. Natural history data from Sri Lankan tea plantation workers, with untreated periodontal disease, however, suggest a rate of attachment loss of 0.5 mm/year and tooth loss of 0.7 per year for those aged 45 years or over and these may provide a reasonable estimate of disease progression in the absence of SPC (Löe et al. 1986). The functions were chosen to ensure values of 0.5 for tooth loss (an estimate below the upper bound for the Sri Lankan population); 0.5 mm of clinical attachment loss in years 1-3; and 0.5 mm of clinical attachment loss in years 4+ when clinician time was zero. This necessitated applying a kinked function for attachment loss in years 1-3, which assumes a small linear reduction in attachment loss as clinician time increases from 0 to 40 min., followed by an exponential decline in attachment loss as clinician time increases beyond 4 min. These functions are displayed in Fig. 2 and listed in Appendix A1.

The exponential functions chosen allow for a modest gain in clinical attachment from intensive SPC (Nyman et al. 1975, Axelsson & Lindhe 1981, Cortellini et al. 1994). A more conservative assumption is that the maximum achievable effectiveness of SPC is to reduce clinical attachment loss to zero. This would reduce the estimated effectiveness of intensive SPC. Data on clinical attachment loss are intended to refer to the mean attachment loss at all sites in the mouth, and not attachment loss for a single site.

Data source for costs and clinician time

Estimates of patient charges for SPC and clinician's time under publicly subsidized, private and specialist care were collected for the following countries:



Fig. 2. Clinical attachment loss (CAL) and tooth loss as a function of the clinician's time in providing supportive periodontal care. (See text for a detailed explanation.)

Australia, Germany, Ireland, Japan, Spain, Sri Lanka, United Kingdom and United States. We assumed that all patients in the analysis would receive their periodontal treatment at a specialist periodontal practice. Where SPC is primarily delivered by hygienists rather than dentists or specialists, this was reflected in the relevant costs. Data were also collected on patient charges and times for extractions and prosthetic tooth replacement options for teeth lost through periodontal disease: single implant restorations, removable partial dentures and resin-bonded (retained) bridges. Estimates of the proportions of patients receiving each of these replacement options together with those opting for no tooth replacement were made by specialists in each country. Travelling times for patients to generalist and specialist practices were also estimated. Monetary values are for the year 2009.

Calculations of the effectiveness of SPC

The total clinician time under each SPC option was summed for each country. This time was used to estimate the effectiveness of SPC in terms of tooth loss and attachment loss using the functions described above and listed in Appendix A1.

Calculations of overall patient costs

The total patient time (clinical provision and travelling) for SPC was valued against the average wage for that country and added to SPC charges to determine the total cost of SPC from the patient's perspective. The same principle was applied to determine the cost of tooth replacement using each of the

prosthetic methods described above. We assumed that a resin-bonded bridge required three visits by the patient and that a metal-based denture or a single implant restoration required five. We also assumed that any prosthetic work to replace lost teeth would be undertaken by the patient's regular dentist. An overall cost of tooth replacement was calculated as a weighted mean, weighted by the estimated proportion of each type of prosthetic replacement. Where data were available to differentiate the proportion of replacement restorative treatments chosen under publicly subsidized and private care, these were applied.

Overall patient costs were considered the sum of costs for SPC and costs for any teeth replaced due to periodontitis. Tooth loss each year was multiplied by the mean cost of prosthetic tooth replacement. These costs were added to the SPC costs to calculate the total cost of SPC and related tooth loss under each option.

Economic analysis

The economic evaluation technique used in this study was a cost-effectiveness analysis by which the benefit of SPC was quantified using a single effectiveness measure and the additional cost per unit of additional effectiveness provided as a guide as to whether a more effective treatment is worth paying for. The primary outcome measure for the analysis was clinical attachment loss with a secondary outcome of tooth loss. A tooth-year was recorded for each year a tooth was missing/replaced. Costs and outcomes were summed over 30 years assuming a lifetime of treatment. All costs and outcomes were discounted at a rate of 3.5% in line with National Institute of Clinical Excellence (NICE 2008) recommendations. Discounting is standard economic practice and reflects time preference: that is, receiving a benefit now being preferred to receiving a benefit at any point in the future, or alternatively, a cost now being preferred less than a cost at any time in the future. The resulting discounted attachment loss was less than the actual attachment loss that would occur over 30 years because attachment loss near the end of the 30-year period is given a reduced weighting. This reflects the fact that it is experienced later in life and hence for a shorter period of time.

