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An exploratory study of the cost-effectiveness of orthodontic care in seven European countries

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SUMMARY This study investigated the orthodontic treatment of 429 consecutive patients [172 male (40.1 per cent) and 257 female (59.9 per cent)] carried out by 10 orthodontic specialist practitioners in seven European countries [two in the Czech Republic (A and B), two in Germany (A and B), Italy, Latvia, Lithuania, and Netherlands, and two in Slovenia (A and B)]. The median age of the patients at the start of treatment was 13.0 years (minimum 7.3 years maximum 50.3 years). The patients had a range of malocclusions and the majority (97 per cent) were treated with upper and lower fixed appliances.

Real exchange rates were calculated using purchasing power parity (PPP) indicators to allow cross-border comparisons of costs. The Index of Complexity, Outcome and Need (ICON) was used to measure the effectiveness of treatment and cost per ICON point reduction to compare cost-effectiveness of orthodontic treatment between practitioners in different European countries.

The median cost per ICON point reduction for all the cases treated was €57.69. The median cost per ICON point reduction varied greatly between practitioners from €21.70 (Lithuania) to €116.62 (Slovenia A). Analysis of variance and Tukey *post hoc* tests showed the differences in cost-effectiveness between the practitioners to be statistically significant ($P < 0.001$).

The cost per ICON point reduction is a simple and effective method of comparing cost-effectiveness between orthodontic practitioners in different countries.

Introduction

Cost-effectiveness in health care can be defined as 'that intervention indicated relative to the resources consumed' (Atherly *et al.*, 2000). In orthodontics, this is of importance to the patient, the practitioner, and the health care provider. In the case of publicly funded or insurance-based services, cost-effectiveness is of interest to the health care providers, be they a department of health or an insurance company. Where finite resources exist, failure to apply the principles of cost-effectiveness may bring an 'opportunity cost' (Tickle, 1997) manifesting as an unsustainable financial overspend or reduced health care services in other areas. When orthodontic provision is paid for solely by the patient, cost-effectiveness is of interest to both patient and practitioner, as improved cost-effectiveness results in lower patient costs and/or increased practitioner profit.

Orthodontic treatment has been reported to have no effect on quality of life (Shaw *et al.*, 2007), so a cost-effectiveness analysis (CEA) may be more appropriate than a cost-utility analysis. In order to carry out a CEA, a well-defined treatment outcome is required. Orthodontic indices provide a valid and reliable method of measuring treatment outcomes (Shaw *et al.*, 1991). The Index of Complexity, Outcome and Need (ICON) with its internationally agreed values (Daniels and Richmond, 2000) allows quality assurance assessments to be carried out and compared between different operators.

Incremental cost-effectiveness ratios (ICERs) have previously been used to study cost-effectiveness in orthodontics (Richmond *et al.*, 2005). Such ratios are accepted as the 'gold standard' in the health economics community (Karlsson and Johannesson, 1996) and permit the construction of cost-effectiveness league tables to rank practitioners. In order to allow significance testing to be applied to these leagues tables, complex statistical inference techniques such as non-parametric bootstrapping (Efron and Tibrishani, 1993) are required. Although cost per ICON point reduction is only an average cost-effectiveness ratio, it is a simple means of comparing the cost-effectiveness of practitioners without the need for complex statistical advice or software.

'Health tourism' is a commonly used term in the medical and lay press describing the situation whereby patients seek treatment in countries in which they are not normally resident. This situation occurs across the European Union (EU) and has implications for health care planners and providers. Notably, the patient's right to claim remuneration for cross-border orthodontic care without pre-authorization has already been ratified by the European Court (Hermans, 2000). The future is likely to see a rise in health tourism with the possibility also of a trans-European health care provider. The choice of location to receive care will have many factors but the quality and cost of treatment will always be considered. Health care providers and patients may increasingly demand cross-border analysis of both factors.

