ORIGINAL ARTICLE

Comparison of Plaque Index (PI) calculation time between a Digital Dental Calculator (DDC) app and the manual method: a quasi-experimental study

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ABSTRACT

Introduction: Dental plaque is a soft biofilm that accumulates on the tooth surface and around the gingival margin. If not properly managed, it can lead to oral diseases such as gingivitis. The manual assessment of the Plaque Index (PI) has several limitations, including variability in the number of teeth examined, assessor subjectivity, and potential inaccuracy, particularly at low or high plaque levels. To overcome these challenges, a technology-based approach is needed to enhance standardization and consistency. This study aims to compare the calculation time of PI using a Digital Dental Calculator (DDC) app and the conventional manual method. **Methods:** A quasi-experimental study with a one-group posttest-only design was conducted among 70 dental students at Universitas Baiturrahmah who had completed the periodontics module and met inclusion and exclusion criteria. Participants performed PI calculations using both manual and digital methods under standardized conditions. The time required for each method was measured in seconds. Data were analyzed using descriptive statistics (mean ± SD) and the Mann–Whitney U test to compare calculation times between the two methods, with a significance level of $p < 0.05$. All analyses were conducted using IBM SPSS Statistics version 26.0 to ensure transparency and reproducibility. **Results:** The mean PI calculation time using the manual method was 178.74 seconds, while the digital DDC method required 143.97 seconds, showing a mean difference of 34.77 seconds. Statistical analysis revealed a highly significant difference between the two methods ($p < 0.001$), indicating that the DDC significantly reduced PI calculation time. **Conclusion:** The use of the Digital Dental Calculator (DDC) significantly shortened the time required to calculate the Plaque Index compared to the manual method. These findings highlight the potential of digital tools to improve efficiency, standardization, and accuracy in both clinical and educational dental settings.

KEYWORDS

Plaque index, digital dental calculator app, calculation time, Manual Method

INTRODUCTION

Dental and oral health problems in Indonesia remain a major public health concern, necessitating the attention of health professionals. The most prevalent dental and oral disease is gingivitis.[1] The WHO Report on the Status of Dental and Oral Health (2022) shows that around 3.5 billion people, or almost half of the world's population, suffer from dental and oral diseases.[2]

Gingivitis is an inflammation of the soft tissue surrounding the teeth, specifically the gingival tissue. The clinical manifestations of gingivitis include changes in tooth color, bleeding, swelling, and lesions.[3] The etiology of gingivitis

is typically attributed to the accumulation of plaque around the gingival margin. The accumulation of plaque on the surface of the teeth provides a favorable environment for bacterial growth, leading to gingivitis. [4]

Dental plaque is an accumulation of soft biofilms that form on the tooth surface. These biofilms consist of bacterial colonies and saliva from various microbial species that begin to colonize the teeth after they erupt. [5] The formation of dental plaque occurs in three stages: initial colonization with the formation of a dental pellicle, secondary colonization, and plaque maturation. Initial colonization begins with the formation of a thin layer containing glycoproteins and salivary biofilm, as well as food debris that adheres to the teeth, particularly in an unclean oral cavity. [6] Dental plaque containing more than 10 mg of bacteria has been identified as a causative agent of dental health problems. [7]

Maintaining optimal oral hygiene is a critical component of achieving optimal dental health. Various metrics are employed to assess an individual's oral hygiene status. These metrics include the measurement of plaque and calculus accumulation, which form the basis for various quantitative oral hygiene indices. [8] The index serves as a tool that can be used to monitor changes in oral health status and differentiate clinical conditions across different populations. [9]

Oral health surveys are routine activities carried out to measure oral health status. Conventionally, dentists conduct these surveys by processing examination data manually and filling out handwritten forms. [10] The utilization of paper and pen as tools for data collection remains widely used, primarily due to its cost-effectiveness and minimal reliance on electricity. [11] However, manual plaque index measurement is subject to limitations, including variations in the number of teeth assessed, assessor subjectivity, and inaccuracy at low or high plaque levels. To address these limitations, a technology-based approach is needed to improve standardization and consistency. The advent of digital methodologies enables more objective and precise calculation of plaque index scores, thereby streamlining the assessment process and mitigating human error. [12]

