Challenges in dental statistics: survey methodology topics

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ABSTRACT

This paper gathers some contributions concerning survey methodology in dental research, as discussed during the first Workshop of the SISMEC *STATDENT* working group on statistical methods and applications in dentistry, held in Ancona on the 28th September 2011.
The first contribution deals with the European Global Oral Health Indicators Development (EGOHID) Project which proposed a comprehensive and standardized system of epidemiological tools (questionnaires and clinical forms) for national data collection on oral health in Europe. The second contribution regards the design and conduct of trials to evaluate the clinical efficacy and safety of toothbrushes and mouthrinses. Finally, a flexible and effective tool used to trace dental age reference charts tailored to Italian children is presented.

Key words: Dental research; Oral health; Mouthrinse; Toothbrush; Dental age; Statistics

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EUROPEAN GLOBAL ORAL HEALTH INDICATORS DEVELOPMENT PROJECT

Promoting standardized methods of data collection and reporting, in order to facilitate comparison of data at national and international level, has always been a major goal in Public Dental Health. World Health Organisation recommended a basic standardized methodology for conducting epidemiological oral health surveys at global level [1].

Furthermore, is important to encourage the identification of oral health priorities, strategies and objectives that may apply, in particular, at the European Union level.

The European Project EGOHID (European Global Oral Health Indicators Development), initiated and co-ordinated by Prof Bourgeois from the University of Lyon I (France) with the task of implementing an Oral Health Surveillance system in Europe, received the support of the Directorate-General "Health and consumer protection" of the European Commission.

EGOHID initiated in 2002 and since then has involved a panel of international experts (Italy was represented both in Phase I and Phase II) [2, 3] who identified and proposed in 2005 a shared set of 40 oral health indicators [4-6] and in 2008 a comprehensive and standardized system of epidemiological tools (questionnaires and clinical forms) for national data collection on oral health in Europe [7] (Table 1).

These indicators are essential for periodical comparing studies and to support dental public health decision-making at local, national and European level. These comparisons of data can be used as a basis for process, development and quality studies at all levels of care and services in the field of Dentistry.

The proposed set of indicators is based on a thorough literature review of methodologies, analysis of the existing data collection methods and recommendations for which there is agreement on validity and relevance, and for which the majority of EU countries already have available data [8].

The expected results are:

- Facilitation of comparisons of data on oral health essential indicators by promoting the standardization of detection methodology.
- Implement standardized monitoring capabilities, long-term care and oral health activities by national health services.
- Facilitating the standardization of service features in health systems with the purpose to maintain and improve the long-term performance.
- Improvement of the analytical capabilities of the social, economic, and political behavior, with particular attention to the need for intervention in populations and social and health vulnerability.

The EGOHID Phase II identified for each indicator its own collecting methods (Clinical/ Interview survey). Validated recommended common instruments are available on line at www.egohid.eu, where is possible to download the final document [7] with all the definitive formats for clinical forms, questionnaires for adults, children and dental practitioners, along with guidance and training manuals.

DESIGN AND CONDUCTION OF TRIALS TO EVALUATE THE CLINICAL EFFICACY AND SAFETY OF TOOTHBRUSHES AND MOUTHRINSES

The most common diseases of the oral cavity, dental caries and periodontal disease, share the same causative agent: dental plaque, a complex and structured microbial community (biofilm) embedded within a glycoproteic matrix which adheres and develops on the oral surfaces.

Even today, the mechanical removal of the biofilm present on the dental surfaces, through the regular and proper use of the toothbrush and dental floss (self-performed plaque control), represents the most appropriate method for the control of supragingival plaque and the prevention of caries and periodontal disease. Unfortunately, a vast number of the general population do not properly control dental plaque due to poor manual skill and/or scant compliance with oral hygiene recommendations. Furthermore, a large number of individuals, due to their socio-economic-cultural background, do not have regular access to oral care. This does not allow for the periodical reinforcement of oral hygiene habits required for most people, who experience a “physiological” decline in compliance a few months after having received instructions of proper oral hygiene methods [9].

