Design and Build Lighting Aids at Fingertips for Dentists

Fauzyah Aprillia [1], Netya Dzihni Kinanggit[1], Indra Bramanti[2], Yarabisa Yanuar[3], Yusuf Maulana[3], Herianto[4*]

[1] Master of Biomedical Engineering, Gadjah Mada University, Teknika Utara street, Pogung, Sinduadi, Mlati, Sleman, Yogyakarta, 55284
[2] Department of pediatric Dentistry, Gadjah Mada University, Teknika Utara street, Pogung, Sinduadi, Mlati, Sleman, Yogyakarta, 55284
[3] ACTA Techno Inava, Mijil street, Sinduharjo, Ngaglik, Condongcatur, Sleman, Yogyakarta, 55581
[4] Department of Mechanical and Industrial Enginering, Gadjah Mada University, Teknika Utara street, Pogung, Sinduadi, Mlati, Sleman, Yogyakarta, 55284

ABSTRACT

The importance of maintaining oral health, especially the condition of the teeth and mouth, cannot be denied. These parts of the body play an important role, not only facilitating the digestive process but also as indicators of overall well-being. Dentists play an important role in ensuring dental health through prompt and accurate treatment, using the condition of the teeth and mouth as a window to view a person's health more broadly. However, examinations in underdeveloped areas have their own obstacles, such as a lack of adequate medical equipment facilities. therefore, the effectiveness of dental examinations can be hampered by a lack of lighting in the oral cavity, a challenge for researchers to solve this problem. This problem is often associated with a lack of available light sources. To overcome this problem, we designed a new intraoral lighting device that has been developed to perform oral cavity and dental examinations. This compact and ergonomically designed mini lamp is mounted on the dentist's fingertip, then the lamp provides optimal lighting in the oral cavity. This device was tested at the pediatric dental clinic RSGM UGM Prof. Soedomo, this device received positive reviews due to its practical design, flexibility, and ability to provide superior lighting during examinations. The enthusiastic response from medical staff underscores the potential of this innovative solution in improving oral care practices.

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***Correspondence**

fauzyahaprillia@mail.ugm.ac.id

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1. Introduction

Based on the 2018 Basic Health Research Results, the prevalence of oral dental problems in Indonesia is quite high, namely 57.6% of the Indonesian population experiences dental and oral problems, but only around 10.2% have received medical services. One of the main factors causing this is the shortage of dental medical personnel and the imbalance in the distribution of dental medical personnel, which results in geographic and socioeconomic disparities in access to dental health services in Indonesia. Dental medical personnel who carry out examinations in disadvantaged, border and island areas (DTPK) experience obstacles, namely not having standard dental examination equipment, including lighting aids. To analyze teeth and perform procedures, doctors must be able to distinguish small details and low contrast.

Lighting is very important in dental examinations because it can improve the accuracy of diagnosis and the quality of treatment. Optimal lighting helps dentists clearly see detailed anatomical teeth and surrounding tissue, enabling early detection of dental health problems, and improving the ability to perform procedures precisely and efficiently.

Therefore, adequate lighting is very important for optimal perception. Research on fingertip lighting aids for dentists in remote areas is important because it increases the accessibility of health services, makes dental examinations easier, emphasizes ergonomics, increases diagnostic accuracy, and contributes to public health independence in hard-to-reach areas.

Overall, the ability to receive medical services from dental medical personnel is only 8.1% (Kementerian RI, 2019) . The Indonesian government is trying to improve the level of public health through the Healthy Indonesia Program. One of the main pillars of the Healthy Indonesia Program is the application of a healthy paradigm. This effort is carried out by implementing programs based on promotive and preventive strategic approaches to dental and oral health. Community Health Centers through the School Dental Health Business Program (UKGS) and Community Dental Health Business have carried out promotive and preventive efforts throughout Indonesia since 1951, but the results are still not optimal because they have not been able to achieve the Global Goals for Oral Health 2020 from WHO (World Health Organization, 2023).

2. Literature Review

One of the obstacles faced by healthcare professionals in the field is the lack of adequate light sources during dental and oral examinations. A light source is essential to providing clarity for dental healthcare professionals during the diagnosis process. The use of flashlights is considered impractical because it requires assistance from another operator to direct the light, and without an assistant's help, the operator must hold the flashlight themselves. The use of non-sterilizing flashlights can pose a high risk of cross-infection. Dentists in private practice also encounter challenges when using dental chair lights. Some of the issues include lights that do not reach deep within the oral cavity, manual operation of the lights, and in the case of power outages, the lights cannot operate, hindering dental and oral care procedures. Additionally, from the patient's perspective, medical spotlight lights can be dazzling and uncomfortable.