Digital data collection is undergoing a paradigm shift due to its capacity to minimize errors compared with conventional manual methods. [13] While digital technology offers numerous advantages, including enhanced accuracy in dental plaque assessment, challenges such as high costs, additional training requirements, data security concerns, and reliance on technology persist. Consequently, some conventional procedures may remain necessary, given that digital technology does not entirely supplant traditional methods. [14] Automated digital scoring systems have demonstrated higher accuracy than conventional visual methods, often yielding lower plaque scores than manual systems when calculating plaque indices. However, the implementation of these automated systems requires additional resources, financial investment, and technical expertise. [15]

Digital technology plays a pivotal role in ensuring the well-being of populations, particularly in the context of enhancing healthcare services worldwide. Numerous industries, including the health sector, have undergone significant transformations due to advancements in information technology. Consequently, it is unsurprising that a significant proportion of the global population now relies on digital technology in their daily lives. Digital technology can be defined as a high speed computing process that converts and analyzes data in numerical form. [16]

The use of technology in research is increasingly prevalent, such as that developed by Nagarajappa and Vyas, (2021) with the *Mobile Assisted Recording System* (MARS) application.[17] This application collects oral health data from the general public with a wide range of oral disease levels. It is paperless, highly accurate, fast, and poses minimal risk of data loss. However, this application is intended solely for research, is available only in English, and cannot be adapted for dental medical personnel. In a previous study conducted by Mariana et al., (2024) from Baiturrahmah Padang University, an application was developed to

calculate the Decayed, Missing, and Filled Teeth (DMFT), Oral Hygiene Index Simplified (OHIS), and Personal Hygiene Performance Modified (PHPM) indices.

This application can be used for disease surveys, collecting patient data, measuring and calculating dental indexes. In addition, this application can be accessed on all devices connected to the internet.[18] In light of these findings, researchers are interested in developing new features on the "Digital Dental Calculator Application (DDC)" by adding the PI index. The novelty of this study lies in its direct comparison of PI calculation time between the newly developed DDC application and the conventional manual method. By introducing a standardized digital workflow for PI computation, this study contributes new insights into the digital transformation of oral health assessment. Furthermore, it provides evidence-based support for integrating digital tools in clinical and educational settings, enhancing time efficiency, objectivity, and user experience in routine dental examinations. The aim of this study is to determine the difference in calculation time between the DDC and the manual method in assessing the plaque index (PI).

METHODS

The present study was conducted at RSGMP Baiturrahmah, Padang, from October 2024 to January 2025. The research employed was a quasi-experimental design with a one-group post-test only design. This research design involves a single group designated as the experimental group and does not include a control group.[19] The population refers to the entire group of individuals meeting the criteria of interest.[20] The population included all active dental profession students at Baiturrahmah University from semester 3 onward, totaling 170 individuals as of July 2024. The sample size consisted of 70 dental students at Baiturrahmah University. The sampling technique employed was convenience sampling, a method whereby researchers select readily accessible participants. [21]

The determination of the number of samples was calculated using the Slovin formula. The calculation yielded a sample size of 70 active dental profession students who had completed the periodontal module, thereby ensuring an adequate number of participants for the study.

A set of procedures was conducted in which several tools and materials were utilized. The instruments used included the DDC app, a smartphone, a pen, and SPSS data processing tool. The materials required were informed consent forms, plaque index (PI) examination sheets, and scenario sheets.

The research process began with the researcher obtaining a research permit from the Faculty of Dentistry, Baiturrahmah University. Following this, the researcher obtained ethical clearance from the same faculty. Subsequently, the research permit was submitted to the RSGMP, Baiturrahmah University in Padang.