In order to evaluate whether an SPC option offers value for money, the marginal or incremental cost and the marginal benefit of that treatment should be compared with all other reasonable treatment options (Drummond et al. 1997). This was done by calculating the ICER based on the lifetime (30 vear) costs and outcomes for patients under each SPC option. The three SPC options were ranked in order of the overall patient cost in each country. Any option that was more expensive and less effective than another SPC option was identified as being dominated. Any option that was more expensive and less effective than any combination of two other SPC options was considered to be extendedly dominated. (In this case, privately provided SPC was extendedly dominated if there existed a proportion of patients offered publicly subsidized SPC and a proportion offered specialist SPC for which the total effectiveness for the group was superior and the cost was less than if the entire group had received privately provided SPC.) Dominated and extendedly dominated options are never costeffective whatever the value based on the outcome (another option will always be superior), and hence they are eliminated. The remaining SPC options are ranked in order of effectiveness. The incremental effectiveness, the increase in effectiveness for that option over and above the option below it, was calculated and likewise, the incremental cost. The ICER was calculated for each option above the least effective option by dividing the incremental effectiveness by the incremental cost.

ICERs were calculated for tooth loss and for clinical attachment loss for each country, and then converted to US dollars at purchasing power parity exchange rates (Organisation for Economic Cooperation and Development 2010). These exchange rates attempt to equate for differences in the cost of goods and services in each country so that the conversion rate equates the "buying power" of the sum of currency in that country and the equivalent amount in US dollars.

Sensitivity analysis

In order to assess how sensitive our costeffectiveness findings were to assumptions made in modelling the effectiveness of SPC, we explored alternative assumptions for the relationship between clinician time and outcomes. Firstly, the clinical reference data (Axelsson & Lindhe 1981) were extrapolated linearly until tooth loss or clinical attachment loss was reduced to zero, at which point no further gains were assumed. Secondly, we explored the sensitivity of the results to the accuracy of the clinical reference data. We applied the same exponential functions but shifted each curve by 0.1 units. Hence, tooth loss was assumed to be 0.1 teeth higher for each value of clinician's time. And clinical attachment loss in years 1-3 and years 4+ was assumed to be 0.1 mm greater for each value of clinician's time. These assumptions impact on both costs (through tooth loss) and effectiveness. ICERs were recalculated under each scenario. A third sensitivity analysis explored the impact of increasing the discount rate for costs and outcomes to 5%.

Results

The raw data for the cost of SPC, estimated clinician's time to provide SPC over a specified number of patient visits, the cost to the patient of replacing lost teeth and the estimated percentage of patients opting for each restorative treatment option are shown in Table 1. The estimated costs and outcomes used in the cost-effectiveness analysis are presented in Table 2. In each country, the provision of SPC delivered in specialist periodontal practice (where available) is more expensive than SPC provided in a general practice under private contract, whereas SPC provided in a general practice in the publicly subsidized system (where available) is the cheapest option. Clinician's time, and hence inferred effectiveness, is highest under specialist care in each country. Further, in general terms, SPC delivered under private payment is afforded more clinician's time than is the case for publicly subsidized treatment, although this is not the case in the United Kingdom.

Dominated and extendedly dominated options

For patients accessing publicly subsidized care in the United Kingdom, private SPC is dominated by publicly subsidized SPC; private SPC provides the same amount of clinician's time, and hence the same assumed clinical effectiveness but at a higher cost than publicly subsidized treatment. For patients using the publicly subsidized sector in Australia, private SPC is extendedly dominated by periodontal specialist care in the domain of clinical attachment loss. The cost per millimetre of attachment loss averted in moving from private to specialist care is lower than moving from publicly subsidized to privately delivered SPC.

For patients using the publicly subsidized sector in the United Kingdom and Australia, private SPC is not the optimal treatment whatever value the patient places on the outcome evaluated. Hence, this option is discarded and publicly subsidized SPC is compared directly with specialist SPC; the ICER then reports the cost per unit change in outcome in moving from publicly subsidized to specialist-delivered SPC.