Several innovations related to dental and oral illumination devices have been developed, but they have not yet addressed the specific needs of healthcare professionals due to certain limitations. The current ISO standards (ISO 9680) specify the distribution of intensity within the mouth in an elliptical form. Practice has shown that the 'inside' area as per ISO norms is too small to illuminate the entire mouth (including the lips). Therefore, it is insufficient to achieve the desired light distribution in the working area. To achieve adequate illumination within the oral cavity, adjustments to the quality of light, intensity distribution, and physical positioning of the light by both the dentist and the patient are necessary. This research involves a literature review on lighting, ergonomics, and dental care (Boheemen Jurjen Paul Van et al., 2021)

In addition to the technical challenges mentioned above, in reality, nearly 90% of the healthcare equipment available is imported, making the product highly suited for localization (Abdar et al., 2017). In preparation for this localization, the product requires refinement, such as a more compact device design and longer-lasting batteries, to enhance its practicality and ergonomics. Furthermore, a series of trials are still needed before this product is ready for mass production. As part of the preparation for localization, there is a need for innovation in alternative light sources for dental examinations in the form of a more compact and ergonomic device design to enable more accurate and efficient dental inspections. To achieve product suitability, the development of this device requires phased testing and refinement before mass production (Young et al., 1987).

3. Methodology

This research was conducted at the Pediatric Dental Clinic of RSGM UGM Prof. Soedomo to observe user needs and was based on a literature study conducted to obtain appropriate references for the product, which would subsequently be developed as a finger-tip illumination device for dental and oral examinations. In brief, all stages of the research method are illustrated in Figure 1, which represents the research and product design processes (Samsuar et al., 2022).

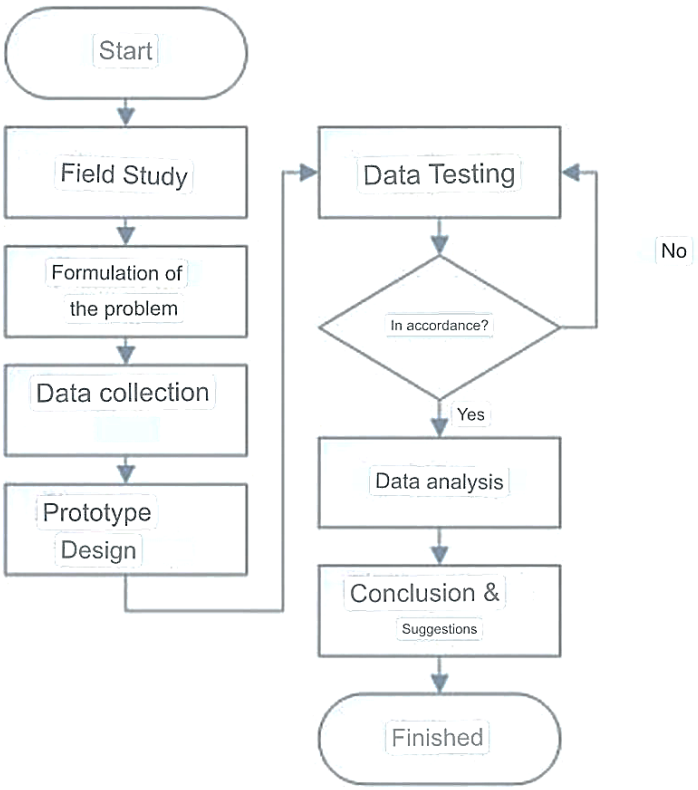

Figure 1 Research and Product Design Process

The stages conducted include the following:

A. Field Study

This stage involves evaluating current use through visits and interviews. In this research, there are two types of data sources used as references, namely primary data and secondary data. Primary data refers to data obtained directly through field studies from research at the Children's Dental Clinic at RSGM UGM Prof. Soedomo using user interviews with 35 medical personnel. Secondary data is data obtained indirectly by collecting data from various sources and literature related to the research problem in order to obtain an appropriate design and appropriate problem formulation.

