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ORIGINAL ARTICLE

Validity of data collection methods for time spent, professional involvement and treatment volume for the purpose of cost-effectiveness studies in dentistry

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ABSTRACT

Objectives: Economic evaluations can support provision of adequate and affordable oral care, requiring valid information on costs. The aim was to assess the validity of (a) patients' self-report (PS) and routine electronic patient records (EPR) regarding time spent per visit and (b) PS regarding types of treatment and type of dental professionals involved.

Methods: Data were collected in four dental clinics regarding time spent using PS and EPR, on types of treatment and dental professionals involved using PS. As reference standard for time spent, independent research assistants (RA) collected data on time per visit using stopwatches. As reference standard for types of treatment and of dental professionals involved, we used the dental clinic's Electronic Patient Files (DEPF). The two one-sided tests (TOST) equivalence procedure for the difference between paired means for time and kappa statistics for treatment and professional were used to assess agreement of data collection methods with the reference standards.

Results: Equivalence and agreement was good between (a) PS and RA registration concerning waiting time, appointment time and total time spent and (b) EPR and DEPF concerning appointment time. Agreement between PS and DEPF concerning types of treatment was moderate to fair (kappa values between 0.49 and 0.56 for preventive consultation, restoration, radiographs and extractions and between 0.15 and 0.26 for fluoride applications and sealants). Agreement between PS and DEPF for dental professional involved was fair (kappa = 0.41).

Conclusions: Data collection regarding time using PS and EPR was valid. Data collection via PS on treatment and professionals involved were not sufficiently valid and should occur via DEPF.

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Data collection; time registration; economic evaluation; societal perspective

Introduction

Healthcare expenditures comprise a considerable share of total national expenditures in most countries worldwide, with oral health being a significant component. In the Netherlands, health care expenditures are estimated to be 11.2% of the gross domestic product (GDP) [1]. From these health care expenditures was 2.8% related to oral health care [1,2]. This is lower compared to the Scandinavian countries. In Norway, healthcare expenditures were 11.3% in 2020 and 4.6% of total healthcare expenditures represented oral healthcare expenditures [1,3]. Since financial resources are limited treatment choices must be made [4]. Economic evaluations can provide data which these choices can be based on. Since the 1980s, economic evaluation and systematic reviews have been increasingly available in evidence-based dentistry [5].

Countries have different systems of financing dental treatment. For example, in the Netherlands, all dental procedures have fixed maximum rates. Children are covered by a national health insurance, adults have to pay dental treatment out-of-pocket or could voluntarily take out an additional dental insurance. Assuming that there are different options for treating a particular case. Cost-effectiveness analyses (CEA) could then help what intervention is the most cost-effective. These kind of studies will help policymakers to are to select the most cost-effective health policy options [6]. The costs in CEA studies are based on time consumption, type of treatment, and type of dental professional performing the treatment. These factors are relevant because time is costly; one treatment may use more expensive materials than another and type of professional matters since hourly rates differ between dentists, other dental healthcare provider such as dental hygienists and dental assistants. In the medical literature, estimates have been established for certain costs and cost factors [7]. These estimates have mostly been based on collection of additional data by questionnaires or diaries about utilization of healthcare services [8,9].

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Estimates of costs and cost factors of treatments are lacking in dentistry, and evidence is even lacking on the validity of various ways to collect data on cost factors. A likely best method to obtain reliable unbiased data is to use assessors of cost factors that are independent from care. For example, data measuring time spent in a dental clinic could be collected by temporarily providing patients with electronic chips or by using independent research assistants recording the time spent with a stopwatch. An independent research assistant could in addition observe what kind of care professional is performing the treatment. However, even though these methods would provide valid data, they can be too time consuming and expensive for many research settings.

Alternative, these types of time measures and measures of type of care professional could also be retrieved from electronic software systems for patient records (electronic patient record (EPR)) or by asking patients to report data themselves (patient self-report (PS)). Both alternative methods are less time consuming and less expensive as the previous mentioned methods. The type of treatment could be retrieved from Dental clinic's Electronic software for Patient Files (DEPF). Not all dental practices have EPR yet, as an alternative the time for the treatment booked in the calendar on paper could be used. However, the validity of data collecting by EPR or PS should be confirmed. When any of the methods provides valid data, one could make recommendations about collecting data about costs. Therefore, the aim of the present study was to assess the validity of (a) PS and EPR regarding time spent per dental visit and (b) PS and DEPF regarding type of treatment and dental healthcare provider involved in treatment.