Toothbrushes and antiplaque mouthrinses are the most common dental care tools used to promote individual oral health. In recent years, various forms of manual toothbrush heads and handles have appeared on the market, with the aim of improving plaque removal. Moreover, technological evolution has led to the marketing of electric toothbrushes which have the potential to enhance plaque removal, gingival health and patient motivation [10]. Antiplaque mouthrinses contain a series of chemical agents which act in various ways on the development or maturation of dental plaque [11]. They cannot completely substitute the use of toothbrushes and are therefore considered as adjuncts to mechanical oral hygiene procedures [12].

The number and use of toothbrushes and mouthrinses has notably increased in recent decades. In view of their increasing diffusion in the population, it is essential that their efficacy, not to mention their safety, both of which are often affirmed in advertising slogans, be sustained by scientific evidence, without which dental professionals and the general public

TABLE 1

40 ESSENTIAL ORAL HEALTH INDICATORS (EGOHID PROJECT)
ORAL HEALTH OF CHILDREN AND ADOLESCENTS
A1 Daily toothbrushing with fluoride toothpaste
A2 Preventive care-seeking for pregnant women
A3 Mother's knowledge of fluoride toothpaste for child caries prevention
A4 Fluoridation exposure rates
A5 Preventive oral health programmes in kindergartens
A6 Schools with based programs centered on daily brushing with fluoride toothpaste
A7 Screening oral health programme coverage
A8 Protective sealants prevalence
A9 Orthodontic treatment coverage
A10 Early childhood caries
A11 Decay experience in 1st permanent molars in children
A12 Dental fluorosis
ORAL HEALTH OF GENERAL POPULATION
B1 Daily intake of food and drink
B2 Tobacco usage prevalence
B3 Geographical access to oral health care
B4 Access to primary oral care services
B5 Dental contact within the previous twelve months
B6 Reason for the last visit to the dentist
B7 Reason for not visiting the dentist in the last two years
B8 Tobacco use cessation
B9 Untreated caries prevalence
B10 Periodontal health assessment
B11 Removable denture prevalence
B12 No obvious decay experience
B13 Dental caries severity
B14 Periodontal disease severity
B15 Cancer of the oral cavity
B16 Functional occlusion prevalence
B17 Number of natural teeth present
B18 Edentulous prevalence
ORAL HEALTH SYSTEMS
C1 Cost of oral health services
C2 Gross national product spent on oral health care services
C3 Dentists and other oral care clinical providers
C4 Satisfaction with the quality of care given
C5 Satisfaction with the remuneration provided
ORAL HEALTH-RELATED QUALITY OF LIFE
D1 Oral disadvantage due to functional limitation
D2 Physical pain due to oral health status
D3 Psychological discomfort due to oral health status
D4 Psychological disability due to appearance of teeth and dentures
D5 Social disability due to oral health status

cannot make well informed decisions or, even worse, could be misled.

There are various experimental designs for the conduct of clinical trials aimed at evaluating the antiplaque efficacy of toothbrushes and mouthrinses [13, 14]. Due to the considerable number of products available on the market, a preferable approach is that of the "pyramid", that is the initial evaluation of a large number of products on groups of relatively few subjects. This approach permits a restricted number of agents, formulations or types of toothbrushes, nominated for evaluation by a larger number of subjects.

Short-term plaque regrowth studies are the most commonly used clinical experiments to evaluate the antiplaque activity of mouthrinses and toothbrushes, with opportune modifications in the study design. Particularly for mouthrinses, such studies offer the advantage of assessing the antiplaque action of the formulation divorced from the indeterminate variable of daily toothbrushing.

The most widespread experimental design for the evaluation of mouthrinses is the *4-day plaque regrowth*, to be performed blind and in cross-over [15]. The random assignment of products to participants is carried out according to a Latin square balanced for carryover effects [16, 17]. The study is articulated in periods in which the subjects suspend oral hygiene practice, instead rinsing with the allocated mouthrinse. On day 1 of each period, the participants receive professional plaque removal (polishing). On day 5, subjects are scored for disclosed plaque. Plaque scoring is generally performed using the Turesky et al. modification of the Quigley and Hein plaque index [18, 19]. The introduction of positive controls is expected (chlorhexidine, the most effective antiseptic for plaque inhibition) as well as negative controls (placebo).