Incremental cost-effectiveness ratios

The ICERs for patients receiving their routine dental care from general dentists in the publicly subsidized sector are shown in Table 3. ICERs are calculated for tooth loss and for clinical attachment loss. The ICERs designated "private" refer to the cost-effectiveness of SPC provided in general practice under private contract, assuming patients receive routine care in the publicly subsidized system. The ICERs for clinical attachment loss show the additional cost per millimetre of attachment loss across all tooth sites prevented by seeking SPC from a private treatment from a general practitioner rather than publicly subsidized treatment. Similarly, the ICERs for tooth loss show the cost-effectiveness of SPC with respect to tooth-years as an outcome measure. This is the additional cost per year that a tooth is

	Sri Lanka (Rupee)	USA (Dollar)	Spain (Euro)	Japan (Yen)	Ireland (Euro)	UK (Pound)	Germany (Euro)	Australia (Dollar)
Supportive periodontal care								
State								
Cost	0	50.0	NA	2958	NA	10	NA	0.0
Clinician time	20	45.0	NA	30	NA	20	NA	30.0
Number of visits	2	1.5	NA	4	NA	2	NA	1.5
Private								
Cost	1000	106.0	60.0	15,000	80	37	70	90.0
Clinician time	45	45.0	30.0	75	30	20	38	30.0
Number of visits	4	2.0	1.5	3	2	2	3	2.0
Specialist								
Cost	NA	145.0	150.0	NA	180	51	150	150.0
Clinician time	NA	60.0	45.0	NA	60	30	53	45.0
Number of visits	NA	3.0	2.5	NA	4	4	3	2.5
Cost to patient of replacement	of lost teeth							
State								
Extraction only	0	33	NA	1716	NA	11	0	0
Bridgework	10,000	2086	NA	11,865	NA	129	370	0
Removable prosthesis	0	481	NA	7605	NA	64	80	0
Implant	50,000	3327	NA	350,000	NA	2000	1960	NA
Private								
Extraction only	500	121	50.0	12,000	100	60	20	140
Bridgework	10,000	2,086	250.0	300,000	1000	600	880	1600
Removable prosthesis	3000	1419	250.0	50,000	400	350	340	1000
Implant	50,000	3327	1200.0	400,000	4500	2000	2400	4000
Time taken								
Extraction only	15	20	30.0	35(60)*	30	20	28	30
Bridgework	45	200	60.0	130(240)*	90	100	136	120
Removable prosthesis	120	145	60.0	150(180)*	45	80	92	75
Implant	120	224	180.0	270(480)*	165	230	488	240
Proportion of patients selecting	g prosthesis							
State	51							
Extraction only	5%	23%	NA	8%	NA	15%	14%	40%
Bridgework	15%	31%	NA	65%	NA	45%	51%	15%
Removable prosthesis	75%	30%	NA	13%	NA	40%	28%	45%
Implant	5%	16%	NA	13%	NA	5%	7%	0%
Private								
Extraction only	5%	10%	20%	10%	33%	10%	14%	25%
Bridgework	15%	40%	10%	40%	22%	20%	51%	30%
Removable prosthesis	75%	10%	30%	10%	37%	25%	28%	30%
Implant	5%	40%	40%	40%	7%	20%	7%	15%
Travel time								
Generalist	30	15	30	30	60	30	20	15
Specialist	60	45	45	60	120	60	60	45

Table 1. Data collected from each country: the cost and delivery of supportive periodontal care; cost of replacing missing teeth and the estimated proportion of patients choosing each restorative treatment option

*Figures in brackets refer to private treatment.

Costs are in local currencies; hence, cross column comparisons are not possible.

NA, not applicable.

retained. The cost-effectiveness of SPC provided at a specialist periodontal practice is indicated by the ICERs designated "specialist". These ICERs compare specialist periodontist care with the next best care option. Where "private" SPC is dominated or extendedly dominated, the next best option is publicly subsidized SPC.

The ICERs for patients receiving their routine dental care in general practice in the private sector are shown in Table 4. For patients from the private sector, all ICERs refer to the costeffectiveness of SPC provided at a specialist periodontal practice compared with SPC delivered by their private general practitioner.