The sample selection was conducted according to the inclusion and exclusion criteria. The inclusion criteria included active dental profession students at Baiturrahmah University who had completed or were enrolled in the periodontics module, were willing to be samples, filled out the informed consent, and had electronic devices connected to the internet. The exclusion criteria were students who were unable to attend, did not fill out the research instrument completely, or experienced network problems. The researcher explained the study's purpose and procedures to participants before beginning.

Following the completion of all preparatory procedures, the researcher proceeded with preparing all necessary tools and materials. The research was conducted with the utmost consideration for the subject's time, and the researcher offered a reward as a gesture of appreciation. During the preliminary session, the subject was instructed to read the PI index measurement scenario and the researcher took the manual measurements using a paper and pen. The duration of the measurement was precisely recorded using a stopwatch.

After two weeks, the researcher held a second meeting to ensure that the subjects did not remember the answers from the previous scenario. At this meeting, the researcher explained the use of the DDC to the same subjects with identical scenarios to maintain consistency. Measurements were taken by opening the application, entering a username and password, then clicking login. The subjects selected the PI index assessment and entered the plaque score value according to the scenario. The plaque score category results generated by the system reflected the patient's oral cavity condition, and the duration of the measurement was recorded.

Data analysis compared the duration of PI index score measurement between manual and digital methods. Validity was assessed through expert judgment. The analysis consisted of univariate for variable characteristics and bivariate using the Kolmogorov-Smirnov test for normality, followed by the Independent Test or Mann-Whitney for non-normal data.

Therefore, the objective of this study was twofold: first, to assess the efficacy of the DDC, and second, to evaluate the potential for enhancing the efficiency of plaque index measurements among dental students.

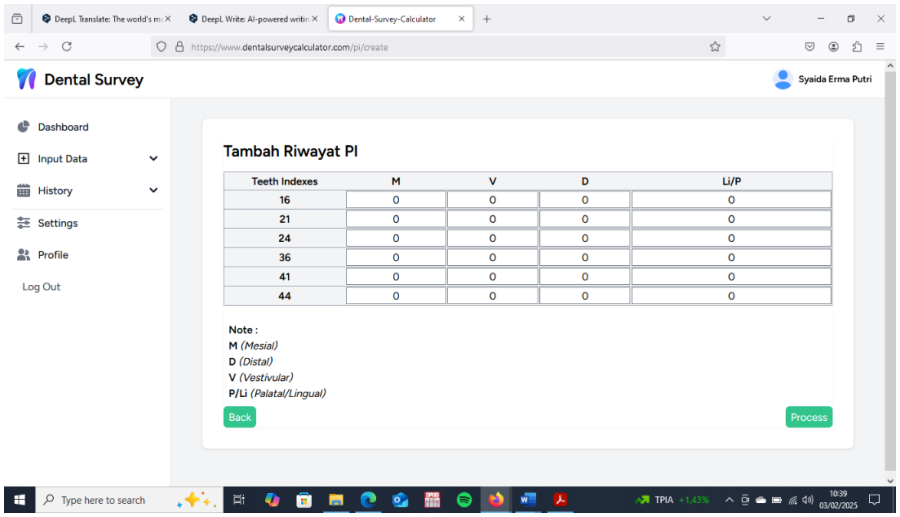

Figure 1. The PI index measurement using a DDC

The operating procedure requires selecting the plaque score in accordance with the results furnished by the operator.