An analogous experimental design (observer-masked, cross-over, single use) can also be used to test the plaque removal efficacy of manual/electric toothbrushes. Participants suspend oral hygiene measures for 23-25 hours and after this time interval they use the assigned toothbrush. The efficacy of the removal of plaque is evaluated by measuring the quantity of plaque present before and after a single use of the toothbrush [20, 21]. Also in this study design, positive and negative controls are expected, for example through the use of toothbrush models with various plaque removal efficacies which have been proved by previous studies.

Further to the short-term studies, long-term ones can be performed to demonstrate the efficacy against plaque and more specifically against gingivitis (an inflammatory gingival disease caused by the accumulation of plaque) [22, 23]. These studies for both toothbrushes and mouthrinses last between 3 and 6 months, as the level of safety of the product must be examined and, for mouthrinses exclusively, their efficacy in conjunction with daily tooth-brushing. Long-term studies are usually conducted in parallel and the groups of subjects enrolled must be numerically large enough to ensure a high chance of detecting a difference among the products tested [13, 14].

With regards to the study design, two typologies can be defined in long-term studies: those conducted on patients who present a certain level of plaque and/or gingivitis before taking part in the study, and those conducted on patients affected by gingivitis but subjected to successful treatment prior to enrolment in the study. In this case the efficacy of the mouthrinse or toothbrush is evaluated in the maintenance of gingival health obtained at the baseline, whereas in the first case the efficacy of the product is evaluated by the reduction of the pre-existing plaque and gingivitis. In long-term studies, further to the plaque and gingivitis, other conditions can be evaluated by specific clinical indexes, such as dental/tongue pigmentation (a side effect of some mouthrinses), calculus accumulation (calcified deposit which adheres to the teeth, formed by mineralized plaque which has not been removed), and gingival abrasions (to evaluate the safety of toothbrushes) [24-26]. Furthermore, the appreciation of the subjects of each product can be revealed through structured questionnaires or the visual analogic scale with necessary modifications.

In reporting data obtained by clinical trials, particularly long-term studies, the clinical significance of results should be considered as well as statistical significance, in strict compliance with the guidelines and procedures of the American Dental Association for the concession of the Seal of Acceptance to mouthrinses, toothbrushes and other dental products [27].

TAILORING A REFERENCE CHART TO A SPECIFIC POPULATION: THE CASE OF HÄÄVIKKO'S GROWTH CURVES

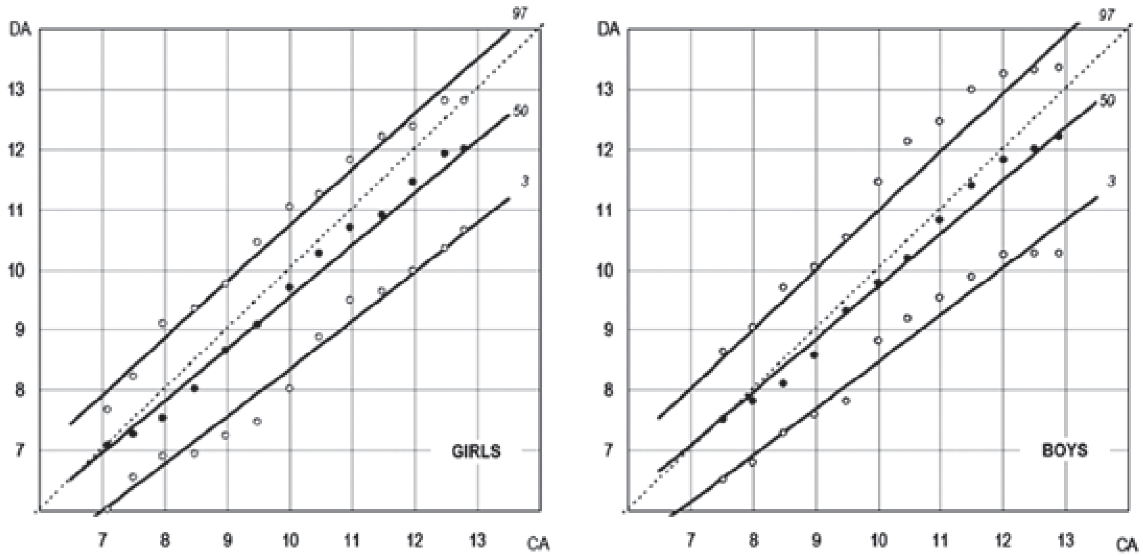
The expression "dental age" (DA) denotes the mean age at which a given stage of dental development is achieved in a population chosen as calibrator. As discussed at length in a previous paper [28], the use of an age-scale to measure maturity implies that, during growth, the teeth undergo a process of "maturation", that is a monotone morphological change from a childish structure to a final or adult structure, ordinarily achieved by all subjects. By definition, in the calibration set a one-year increase in DA corresponds, on the average, to one-year increase of chronological age (CA), except for the extremes of the maturation process. The interval between any two stages of development depends on genetic, nutritional and environmental factors, differs between individuals as well as ethnic groups, and may change slowly with time. So, the rhythm at which the maturation occurs, defined by JM Tanner [29]. as *tempo* of maturation, is a characteristic of a given population in a given period. As a consequence, when DA is determined on subjects of a population different from the calibrator, the relationship of DA to CA may be not linear. All these difficulties are intrinsic to the nature of DA, independently of the method used to assess the dental maturation [30-34].