This study aims to demonstrate a simple method of comparing cost-effectiveness of orthodontic practitioners from different countries within the EU.

Subjects and methods

Ten specialist orthodontic practitioners were visited in seven European countries [two in the Czech Republic (A and B), two in Germany (A and B), Italy, Latvia, Lithuania, and Netherlands, and two in Slovenia (A and B)] during the summer of 2005. Data were collected retrospectively for consecutively treated patients. Cases that had insufficient or inadequate records were excluded, as well as those that involved orthognathic surgery. The costs of surgery for orthognathic patients are complicated to assess and have been shown to be proportionately larger than the associated costs of orthodontic treatment (Kumar *et al.*, 2006).

ICON considers dental aesthetics, crossbites, anterior vertical relationship, upper anterior crowding, and buccal segment relationships. ICON uses the Standardized Continuum of Aesthetic Need (Evans and Shaw, 1987) used in the Aesthetic Component of the Index of Orthodontic Treatment Need. Each component is adjusted by its pre-determined weighting and then totalled to give an ICON score. One author (JD) was formally calibrated in the use of ICON and scores were calculated for pre- and post-treatment study models. Intra-operator reliability testing was carried out by randomly repeating ICON scoring for 10 per cent of the cases at the end of each day of data collection.

Direct treatment costs were recorded as the fee received by the practitioners. These costs were converted into Euros (€) using current exchange rates and then adjusted to reflect real exchange rates as described by Schreyer and Koechlin (2002) using purchasing power parity (PPP) indicators published by the Union Bank of Switzerland (2005). PPP indicators are calculated by comparing the cost of living, domestic goods and services in cities across the world. All cities are compared with Zurich which is given a score of 100. The costs in this study were adjusted according to equivalent United Kingdom PPP score of 99 (Table 1). Cost-effectiveness was calculated as the cost per ICON point reduction for each of the practitioners.

Intra-operator reliability testing was measured graphically by Bland–Altman plots and the root mean square error was calculated. A root mean square error of less than nine for reliability scoring using ICON has been recommended (Richmond *et al.*, 2005).

All data were checked for normality. Data not normally distributed were assessed using a non-parametric Kruskal–Wallis test. A one-way analysis of variance (ANOVA) was used to test normally distributed data with Tukey *post hoc* tests where applicable. Where possible, skewed data were transformed to its natural log to allow an ANOVA to be carried out.

Table 1 ‘Real’ exchange rates applied to costs for countries in this study.

Country	Purchasing power parity indicator conversion ratio	Equivalent value of €1 to the UK consumer
Czech Republic	99/43.8	€2.260
Germany	99/83	€1.193
Italy	99/80.6	€1.228
Latvia	99/42.1	€2.352
Lithuania	99/48.2	€1.933
Netherlands	99/82.5	€1.200
Slovenia	99/60.4	€1.639

Results

A total of 429 cases were included in the study, 172 male (40.1 per cent) and 257 female (59.9 per cent). The median age of the patients at the start of treatment was 13.0 years, with a minimum of 7.3 years and a maximum of 50.3 years. The patients had a range of malocclusions and the majority (97 per cent) were treated with upper and lower fixed appliances.

Bland–Altman plots were constructed to provide a visual appreciation of intra-operator reliability testing. They showed that 87 per cent of pre-treatment and 69 per cent of post-treatment ICON scores lay within 1 standard deviation (SD) of the mean. The 1 SD for pre-treatment scores was 6.5 and for post-treatment scores 2.3 ICON points. The root mean square error was calculated which for pre-treatment ICON scores was 7.83 and for post-treatment ICON scores 2.12.

The median adjusted cost of treatment was calculated for each of the practitioners (Table 2) and ranged from €1119.67 (Lithuania) to €5811.89 (Slovenia A). There were significant differences in the cost of treatment between practitioners (Kruskal–Wallis $P < 0.001$).

