






Inter-Examiner Training and Calibration to Assess Dental and Oral Disease in the Elderly

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Abstract

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BACKGROUND: Examiner training and calibration in clinical measurement of important variables is carried out to equalize perceptions among examiners.

AIM: This study aims to obtain intra- and inter-examiner perception similarities after training and calibration in measuring dental caries, tooth mobility, periodontal pockets, and tooth loss in the elderly.

MATERIALS AND METHODS: A total of ten examiners performed clinical measurements of dental caries, tooth mobility, periodontal pockets, and tooth loss. The measurement was carried out by a researcher to examine 25 elderly respondents. The calibration process was carried out twice for each respondent who was examined by each researcher. The results of the assessment were compared with one of the researchers as a reference for assessment (gold standard). Pearson correlation was used to determine the level of intra-examiner agreement, while Cohen's kappa was used to determine inter-examiner reliability.

RESULTS: The results of the intra-rater for calibrations I and II using the Pearson correlation showed significant ($p = 0.000$). The inter-examiner showed almost perfect agreement and increased between calibrations I and II for examination of dental caries (I = $k\ 0.829-1.000$, and II = $k\ 0.871-1.000$), examination of tooth mobility (I = $k\ 0.886-0.944$ and II = $k\ 0.886-1.000$), periodontal pocket examination (I = $k\ 0.855-1.000$, and II = $k\ 0.855-1.000$), and tooth loss examination (I = $k\ 0.955-1.000$, and II = $k\ 0.955-1.000$).

CONCLUSION: The results of intra-examiner measurements showed agreement ($p = 0.000$) and inter-examiner reliability ($k = 0.829-1.000$).

Introduction

One indicator of improvement in the country's development is the increasing life expectancy of the population, which increases the number of elderly people (the elderly) in the country annually. The number of elderly people worldwide is estimated at 500 million, with an average age of 60 years, and by 2025, the number is expected to reach 1.2 billion. The World Health Organization (WHO) claimed that the proportion of the elderly population in Indonesia in 2020 was 11.34% (28.8 million people; an increase of 8.48% since 2005), which is the largest number of elderly people in the world [1].

Increasing age harms a person's ability to maintain oral hygiene; hence, the elderly experience many dental and oral problems, such as tooth loss due to irregular dental examinations and poor oral hygiene [2], which gradually decrease tooth retention. Incomplete sets of teeth make eating uncomfortable and limit the types of food consumed. The production of enzyme-containing saliva also decreases with age, leading to dry mouth, reduced chewing of food, and the possibility of tartar

build-up. All of these factors can affect dental health in the elderly. Tooth loss is an indicator of oral health conditions in adults [3], and currently, the overall prevalence of tooth loss in Indonesia among the elderly is around 12.5% [4].

Tooth loss, which is an indicator of dental and oral health, results in aesthetic, functional, and social disorders that can reduce individuals' quality of life. The World Dental Federation (FDI) and the WHO established the Global Oral Health Goals for 2020, one of which was to reduce the percentage of functional tooth loss in the 35–44 and 65–74 age groups [5]. Tooth loss in the elderly can disrupt daily activities and increase the incidence of severe disease [6].

Tooth loss in the elderly occurs throughout the world due to several factors [7], influenced by dental caries and tooth mobility. There are significant relationships between dental caries and tooth loss, $p = 0.000$ ($p < 0.05$), and between tooth mobility and tooth loss, $p = 0.007$ ($p < 0.05$), in the elderly. However, there was no significant relationship between periodontal pockets and tooth loss in the elderly, as shown by $p = 0.947$ ($p > 0.05$). Dental caries is the most frequent cause of tooth loss (87.6%) [8] and is a

multifactorial process involving dental caries periodontal disease and socio-environmental factors, such as socioeconomic status, education level, income, race, access to services, insurance status, and general health status [9]. Tooth loss is also influenced by attitudes, dental hygiene behavior, culture, and accessibility to dental services [3].

Epidemiological surveillance includes systematic and continuous analysis of the increase and transmission of diseases or health problems/conditions to ensure effective and efficient response through data collection and processing and dissemination of epidemiological information to health program providers, as stated in the Ministry of Health. Health Regulation Number 45 of 2014 concerning the Implementation of Health Surveillance [10].