To show how the LMS method [35] may be used to trace reference charts tailored to a population different from the calibrator, a set of 492 panoramic films were selected among those taken on Italian children (263 girls and 229 boys aged 5.5-14.5 years) who attended an orthodontic check-up at Istituto Stomatologico Italiano of Milan between 1992 and 2003. Subjects having incomplete medical history, or with poor quality films or having conditions that may affect dental development [36] were excluded. DA were derived in accordance with Häävikko's method [33], which was originally defined between 3 and 14 years of CA [37].

Raw running centiles, means and standard deviation of DA distribution conditional on CA were computed [38], the length of the running window (i.e. the number of consecutive DA values sorted by CA on which running centiles are computed) being set equal to 45. The LMS methods, which is still the most commonly used method to trace cross-sectional growth references, was used to trace the charts of DA for Italian children. This method assumes that the distribution of an auxometric trait y (such as DA) at each age may be described by three parameters: the median (M) for position, the coefficient of variation (S) for variability and the Box-Cox parameter (L) allowing for skewness, in the sense that y raised to the L^{th} power becomes gaussian. The three age-

FIGURE 1

REFERENCE CHARTS OBTAINED WITH $L_0M_2S_2$ MODEL



3^{rd}, 50^{th} and 97^{th} centiles of $L_0M_2S_2$ model (solid lines) and 6-month averages of running centiles (open and solid circles). The bisector (dotted line) represents the line where dental and chronological age are identical.

dependent parameters are estimated in terms of three smoothing splines called *L(t)*, *M(t)* and *S(t)* with the penalised likelihood algorithm provided by LMS program version 1.29 [39]. From these curves, at each age, the expected value of the 100α centile of DA distribution at age t is

$$C100_{a}(t)=M(t)\times(1+L(t)\times S(t)\times SDS100_{a})^{1/L(t)}$$

where the standard deviation score (SDS) for a child having DA=*y* and CA=*t* is

$$SDS=\frac{\left(\frac{y}{M(t)}\right)^{L(t)}}{L(t)S(t)}$$

The figure 1 reports the reference charts obtained with $L_0M_2S_2$ model, where the subscripts refer to the equivalent degree of freedom of the smoothing splines. The number of equivalent degrees of freedom represents the best trade-off between smoothness of centiles and goodness of fit in terms of penalised likelihood. *M(t)* and *S(t)* of DA linearly change with CA, whereas *L(t)* is equal 1 at each CA. For both genders, the slope of the 50th centile is lower than 1 (the slope of bisector which represents the line where DA and CA are identical), and the *S(t)* decreases slightly with age. Smooth centiles are rather close to the corresponding raw running centiles, although a slight departure from linearity is apparent. It emerged that a girl whose dental maturation follows the mean maturation of a girl in Häävikko's reference set is on the 50th centile of DA distribution of Italian reference set at 6 years and near the 95th centile at 13 years. Similarly the average boy in the Häävikko's reference set is on the 50th centile at 7 years and on 75th at 13 years.

Häävikko's reference generally tends to underestimate chronological age in Italian children and cannot be used to monitor their dental maturation. The LMS method demonstrated to be a flexible and effective tool to trace DA reference charts and provide adjusted centiles of DA suitable for assessing the dental maturation of the Italian children.

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