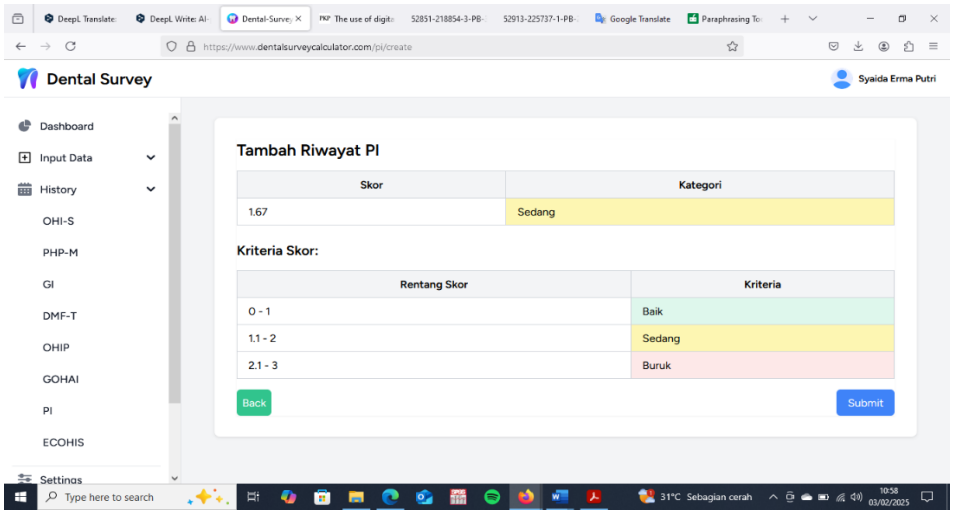

Figure 2. Example of the results obtained using the DDC PI index

Upon completion of Figure 1, the results will be displayed as shown in Figure 2. It is important to note that the PI score is automatically calculated and categorized.

RESULTS

This study was conducted at RSGMP Baiturrahmah University. The study's participants were 70 dental students who met the inclusion criteria. The main objective was to compare the time required to calculate the plaque index (PI) using manual and digital methods.

Table 1. Frequency Distribution of Respondents' Gender and Age

Gender	*f*	%
Woman	64	91.4
Man	6	8.6
Age	23,15	
Standard Deviation	1.07	
Minimum	22	
Maximum	28	

Table 1 above shows that most respondents were female, reflecting the gender composition among dental students. The average age of respondents was 23 years, with a range indicating variation across participants. This provides an overview of the demographic characteristics of the research participants at RSGMP Baiturrahmah. The results of the univariate analysis showed the frequency distribution of PI measurement time manually using pen and paper and digitally using the digital dental calculator application according to the age and gender of the research subjects.

Table 2. Frequency Distribution of PI Measurement Time Manually and Digitally (seconds)

Research Variables	*Min*	*Max*	*Mean*	*SD*
Manual	150	208	178.74	17.54
Digital	100	168	143.97	18.01

Table 2 shows that the average time required for manual PI measurement is longer than the digital method. The difference of 34.77 seconds indicates that the use of digital applications can speed up the measurement process, which is an important consideration in dental practice.

The results of the bivariate analysis were conducted to determine the difference in Plaque Index (PI) measurement time between manual techniques and DDC. The Kolmogorov-Smirnov normality test was used to determine the data distribution. The results of the normality test showed p-values of 0.200 and a 0.00 for the digital method, indicating that the data were not normally distributed (p value> 0.05). The analysis was followed with the non-parametric Mann Whitney U Test.

Table 3. Mann Whitney Test Results

Research Variables	P Value
PI Measurement Time Manually and Digitally	0.001

Table 3 shows the results of the Mann-Whitney U test with a p value of 0.001, which indicates that there was a significant difference between the PI measurement time using manual and digital methods. Thus, it can be concluded that the use of the DDC was significantly more efficient in terms of measurement time.

DISCUSSION

This difference is evident in the PI measurement time using the digital dental calculator application, which is shorter than the time required with the manual method using paper and pen. The average time required for respondents to perform PI measurements manually was 178.74 seconds, whereas the average time required to perform PI measurements digitally is 143.97 seconds. The difference in PI calculation time between the manual and digital methods was 34.77 seconds. Although the difference was less than one minute, the digital method proved to be more efficient and productive. It reduced human error, simplified data storage, and improved the patient experience, making it a better choice in dental practice. This finding aligns with research conducted by Moryka et al., which showed that digital applications were significantly faster than manual measurements, with a recorded time difference of 139.66 seconds. Their study involved 59 samples obtained through the Slovin method, consisting of active dental students enrolled in the periodontics module at Baiturrahmah University.[22]