Publicly subsidized patients in the United Kingdom and Australia

In the United Kingdom, a publicly subsidized system is used by the majority of the population. These patients should seek specialist SPC if they value the prevention of attachment loss at more than £950 (1450 international dollars) per millimetre avoided over 30 years. Any patient valuing the retention of teeth (compared with prosthetic replacement) at more than £200 (300 international dollars) per year per tooth should also seek SPC from a specialist periodontist. The data and implications are similar in Australia, although in this country, publicly subsidized care is only available to a minority of the population who are financially disad-

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Table 2. Cost and effectiveness data

	Sri Lanka (Rupee)	USA (Dollar)	Spain (Euro)	Japan (Yen)	Ireland (Furo)	UK (Pound)	Germany (Furo)	Australia (Dollar)
	(Rupee)	(Dollar)	(Euro)	(Tell)	(Euro)	(i ound)	(Euro)	(Donar)
Treatment costs for	r SPC (inc travel)							
State	76	116	NA	20,162	NA	46	NA	41
Private	4229	267	110	59,058	239	101	270	234
Specialist	NA	579	425	NA	1036	299	568	511
Cost of tooth repla	cement							
State	6457	1424	NA	64,583	NA	239	414	0
Private	4480	2431	639	304,943	848	661	782	1507
Hygienist time (mi	n)							
State	40	68	NA	120	NA	40	NA	45
Private	80	90	45	225	60	40	113	60
Specialist	NA	180	113	NA	240	120	158	113
Tooth loss per year	r							
State	0.117	0.057	NA	0.033	NA	0.117	NA	0.100
Private	0.030	0.040	0.100	0.030	0.067	0.117	0.034	0.067
Specialist	NA	0.030	0.034	NA	0.030	0.033	0.031	0.034
Attachment loss pe	er year: years 1-3							
State	0.433	0.184	NA	0.000	NA	0.433	NA	0.374
Private	-0.053	0.076	0.374	-0.063	0.236	0.433	0.014	0.236
Specialist	NA	-0.053	0.014	NA	-0.064	0.000	-0.041	0.014
Attachment loss pe	er year: year 4 onwa	rds						
State	0.167	0.071	NA	0.000	NA	0.167	NA	0.144
Private	-0.020	0.029	0.144	-0.024	0.091	0.167	0.005	0.091
Specialist	NA	-0.020	0.005	NA	-0.025	0.000	- 0.016	0.005

Data are from eight countries and for patients receiving SPC in state and private sectors as well as from periodontal specialists. Costs are in local currencies; hence, cross column comparisons are not possible.

NA, not applicable.

Table 3. Incremental cost-effectiveness ratios

	Local current	Local currencies										
	Sri Lanka (Rupee)	USA (Dollar)	Spain (Euro)	Japan (Yen)	Ireland (Euro)	UK (Pound)	Germany (Euro)	Australia (Dollar)				
Tooth loss												
Private	3400	590	NA	1,000,000	NA	D	NA	450				
Specialist	NA	2250	NA	NA	NA	200	NA	650				
Clinical attachment	loss											
Private	17,200	2450	NA	1,300,000	NA	D	NA	ED				
Specialist	NA	4850	NA	NA	NA	950	NA	2700				
Converted to USD a	at purchasing powe	er parity										
Tooth loss												
Private	US\$100	US\$590	NA	US\$8800	NA	D	NA	US\$300				
Specialist	NA	US\$2250	NA		NA	US\$300	NA	US\$450				
Clinical attachme	ent loss											
Private	US\$450	US\$2450	NA	US\$11,050	NA	D	NA	ED				
Specialist	NA	US\$4850	NA	NA	NA	US\$1450	NA	US\$1850				

For patients who receive their routine dental care with a state health care system (scenario A in Figure 2).

Data presented in national currency and when converted to US\$ at purchasing power parity.

NA, not applicable; D, dominated; ED, extendedly dominated.

vantaged, and for those patients, these thresholds may represent significant sums of money.

Publicly subsidized patients in the United States

The publicly subsidized system in the United States is also restricted to disadvantaged patients. Consequently, the high threshold for the cost-effectiveness of specialist SPC is unlikely to represent value for money for these recipients. Privately delivered SPC, however, is not dominated in the United States. For patients accessing the publicly subsidized system who are prepared to pay between \$2500 and \$5000 for each millimetre of attachment loss averted, or who value retaining teeth at \$590– \$2250 per tooth year, private SPC represents good value for money.

Publicly subsidized patients in Japan and Germany

The generous provision of clinician's time and hence assumed greater effectiveness of publicly subsidized SPC in Japan results in a very high ICER for

private SPC (the gain in effectiveness in moving to private SPC is relatively small). Only patients placing high values on avoiding attachment loss or retaining their dentition are likely to regard private SPC as value for money. A similar result is observed in Germany, where the high effectiveness of private SPC results in little additional gain and hence a high cost-effectiveness threshold for specialist SPC. ICERs for Germany are virtually identical whether the patient is covered by BEMA (state provided) or GOZ (privately provided) insurance.