Materials and methods

Sample

This study was part of the Dutch 'Healthy teeth, all aboard' (HTAA) project in which the cost-effectiveness of a new approach to prevent dental caries in young children was compared to 'routine' care (Trial NL4174). Prior to the cost effectiveness analysis, data for the present validation study were collected in four dental clinics participating in the HTAA project.

Ethical approval

The Medical Ethics Committee of the University Medical Centre Groningen provided a waiver for full assessment and further required the study to be performed in accordance with the Helsinki Declaration (Ref: METc2014.175).

Power and sample size

In our equivalence test of means, a sample size of 120 achieves 80% power at a 5% significance level when the true difference between the means is 4 min, the standard deviation of the paired differences is 4, and the equivalence limits are −5 and +5 min.

Procedure and measures

The validity of data collection methods to determine cost components of dental treatment was assessed. These methods concerned time consumption (waiting time, time spent in the examination room, patients' travel time), type of treatment, and type of dental healthcare provider. The following data sources were used: EPR, DEPF, PS (*via* a questionnaire), and RA (Independent Research Assistants using stopwatches).

Concerning time measurements, the validity of two different methods of data registration on time spent (EPR and PS) was assessed using RA as a reference standard. Concerning the type of treatment and dental healthcare provider involved, the validity of PS was assessed using DEPF as reference standard. Two RAs participated which were both trained by the researcher. Regarding time consumption, data on the following measures were collected per source:

a. EPR: Electronic patient record (EPR) software typically includes a time-management module that may be used to extract data on time consumption, volumes of treatment, and which dental professional performed the treatment. We measured the scheduled appointment time in EPR minus 5 min (which is the estimated time for clinical set-up and cleaning procedures and administrative tasks.
b. PS: Patients were asked to record (a) the exact hour when entering the dental clinic, (b) the exact hour when entering the dental operatory and (c) the exact hour when leaving the dental operatory. PS waiting time (in minutes) was calculated as the difference of between the moment of entering the dental clinic and of entering the dental operatory. The PS appointment time (in minutes) was calculated as the difference between the moment of entering the operatory and of leaving the operatory. The PS total time spent in the dental clinic (in minutes) was the sum of PS waiting time plus PS appointment time. PS travel time was based on patient self-report and is typically included in economic evaluations as concentration of care can lead to more time spend on this by the patient, i.e. it makes part of the societal perspective.
c. c. RA (reference standard time): The RA time measures were regarded as the reference standard for data on time measurements. The RA recorded (a) when the patient entered the dental clinic by starting the stopwatch; (b) the elapsed time when the patient entered the dental operatory (in minutes and seconds); and (c) the elapsed time when the patient left the dental operatory (in minutes and seconds). The RA waiting time (in minutes and seconds) was the time elapsed from the patient entering the dental clinic to entering the operatory. The RA appointment time (in minutes and seconds) was the time elapsed between the patient's entering and leaving the operatory. The RA total time spent in the dental clinic (in minutes and seconds) was the sum of the RA waiting time plus RA appointment time.

Regarding the type of dental treatment undertaken, data on the following measures were collected per source:

a. PS: Patients were asked what treatment they had received by selecting prewritten choices (preventive consultation, taking radiographs, fluoride application, placement of a pit or fissure sealant, placement of a restoration, extraction, dental hygiene).
b. DEPF (reference standard treatment): DEPF records were regarded as the reference standard for data on type of treatment performed, as RAs could not observe all treatments due to patient privacy. Out of the patient files, the performed treatment were extracted using identical options as the PS (preventive consultation, X-rays, fluoride application, pit and fissure sealant, restoration, extraction, other).

Regarding the type of dental healthcare provider involved, data on the following measures were collected per source:

a. PS: By selecting prewritten choices (dentist, dental hygienist, dental assistant, unsure).
b. DEPF (reference standard professional): The recorded type of dental healthcare provider who had performed the treatment regarded as the reference standard for data on dental healthcare provider involved.

Since all patients in the present project were children, the questionnaire was completed by the accompanying parent. Information regarding Demographic variables, level of education and country of birth was collected. Level of education was dichotomized into low and high, based on the Dutch education system. The highest education level was defined as higher general secondary education or higher. All other education was defined as low education level. The country of birth was divided into born in The Netherlands and not born in the Netherlands.