Oral health surveys involve large populations and multiple teams of examiners, but they often assess dental and oral diseases inconsistently. This may be due to differences in the diagnosis of dental and oral diseases between two or more individuals or by the same examiner on more than one occasion. Another factor that affects inconsistency is variability between examiners due to fatigue or differences in visual acuity and tactile sensation [10].

The reliability of test results has traditionally been estimated by agreement between examiners regarding dichotomous variables (e.g., the presence or absence of disease). The most suitable statistic for assessing inter-examiner reliability is Cohen's kappa coefficient, which estimates the corrected level of agreement with probability. The possible kappa values range from -1 to 1, although they usually range from 0 (no agreement) to 1 (perfect agreement). A negative kappa value indicates disagreement or worse-than-expected agreement [11]. The Pearson correlation test can be used to assess intra-examiner understanding, meaning that the examiner performs the same examination at different times, based on the correlation coefficient $p < 0.05$ [12].

The validation of measurement or inspection data must be carried out by competent personnel who are experts in their fields using calibrated measuring equipment, and the use of valid methods is also vital since it can guarantee the accuracy and precision of measurement or inspection data [13].

Calibration is required to ensure that examiners are checking against the same standard,

ideally following the training and calibration processes suggested by the WHO's Basic Oral Health Survey. The purpose of these training and calibration processes is to minimize variations between examiners, harmony interpretations, and understand and apply criteria for oral conditions such as dental caries, tooth mobility, periodontal pockets, and tooth loss [10].

Materials and Methods

A total of ten examiner (dentists and dental and oral therapists) from the Department of Dental Health, Poltekkes Ministry of Health, Tasikmalaya, Indonesia, participated in training and calibration for a dental and oral health survey. The training was held at the Dental Health Department Campus in May 2021. Benchmark (gold standard) examiners delivered a training program that comprised theory and practice. The gold-standard examiners had to meet the following criteria: They must (1) have studied in the field of dental and oral health, (2) have calibration and simulation trainer qualifications, and (3) has participated in a dental and oral health survey research of the Ministry of Health of the Republic of Indonesia. Training and calibration procedures were conducted at the Department of Dental Health, Poltekkes, Ministry of Health, Tasikmalaya, Indonesia.

In the theory sessions, the trainers explained the clinical examination method for measuring dental caries, tooth mobility, periodontal pockets, and tooth loss based on the WHO standards. The second stage of training consisted of calibration exercises for 25 elderly respondents, each of which was checked twice. Each examiner assesses up to nine people and then analyzes the results of the examination against the gold standard. The purpose of the latter step was to determine intra-examiner understanding through Pearson's correlation test and inter-examiner reliability through Cohen's kappa test.

Ethical considerations

This research has received a research permit from the research ethics committee of the Faculty of Dentistry, Gadjah Mada University, and has been

Table 1: The differences between calibration I and calibration II for each examination variable

| Dental caries | | | Tooth mobility | | | Periodontal pocket | | | Tooth loss | | |
|---------------|-------|------------|----------------|------|------------|--------------------|------|------------|------------|------|------------|
| C1 | C2 | Difference | C1 | C2 | Difference | C1 | C2 | Difference | C1 | C2 | Difference |
| 10.88 | 10.88 | 0.00 | 1.76 | 1.76 | 0.00 | 2.48 | 2.48 | 0.00 | 3.96 | 3.96 | 0.00 |
| 10.92 | 10.88 | -0.04 | 1.72 | 1.72 | 0.00 | 2.52 | 2.48 | -0.04 | 3.96 | 3.96 | 0.00 |
| 10.92 | 10.96 | 0.04 | 1.72 | 1.72 | 0.00 | 2.52 | 2.48 | -0.04 | 3.96 | 3.96 | 0.00 |
| 11.04 | 11.04 | 0.00 | 1.72 | 1.68 | -0.04 | 2.56 | 2.52 | -0.04 | 3.96 | 3.96 | 0.00 |
| 10.96 | 10.88 | -0.08 | 1.72 | 1.72 | 0.00 | 2.48 | 2.44 | -0.04 | 3.96 | 3.96 | 0.00 |
| 11.00 | 11.00 | 0.00 | 1.68 | 1.64 | -0.04 | 2.48 | 2.48 | 0.00 | 3.96 | 3.96 | 0.00 |
| 10.96 | 10.92 | -0.04 | 1.76 | 1.76 | 0.00 | 2.44 | 2.44 | 0.00 | 3.92 | 3.92 | 0.00 |
| 10.92 | 10.88 | -0.04 | 1.72 | 1.72 | 0.00 | 2.44 | 2.44 | 0.00 | 3.92 | 3.96 | 0.04 |
| 11.00 | 10.88 | -0.12 | 1.68 | 1.72 | 0.04 | 2.36 | 2.4 | 0.04 | 3.96 | 3.96 | 0.00 |

C1: Calibration I, C2: Calibration II.

assessed for feasibility and received approval based on the Ethical Examination Pass Certificate Number 00689/KKEP/FGK-UGM/EC/2021.