Publicly subsidized patients in Sri Lanka

The ICERs for private SPC in Sri Lanka are notably small. For many patients accessing dental care in the developing world, funds may be extremely limited. Nevertheless, the ICER is a valuable guide to whether patients should access private SPC in countries such as Sri Lanka.

Private patients in Australia, Spain and the United Kingdom

For private patients in the United Kingdom, Australia and Spain, the threshold for the cost-effectiveness of specialist SPC is modest. SPC is good value for money for patients prepared to pay at least £700 (1050 international dollars) in the United Kingdom and €1600 in Spain (2100 international dollars) per millimetre of attachment loss avoided during their lifetime.

Private patients in the United States and Ireland

The threshold for the cost-effectiveness of specialist SPC is higher in the United States and Ireland. In Ireland, this is because of the high specialist costs, whereas in the United States, the generous provision of clinician's time in the private sector reduces the incremental effectiveness of specialist SPC. Clearly, some patients in the United States and Ireland will value avoiding attachment loss at less than ca. \$5000 per millimetre and these patients would be best advised to continue to receive care from their private general dentist.

Sensitivity analyses

Table 5 presents the estimates of the effectiveness of SPC and the ICERs calculated after applying a linear extrapolation of the clinical reference data (Axelsson & Lindhe 1981). Apart from values for the United States, the impact on the ICERs calculated for the primary outcome measure is small. The impact on the secondary outcome measure is larger, with significant changes to the

Table 4. Incremental cost-effectiveness ratios

	Local currencies											
	Sri Lanka	USA	Spain	Japan	Ireland	UK	Ger	Australia				
	(Rupee)	(Dollar)	(Euro)	(Yen)	(Euro)	(Pound)	GOZ (Euro)	BEMA (Euro)	(Dollar)			
Tooth loss	NA	2150	300	NA	1600	150	6650	6650	550			
Clinical attachment loss Converted to USD at purchasing power parity	NA	4700	1600	NA	5350	700	11,200	11,250	2150			
Tooth Loss Clinical attachment loss	NA NA	US\$2150 US\$4700	US\$400 US\$2100	NA NA	US\$1650 US\$5450	US\$200 US\$1050	US\$7800 US\$13150	US\$7800 US\$13,200	US\$350 US\$1450			

For patients who receive their routine dental care in the private sector (scenario B in Figure 2).

Data presented in national currency and when converted to US\$ at purchasing power parity.

NA, not applicable; GOZ, Gebührenordnung für Zahnärzte; BEMA, Bewertungsmaßstab zahnärztlicher Leistungen.

Table 5.	Sensitivity	analysis	for the	linear	extrap	olation	of e	effectiveness	data	from	Axelsson	and	Lindhe	(1981)	I)
		~													

	Sri Lanka	ri Lanka USA Spain Japan Ireland UK O		Geri	nany	Australia			
							GOZ	BEMA	
Publicly funded system									
Tooth loss									
Private	US\$100	ED	_	US\$750	_	D	-	_	ED
Specialist	_	US\$300	_	-	_	US\$300	_	_	US\$350
Clinical attachment loss									
Private	US\$500	US\$2000	_	D	_	D	_	-	ED
Specialist	_	US\$2850	_	_	_	US\$1450	-	_	US\$1800
Patients accessing private c	are								
Tooth loss		US\$200	US\$400	-	US\$600	US\$200	US\$600	US\$600	US\$350
Clinical attachment loss		US\$2000	US\$2050	-	US\$4700	US\$1050	US\$16,050	US\$17,000	US\$1450

Data presented in US\$ at purchasing power parity.

GOZ, Gebührenordnung für Zahnärzte; BEMA, Bewertungsmaßstab zahnärztlicher Leistungen; D, dominated; ED, extendedly dominated.

ICERs for tooth loss in Germany, Japan and the United States. The impact of the linear extrapolation is most significant for tooth loss at larger values of clinician's time because this is where the divergence between the exponential and the linear extrapolations is the largest. The impact of increasing tooth loss and clinical attachment loss by 0.1 unit for all values of clinician's time is minuscule. This is not surprising as the economic analysis considers the relative performance of SPC in different sectors. The impact of discounting at 5% was small; hence, the results can be considered to be valid for discount rates in the range 3-5%.