Statistical analyses

First, descriptive analysis of demographic characteristics of the sample of parents who filled out the questionnaire was undertaken. Second, the validity of the different outcome variables concerning time measurements, type of treatment and type of dental healthcare providers was assessed based on agreement with their reference standards. The hypotheses were formulated to determine whether EPR and PS were equivalent to RA. EPR and PS were compared to the reference standard using the two one-sided tests (TOST) equivalence procedure for the difference between paired means. The TOST procedure is started on the smallest relevant effect size and can be used to statistically reject the presence of effects large enough to be considered as valuable. For the TOST, a difference in time of 5 min or less was considered as neither clinically nor economically relevant [10,11]. *p*-values $<.05$ were considered statistically significant. For the two latter analyses, kappa statistics (κ) were used. The categorization of agreement for types of treatment and professional involved was defined as follows: $\kappa < 0$ poor agreement; 0–0.20 slight agreement; 0.21–0.40 fair agreement; 0.41–0.60 moderate agreement; 0.61–0.80 substantial agreement and 0.81–1.00 almost perfect agreement [12,13]. When κ was <0.61, no satisfactorily equivalency was found between the methods. Analyses were performed in R Version 3.5.1 (SAS Inc., Cary, NC, USA).

Table 1. Time (in minutes) registered by the reference standard (RA), self-reported data (PS), and the dental software (EPR).

Outcome	Method	Mean (SD)	Range	*N*
Waiting time	RA	11.5 (10.4)	(0.5; 76.1)	114
	PS	12.1 (10.4)	(0.0; 75.0)	114
	RA – PS*	−0.6 (3.2)	(−14.1; 6.4)	114
Appointment time	RA	19.6 (9.4)	(4.3; 52.6)	108
	PS	19.0 (9.4)	(2.0; 3.0)	108
	RA – PS*	0.6 (3.5)	(−12.6; 14.7)	108
	RA	20.0 (9.3)	(4.3; 52.6)	119
	EPR	19.6 (10.0)	(5.0; 55.0)	119
	RA – EPR*	0.4 (8.2)	(−22.4; 28.0)	119
Total time	RA	30.4 (12.4)	(7.0; 68.0)	115
	PS	30.5 (12.5)	(7.0; 68.0)	115
	RA – PS*	0.1 (3.8)	(−20.4; 14.2)	115

Result equivalence test: *$p<.01$.

Results

Background characteristics

A total of parents of 131 children participated, of whom 37 (28%) lived in rural and 94 (72%) in urban areas. The mean age of the patients was 12.6 years (SD = 13.0). Eighty-five (72%) accompanying parents had a low educational level and 76 (58%) were of non-Dutch origin.

Equivalence of measures for time

Regarding time, waiting time, appointment time and total time for PS, EPR and RA (reference standard), and the results of equivalence tests for these are shown in Table 1. The mean differences in waiting time, appointment time and total time between RA and PS and between RA and EPR were less than 1 min.

There was equivalence in waiting time and total time between PS and RA. Times recorded for PS and ERP appointment time were equivalent to the RA. No differences were found between the RA (mean 30.4, SD 12.4) and PS (mean 30.5, SD 12.5) concerning total time in dental clinic (95% two one-sided TOST interval: (−0.48, 0.70), $p < .01$).

Agreement of measures for dental healthcare provider involved

Regarding the type of dental healthcare provider, κ for agreement between DEPF and PS for dental healthcare provider was fair (0.41); therefore, DEPF and PS data concerning the type of dental healthcare provider were not equivalent.

Agreement of measures for type of treatment

Regarding the type of treatment, κ was below 0.60 for all treatments. Agreements for preventive consultations, restorations, radiographs and extractions between the DEPF and PS

Table 2. Types of treatment selected and kappa values for agreement between PS and DEPF.

	DEPF (*n*)	PS (*n*)	Kappa value
Preventive consultation	69	77	0.54
Fluoride application	17	8	0.26
Sealant	10	2	0.15
Restoration	30	22	0.62
X-ray	13	6	0.50
Extraction	5	2	0.56

were moderate to substantial ($\kappa = 0.4–0.56$) and were slight to fair in cases of fluoride applications and sealants ($\kappa = 0.15–0.26$). The DEPF and PS data concerning the treatment performed were not equivalent. Patients reported less treatment instances for all treatment types, except for preventive consultations (Table 2).