The effectiveness of the practitioners was measured in ICON point reduction and acceptability (Table 3). A successful case was one with an ICON score of less than 31 at the end of treatment. The mean ICON point reduction ranged from 39.04 (Czech Republic B) to 57.67 (Lithuania). ANOVA demonstrated significant differences in the mean ICON reduction between practitioners ($P < 0.001$).

The cost-effectiveness was calculated as the cost per ICON point reduction using costs adjusted for PPP

Table 2 Cost of treatment (in Euros) for each of the orthodontic practitioners.

Practitioner	Total number of cases	Median cost of treatment	Range of costs	
			Minimum	Maximum
Czech Republic A	50	1663.47	1117.80	2053.40
Czech Republic B	50	1779.70	1236.80	2252.70
Germany A	47	3217.52	769.50	4489.30
Germany B	50	3773.46	1647.50	6549.60
Italy	50	4912.00	515.80	6876.80
Latvia	35	1689.66	1013.80	2027.60
Lithuania	49	1119.67	335.90	1830.70
Netherlands	47	2856.49	2002.70	3411.40
Slovenia A	14	5811.89	1130.90	9268.50
Slovenia B	37	4761.29	1414.50	9319.40

Table 3 Effectiveness of treatment for orthodontic practitioners measured by the Index of Complexity, Outcome and Need (ICON) point reduction and percentage of cases achieving an acceptable ICON score (<31).

Practitioner	Mean ICON reduction	95% confidence intervals		Standard deviation	Percentage of acceptable cases (ICON < 31)
		Lower limit	Upper limit		
Czech Republic A	46.66	42.96	50.36	13.03	98
Czech Republic B	39.04	34.79	43.28	14.96	70
Germany A	44.40	39.26	49.55	17.52	81
Germany B	46.38	42.18	50.58	14.785	98
Italy	44.06	39.17	48.95	17.20	98
Latvia	48.63	43.67	53.59	14.44	83
Lithuania	57.67	53.39	61.96	14.91	96
Netherlands	52.47	48.66	56.27	12.96	100
Slovenia A	40.57	31.21	49.93	16.21	86
Slovenia B	47.08	41.18	52.98	17.70	95

indicators. The median cost per ICON point reduction for all the cases in this study was €57.70. There was great variation in the median cost per ICON point reduction for the practitioners (Table 4 and Figure 1). These ranged from €21.70 (Lithuania) to €116.62 (Slovenia A) and the differences between practitioners for cost per ICON point reduction were significant (Kruskal–Wallis $P < 0.001$).

The heavily skewed data for cost per ICON point reduction were converted to its natural log to allow an ANOVA to be carried out. This showed a statistically significant difference in cost per ICON point reduction between orthodontic practitioners ($P < 0.001$). Subsequent Tukey *post hoc* tests showed the individual association between practitioners (Table 5).

Table 4 Cost-effectiveness of orthodontic provision for practitioners measured as cost (in Euros) per point reduction of the Index of Complexity, Outcome and Need (ICON).

Practitioner	Median cost per ICON point reduction	Range	
		Lower limit	Upper limit
Czech Republic A	35.05	21.13	89.22
Czech Republic B	45.53	22.77	309.20
Germany A	68.30	27.19	238.77
Germany B	80.94	38.26	216.99
Italy	105.39	36.84	736.80
Latvia	34.56	17.65	140.80
Lithuania	21.70	8.00	50.85
Netherlands	52.23	32.42	160.14
Slovenia A	116.62	22.28	447.01
Slovenia B	102.78	48.77	347.59

Discussion

This cross-sectional study demonstrates a simple and robust method of comparing the cost-effectiveness of orthodontic practitioners within the EU, which has the potential to be routinely used by the practitioners themselves. The ICON was found to be a reliable index, its international validation permits its use across Europe to assess treatment need, complexity and outcome.