Discussion

Our analysis suggests that the additional costs of seeking periodontal SPC from either private or periodontal specialist providers compared with the cheapest available SPC are not outweighed by the savings generated by increased tooth retention. In fact, comparison of the results for Germany under the BEMA and GOZ tariffs for tooth replacement indicates that these costs have a relatively minor impact on cost-effectiveness. This, however, does not mean that private or specialist periodontal treatment is not cost-effective. The additional costs are certainly justified if the patient places more value on the outcome than the minimum value indicated by the ICER. The value of private or specialist SPC is relative to the options available to the patient; where publicly subsidized or private treatment from a generalist is effective, the ICER for specialist SPC is likely to be high. Hence, it is appropriate to consider separately the cost-effectiveness of SPC for patients accessing state-supported or private dental care.

The ICERs provide an important indication of which treatment options provide value for money for patients and allow simple comparisons to be made across countries. The calculation of ICERs requires an assumption that each millimetre of attachment loss averted is equally valued, although in reality, patients may place a higher value per millimetre of attachment loss where the existing loss is higher and further loss is likely to compromise a functional dentition. It is also important to keep in mind that clinical attachment loss is gradual and that differences in

outcomes will only manifest themselves fully towards the end of the patient's lifetime. The discounting of attachment loss, a process that places a lower weight on attachment loss occurring later in life, helps to account for this. The calculation of ICERs using discounted attachment loss provides an indication of which treatment option provides the best value for money for the patient based on that patient's valuation of the clinical outcome. The ICERs indicate that private treatment in the United Kingdom and Australia is never the best option in terms of value for money. In contrast, private treatment in Germany appears to be highly effective, resulting in very high thresholds before specialist provision can be considered good value for money.

In the absence of good-quality clinical data on each SPC management option in each country, assumptions on the effectiveness of treatment have to be made in order to evaluate cost-effectiveness. This analysis is based on an assumption that the effectiveness of SPC is a function of total clinician's time. This is not to say that time is the only aspect of treatment to have clinical value, but that clinician's time is a good predictor of the overall effectiveness of SPC. The exponential functions used in the base case make plausible assumptions over outcomes arising from differences in clinician's time in different countries. Indeed, the negative attachment loss values and long-term periodontal benefit associated with the higher clinician times may be the overriding consideration and suggests that there would be no difference in treatment effectiveness if all clinicians in all practices were allotted the same time for provision of care. The sensitivity analysis suggests that the results for the primary outcome measure are reasonably robust to alternative assumptions. The results for the secondary outcome measure are more strongly affected. It is apparent that further long-term studies of the effectiveness of specialist SPC compared with general practice are needed to properly inform considerations of cost-effectiveness.

Conclusion

Across different countries, SPC provided by periodontal specialists results in less clinical attachment loss but at an increased overall cost when compared

with SPC provided in publicly subsidized or private practices. In general, for patients routinely accessing publicly subsidized care, private SPC is not cost-effective; patients placing a higher value on avoiding attachment loss should seek SPC from a specialist periodontist. In Sri Lanka, however, where periodontal specialist SPC is unavailable, SPC in private practice is costeffective for patients placing a relatively modest value on avoiding attachment loss. The threshold of the cost-effectiveness of specialist SPC for patients in private practice varies from \$1000 to \$13,000 per millimetre of attachment loss avoided over 30 years across different countries. This variation is driven primarily by the clinician's time, and hence assumed effectiveness, provided in private practice.

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Clinical Relevance

Scientific rationale for the study: Patient decision making should be supported by evidence of the costeffectiveness of treatments. *Principal finding:* Specialist SPC is more effective than SPC provided in

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Appendix A1: Tooth and attachment loss as functions of clinician's time

c = total clinician time per year in minutes

Tooth loss as a function of clinician time:

Tooth loss = $0.47 \exp(-0.0423c) + 0.03$

state or private practices but the additional cost is not entirely offset through reduced costs of tooth replacement. Only in the United States is SPC in private practice a cost-effective option. Clinical attachment loss as a function of clinician time in the first 3 years:

CAL = 0.5 - 0.00167c for c < 40CAL = 1.362exp(-0.025c) - 0.0678

for c > 40

Clinical attachment loss as a function of clinician time, year 4 onwards: CAL = 0.526exp(-0.0251c) - 0.026

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Practical implications: Based on typical SPC provision for a range of dental care systems, the value patients must place on avoiding further attachment loss must be considered if specialist SPC is to represent good value for money.

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