Discussion

To the best of the authors' knowledge, this is the first published study that compares and validates data collection methods required for cost-effectiveness analyses in dentistry. Time measurements collected through the dental clinic's EPR or through PS were equivalent to the measurements by RA. Data collected via patient self-reporting treatment volumes and type of dental health care provider had moderate to fair agreement with DEPF.

The finding of a good validity of PS and EPR for the collection of time, as no such similar studies have been reported, comparison was not possible. A recent review reported a lack of high quality economic evaluations within child oral health research, highlighting the need for more attention on dental costs and economic evaluations in this field [14]. Poley and Vermaire also concluded that there is a need for improvement of the quality of economic evaluations in dentistry [15]. The present study may contribute to these needs by providing possible ways to collect the desired data in a valid and simple manner.

Concerning time measurement, both PS and EPR were valid methods to collect treatment time data. Since no similar studies were found in the literature, comparison to previous findings was not possible. It should be noted that the data was collected before the COVID-19 pandemic. During the COVID period, the estimated time for clinical set-up and cleaning procedures and administrative tasks is assumed to be expanded.

A fair agreement of PS existed for the item 'dental health care provider involved', which also had no comparative data available. The relatively poor ability to identify the type of dental health care provider might be more of an issue for larger dental clinics with a wider variety of providers working due to task delegation, than it is for solo-practicing 'family' dentists. In dental team practices, children may have not one regular dental care provider and see several different kinds of dental health care providers. The dental practices included in the current study were all group practices. That parents of patients did not know which type of dental health care provider had been treating their child, raises some concerns, both ethical and legal, about the clarity of communication about the specific provider type.

Furthermore, PS was not a valid data collection method for the 'type of treatment performed'. There is a lack of comparable studies. A recent qualitative study suggests that there is a need for more dialogue and openness of dentists with their patients [16]. In the present study, parents did not report all different treatments that were actually performed, possibly explained by a poor communication between the dental provider and parent, leading to the parent being unaware of the treatment provided, which raises legal implications regarding informed consent for care. Another possibility is that the questionnaire design was ambiguous. In addition, of all parents, 16.8% reported a language problem, a putative reason for misunderstanding which type of treatment provided to their child or for misunderstanding of the survey. The proportion of parents with low level of education was also higher than in the national reference population. Individuals with a lower socioeconomic position (SEP) often have lower health literacy, and therefore the results might be different if this study was repeated in a higher SEP population [17].

The low kappa values considering the procedure of an extraction are striking. The children in this study were in average 12.6 years old and presumably changing their deciduous teeth. A possible explanation could be that removing of a deciduous tooth by the oral health professional might not be considered as an extraction.

Strengths and limitations

The particular strength of the present study is that it is the first to measure the validity of data collection methods for dental costs in general dental practices. To put the results in perspective, some points should be considered – first, the choice to appoint the dental systems as reference standard with regard to the treatment provided and the oral health provider type assumes that data are entered completely and accurately into the software systems. Since dental clinics participated voluntarily in this study and were intrinsically motivated, we assume the data to be entered completely and accurately. Second, the estimates of appointment time depend on the accuracy of scheduled time versus time actually spent. For this study, accuracy is likely to be high as treatments were usually technically fairly simple and staff of the participating dental clinics was experienced and well attuned to each other, supporting data validity.

Implications

The results of the present study have several implications for research regarding dental treatment costs. First, the validity of various methods regarding data collection for dental care of children should be confirmed in other settings. Second, further research is needed on whether the present results also apply to adult dental care. Those parents of patients were not able to record validly the type of treatments that

their children had received, might not be applicable for adult patients receiving dental care themselves.

Conclusion

The present findings imply that time measurements using parental self-reports and through electronic patient records are valid methods for the purpose of economic evaluations. The fact that time estimations were appropriate using PS and EPR potentially reduces costs of follow-up research since there is no need for RAs to manually record time-periods. RAs' recording time periods for research purposes takes quite much time of the RAs and thereby makes cost-effectiveness studies expensive. Data on treatment types and oral health provider types should be collected using dental management software systems. This can be embedded into routine practice relatively easily, showing excellent opportunities to collect data for the urgently required estimates of costs of dental care.

Disclosure statement

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