The study was retrospective in nature and dependent on volunteers collecting and presenting cases. This may lead to a possibility of some orthodontists selecting their best cases to be scored. Nevertheless, this study showed considerable variability in cost and effectiveness across Europe.

All the practitioners were shown to be effective in their provision of orthodontic care. The percentage of cases achieving an acceptable post-treatment ICON score ranged from 70 to 100. This compares favourably with two previous ICON studies that found 71 and 59 per cent of cases achieved an acceptable outcome (Richmond *et al.*, 2001, 2005). As the 2005 study was carried out prospectively and the practitioners selected randomly, those findings may be a more accurate representation of orthodontic treatment outcome. Other studies investigating the effectiveness of orthodontic provision that have used the Peer Assessment Rating Index have shown great variation in outcomes. The lower outcomes (Kerr *et al.*, 1993, Turbill *et al.*, 1999, Teh *et al.*, 2000) can be partially explained by the high percentage of cases treated with removable appliances or fixed appliances limited to one arch only. Higher outcomes, such as those found in Norway (Richmond and Andrews, 1993) could be explained by the retrospective nature of the study and the voluntary basis of practitioner recruitment.

The findings in the present investigation suggest that there may be significant differences in the cost-effectiveness of orthodontic care when viewed from a pan-European perspective, but this is largely explained by the differences in costs. The prescribing habits of the orthodontists in this study were not sufficiently different to be a significant factor in cost-effectiveness. A larger study is required to confirm that this is the case for all EU practitioners. The true value of a cost-effectiveness study occurs when differences in cost-effectiveness cannot be explained by costs alone. In such a situation, practicing habits should be analysed to identify procedures or appliances that are more cost-effective. Cost per

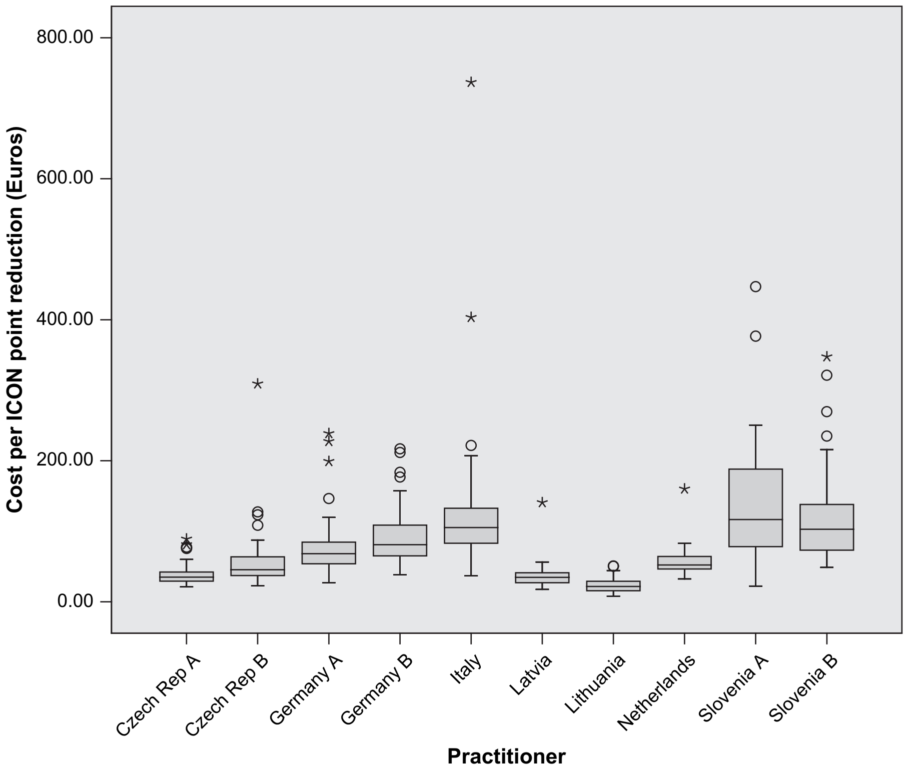

Figure 1 Box plot of data for cost per Index of Complexity, Outcome and Need (ICON) change for practitioners in this study.