This digital application also enhances efficiency in calculating and classifying plaque indices. It significantly reduces errors, as shown by a 5.71% error rate in manual surveys compared with the superior accuracy of digital calculations. These results correspond with previous research on digital dental tools by Fadli et al., which demonstrated that digital media offer greater efficiency and reliability in data storage than manual or paper-based methods. Furthermore, electronic media allows data to be collected more quickly than paper media.[23]

Research conducted by Purba et al. also demonstrated that digital technology enhances the speed and efficiency of healthcare services. The DDC assisted plaque index (PI) was shown to be faster than manual methods, particularly benefiting Generation Z dental students who are highly accustomed to using digital devices. A larger screen display and a user-friendly interface further contributed to shorter calculation times.[24] Consistent with the findings of Hutasoit et al., Generation Z is considered "*digital natives*", given their lifelong exposure to digital communication and information technology, which contributes to their high level of digital literacy.[25]

The results of this quasi-experimental study demonstrate a statistically significant difference in the time required to calculate the Plaque Index (PI) between the manual method and the Digital Dental Calculator (DDC) application. The mean calculation time using the manual method was 178.74 seconds, whereas the DDC app required only 143.97 seconds, yielding a mean difference of 34.77 seconds ($p < 0.001$). These findings align with recent studies emphasizing the growing role of digital tools in improving the efficiency and accuracy of dental data recording. For instance, Lee et al. (2021) and Garcia-Pola et al. reported that digital periodontal charting systems significantly reduced chairside time and minimized calculation errors compared with manual documentation.[26,27]

Similarly, Alqarni et al. highlighted that mobile-based dental assessment applications improved workflow efficiency and reduced examiner fatigue during large-scale screenings.[28] Goob et al. also demonstrated that the integration of a mobile app enhanced process organization and assessment accuracy in dental education, while Hartono et al. confirmed that mobile application–based support for periodontal treatment improved both clinical and psychomotor outcomes among dental students. [29,30] However, most prior research has primarily focused on digital charting, diagnostic imaging, or caries detection technologies, rather than on the quantitative evaluation of plaque index computation time.

This study has several limitations, including the absence of direct surveyors who check the PI index with patients, its early-stage nature, and the need to compare manual and digital calculation times to minimize variation. In addition, sequence bias may have occurred because students completed the manual method before the digital method, potentially influencing measurement

performance. These constraints should be taken into account when interpreting the findings of this study. Similar to research by Mariana et al., this study's primary objective was to ascertain respondents' perceptions regarding the practicality and functionality of novel applications. To this end, it sought to gather empirical evidence through the administration of examinations that incorporated scenarios designed to elicit feedback on the aforementioned applications' relevance and practicality.[18]

In this study, the discrepancy in survey duration between manual and digital methods was relatively small. This is primarily due to the novel nature of the digital survey application, which necessitated a period of adjustment for the study participants to become proficient with the technology. This study corresponds to research conducted by Fauzi et al., who stated that in the transition from a manual to a digital system, the necessity for training and education increases, as the adoption of new technology necessitates adaptation to altered work culture.[31] This study also highlights the need for wider dissemination and familiarization, as the application has not yet been widely introduced. Likewise, research conducted by Moryka et al., stated that the results of the study are subject to limitations, including the necessity of greater effort to promote familiarization with the use of the DDC.[22]

CONCLUSION

This study demonstrated a clear difference in the duration required to calculate the Plaque Index (PI) between the conventional manual method and the Digital Dental Calculator (DDC) application. The manual method required an average of 178.74 seconds, while the digital application completed the process in 143.97 seconds, indicating that the DDC provides a faster and more efficient workflow for PI assessment. These results indicate that integrating digital tools into dental education and clinical practice can streamline data collection, minimize calculation variability, and improve the consistency of oral health evaluations. The implication of this study is that implementing the DDC has the potential to enhance operational efficiency in both clinical and educational settings by reducing assessment time, supporting standardized plaque index calculations, and minimizing human error.

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Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request. Due to participant confidentiality, the dataset is not publicly accessible.
Conflicts of Interest: The authors declare no conflict of interest. No commercial entity influenced the design, conduct, or reporting of this research.

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