Results

Based on the results of the examinations, the data for the degree of similarity among examiners agreement are explained in the following sections.

There was almost no difference between calibration I (C1) and calibration II (C2), as shown by differences of no more than 1, as shown in Table 1.

Almost perfect results were obtained for intra-examiner understanding for calibrations I and II for each element of the examination to assess dental caries, tooth mobility, periodontal pocket, and tooth loss using Pearson's correlation ($p = 0.000$), as shown in Tables 2-5.

Table 2: Dental caries intra-examiner results means of dental caries measurements for calibrations I-II

| Examiner | C1 | C2 | Difference (II-I) |
|-----------------------|-------|-------|-------------------|
| 1 | 10.88 | 10.88 | 0.00 |
| 2 | 10.92 | 10.88 | -0.04 |
| 3 | 10.92 | 10.96 | 0.04 |
| 4 | 11.04 | 11.04 | 0.00 |
| 5 | 10.96 | 10.88 | -0.08 |
| 6 | 11.00 | 11.00 | 0.00 |
| 7 | 10.96 | 10.92 | -0.04 |
| 8 | 10.92 | 10.88 | -0.04 |
| 9 | 11.00 | 10.88 | -0.12 |
| p-Pearson correlation | | | 0.000 |

C1: Calibration I, C2: Calibration II.

The inter-examiner reliability (i.e., agreement regarding calibrations I and II) was near-perfect for each element of the examinations to assess dental caries, tooth mobility, periodontal pockets, and tooth loss using Cohen's kappa test ($k = 0.871-1.000$). The results are shown in Table 6.

Table 3: Tooth mobility intra-examiner results means of tooth mobility measurements for calibrations I-II

| Rater | C1 | C2 | Difference (II-I) |
|-----------------------|------|------|-------------------|
| 1 | 1.76 | 1.76 | 0.00 |
| 2 | 1.72 | 1.72 | 0.00 |
| 3 | 1.72 | 1.72 | 0.00 |
| 4 | 1.72 | 1.68 | -0.04 |
| 5 | 1.72 | 1.72 | 0.00 |
| 6 | 1.68 | 1.64 | -0.04 |
| 7 | 1.76 | 1.76 | 0.00 |
| 8 | 1.72 | 1.72 | 0.00 |
| 9 | 1.68 | 1.72 | 0.04 |
| p-Pearson correlation | | | 0.000 |

C1: Calibration I, C2: Calibration II.

Table 6 shows the inter-examiner agreement for calibrations I and II. There was near-perfect agreement, which increased between calibrations I and II, for the dental caries examinations (I $k = 0.829-1.000$, and II $k = 0.871-1.000$), the tooth mobility examinations (I $k = 0.886-0.944$ and II $k = 0.886-1.000$), the periodontal pocket examinations (I $k = 0.855-1.000$, and II $k = 0.855-1.000$), and the tooth loss examinations (I $k = 0.955-1.000$, and II $k = 0.955-1.000$).

Table 4: Periodontal pocket intra-examiner results means of pocket measurements for calibrations I-II

| Rater | C1 | C2 | Difference (II-I) |
|-----------------------|------|------|-------------------|
| 1 | 2.48 | 2.48 | 0.00 |
| 2 | 2.52 | 2.48 | -0.04 |
| 3 | 2.52 | 2.48 | -0.04 |
| 4 | 2.56 | 2.52 | -0.04 |
| 5 | 2.48 | 2.44 | -0.04 |
| 6 | 2.48 | 2.48 | 0.00 |
| 7 | 2.44 | 2.44 | 0.00 |
| 8 | 2.44 | 2.44 | 0.00 |
| 9 | 2.36 | 2.4 | 0.04 |
| p-Pearson correlation | | | 0.000 |

C1: Calibration I, C2: Calibration II.