Table 5 Statistically significant differences in cost-effectiveness between practitioners for the mean of the natural log of cost per Index of Complexity, Outcome and Need point reduction.

	Czech Republic A	Czech Republic B	Germany A	Germany B	Italy	Latvia	Lithuania	Netherlands	Slovenia A	Slovenia B
Czech Republic A		$P=0.024$	$P<0.001$	$P<0.001$	$P<0.001$	*	$P<0.001$	$P<0.001$	$P<0.001$	$P<0.001$
Czech Republic B			$P=0.004$	$P<0.001$	$P<0.001$	$P=0.006$	$P<0.001$	*	$P<0.001$	$P<0.001$
Germany A				*	$P<0.001$	$P<0.001$	*	*	$P=0.008$	$P<0.001$
Germany B					*	$P<0.001$	$P<0.001$	$P<0.001$	*	*
Italy						$P<0.001$	$P<0.001$	$P<0.001$	*	*
Latvia							$P<0.001$	$P<0.001$	$P<0.001$	$P<0.001$
Lithuania								$P<0.001$	$P<0.001$	$P<0.001$
Netherlands									$P<0.001$	$P<0.001$
Slovenia A										*
Slovenia B										

*Denotes no significant difference in cost-effectiveness.

ICON point reduction offers a simple and robust method for practitioners to calculate the cost-effectiveness of their treatments and to compare their performance with colleagues.

The results of the research are compromised by the small number of orthodontists who took part. The standard of orthodontic treatment provided by the participants in this study may not be representative of orthodontists working in that country. This study was exploratory in nature and to investigate differences in orthodontic provision in detail, a large prospective investigation will be necessary.

The orthodontists from the accession states of the Czech Republic, Latvia, and Lithuania all performed well in terms of cost-effectiveness mainly as a result of the lower costs of care associated with these growing economies. However, unlike other one-off health care interventions, the multiple visit nature of orthodontic care imposes travel and subsistence costs for the health tourist. As a result, cross-border care of this nature is likely to be localized to short car journeys unless the cost differential is significantly great to justify treatments further a field.

Cost-effectiveness league tables are a useful tool for health care planners to allocate finite resources to best treat a population or society as a whole. The accurate construction of these league tables (Karlsson and Johannesson, 1996) involves the exclusion of dominated (the cost effectiveness ratios are usually ranked – the less expensive option dominates) alternatives and recalculation of the ICERs. This means theoretically dismissing the treatment option of using a particular practitioner. Unlike a drug or treatment modality, excluding highly trained practitioners from treating patients on the grounds of cost-effectiveness performance alone is unlikely to be cost-effective. Using cost-effectiveness analyses to identify procedures and appliances that make better use of resources and help implement efficient working practices will enable orthodontists and third-party payment agencies achieve 'value for money'.

Previously, only one publication has considered cost-effectiveness in orthodontics (Richmond *et al.*, 2005). This study used ICON to calculate ICERs and subsequently construct league tables (Fox-Rushby *et al.*, 2001). When constructing league tables, it is important to stress that the order of ranking should be dependent on the statistically significant differences between orthodontists. When orthodontists show similar cost-effectiveness, they should be grouped together rather than ranked.

The use of league tables for the identification of low cost and highly effective orthodontists will be of benefit to the patient, the orthodontist, and third-party payment agencies. The cost per ICON point reduction offers a simple measure that can be used by all parties to evaluate cost-effectiveness.

Conclusions

ICON is a reliable orthodontic index that can be used in cost-effectiveness studies. Cost per ICON point reduction is a simple and effective method of comparing cost-effectiveness between practitioners. By calculating 'real' exchange rates using PPP indicators, treatment costs can be compared between practitioners in different countries.

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