Discussion

Epidemiological examinations conducted on large populations require more than one examiner; hence, they require common perceptions of measurements to ensure that examination results are consistent and accurate, both between and within examinations. In this study, measurements of dental caries, tooth mobility, periodontal pockets, and tooth loss were taken. These variables were analyzed using Pearson's correlation test to measure determine the degree of similarity among examiners, while Cohen's kappa analysis was used to determine inter-examiner reliability.

Table 5: Tooth loss intra-examiner results means of tooth loss measurements for calibrations I-II

| Rater | C1 | C2 | Difference (II-I) |
|-----------------------|------|------|-------------------|
| 1 | 3.96 | 3.96 | 0.00 |
| 2 | 3.96 | 3.96 | 0.00 |
| 3 | 3.96 | 3.96 | 0.00 |
| 4 | 3.96 | 3.96 | 0.00 |
| 5 | 3.96 | 3.96 | 0.00 |
| 6 | 3.96 | 3.96 | 0.00 |
| 7 | 3.92 | 3.92 | 0.00 |
| 8 | 3.92 | 3.96 | 0.04 |
| 9 | 3.96 | 3.96 | 0.00 |
| p-Pearson correlation | | | 0.000 |

C1: Calibration I, C2: Calibration II.

Based on the results of Pearson's correlation analysis, which measured intra-examiner understanding of the dental caries measurement, the results showed strong understanding between the first and second calibrations for the measurements of tooth mobility ($p = 0.000$), periodontal pockets ($p = 0.000$), and tooth loss ($p = 0.000$). The results of the kappa test, which measured intra-examiner reliability, showed no significant difference in assessing dental caries, tooth mobility, periodontal pockets, and tooth loss ($k = 0.829-1.000$), and there was an increase in reliability from calibration I to calibration II, meaning that (both intra- and inter-personally) the measurements in the examinations were consistent and accurate.

The results of the Dental Caries kappa analysis, which measured inter-examiner reliability, revealed near-perfect agreement, which increased between the first and second calibrations for dental caries (I = $0.829-1.000$, and II = $0.871-1.000$), tooth mobility (I = $0.886-0.944$, and II = $0.886-1.000$), periodontal

Table 6: Kappa inter-examiner

| Measurement results | Rater 1 | Rater 2 | Rater 3 | Rater 4 | Rater 5 | Rater 6 | Rater 7 | Rater 8 | Rater 9 |
|---------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| C1 | | | | | | | | | |
| DMF | 0.957 | 0.914 | 0.829 | 0.871 | 0.957 | 0.914 | 0.957 | 1.000 | 0.914 |
| Tooth mobility | 0.886 | 0.888 | 0.886 | 0.888 | 0.889 | 0.943 | 0.886 | 0.888 | 0.944 |
| Periodontal pocket | 0.952 | 0.855 | 0.903 | 0.855 | 0.855 | 0.952 | 1.000 | 1.000 | 0.903 |
| Tooth loss | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.955 | 0.955 | 1.000 |
| C2 | | | | | | | | | |
| DMF | 0.957 | 0.871 | 0.871 | 0.871 | 0.957 | 0.914 | 1.000 | 0.957 | 0.871 |
| Mobility | 0.886 | 0.888 | 0.886 | 0.943 | 0.889 | 1.000 | 0.886 | 0.888 | 0.888 |
| Pocket | 0.952 | 0.903 | 0.855 | 0.903 | 0.904 | 0.952 | 1.000 | 0.904 | 0.952 |
| Tooth loss | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.955 | 1.000 | 1.000 |

C1: Calibration I, C2: Calibration II.

pockets (I 0.855–1000, and II 0.855–1000), and tooth loss (I (0.955–1000, and II 0.955–1000).

Differences in intra-examiner understanding and inter-examiner agreement may have arisen due to factors such as fatigue or differences in visual acuity, fluctuating interest in research, and variations in tactile sensation [10], in addition to a possible lack of training and calibration time leading to reduced clinical assessment skills [13].

The Pearson correlation statistic is used to test the strength of intra-examiner agreement, while the Kappa statistic is used to test inter-examiner reliability. The importance of understanding and reliability in collecting data from the measured variables is a true representative and there are similarities in measurements [13].

Conclusion

1. There was strong intra-examiner reliability in measuring dental caries, tooth mobility, periodontal pockets, and tooth loss ($p = 0.000$).
2. There was near perfect inter-examiner reliability in the measurements of dental caries, tooth mobility, periodontal pockets, and tooth loss (0.829–1.000).

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