B. Formulation of the problem

Based on the findings, new prototypes or recommendations for improvements can be developed to improve the quality of dental health services, which are then presented and published in scientific forums. The formulation of the research problem is: "How to increase the effectiveness of dental practice lighting in remote areas through lighting aids at the fingertips, with a focus on aspects of accessibility, efficiency and comfort to optimize dental health services and early detection of dental health problems in the community?

C. Data Collection

In conducting research, both field studies and literature studies, data collection is carried out using observation techniques, namely data collection is carried out by taking data according to research needs. Researchers used interview methods with dental medical personnel to gain insight into preferences, needs and challenges faced in using lighting aids for dental and oral examinations. This information can help in designing better solutions that better suit user needs. Researchers also conducted literature studies by collecting references related to product design, materials and ergonomic factors through articles, books, journals and so on.

D. Design Development (Prototype)

As a result of a literature review and adjustments to user needs, researchers developed a design for a lighting aid that is placed on the fingertip for dental and oral examinations with a flexible shape, application according to standards, and ergonomics (Bud et al., 2023). This design development was made using Autodesk Fusion 360 software, and the electrical components were assembled taking into account durability, quality and standards.

E. Product Testing

The product prototype is then tested to analyze light intensity, model flexibility, effect on work area visualization, lighting stability, and so on (Ankita Yadav et al., 2020). To achieve product conformity, the development of this tool requires gradual testing and refinement before mass production.

F. Data Analysis

Analysis of research data on lighting aids at the fingertips of dentists in remote areas includes evaluation of effectiveness, ergonomic aspects, and response from doctors and patients. The research also explored the impact of the tool on early detection of dental health problems and its affordability in remote areas. By detailing the responses obtained, it is hoped that the analysis results will provide guidance for tool development and improvement of dental health services in the region.

4. Results and Discussions

A. Analysis of Product Design and Development System

This analysis involved 35 individuals, including students, interns, general dentists, and specialist dentists, in the product design and development process based on consumer needs. The testing was conducted based on a literature review of lighting during dental procedures. Input from potential markets was then collected through a manual system and translated into the product design concept known as Design for Function (DFF). The subsequent product development process followed the principles of Design for Manufacturing (DFM), Design for Ergonomics (DFE), and Design for Market (DFMr) to ensure that the design could be further developed.

In the first stage of this process, the researcher formulated questions about the frequency of using a flashlight or headlamp to support dental procedures. The results of this stage can be seen in Table 1 below, visualized in Figure 2.

Table 1. Frequency of flashliagt/headlamp usage

Frequency	Number of people
Often	15
Rarely	6
Sometimes	11
Never	3

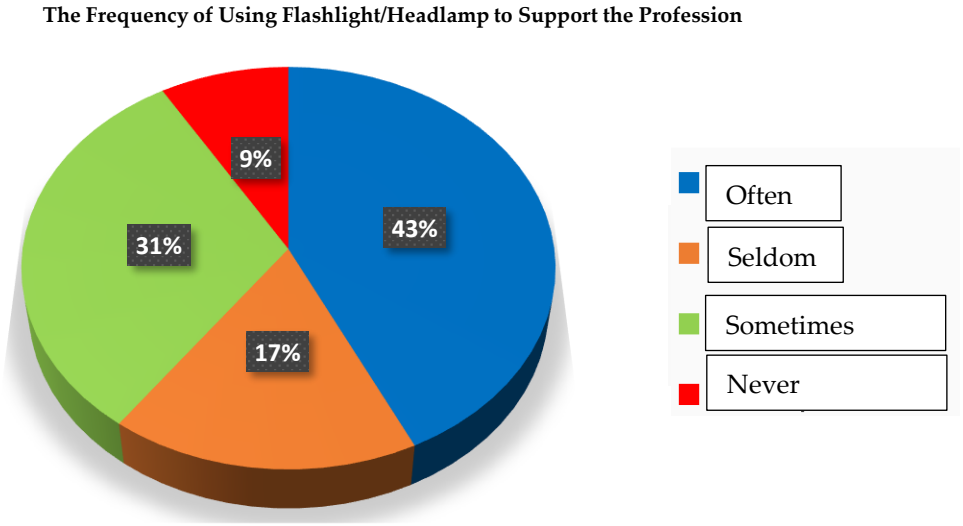

Figure 2: Frequency of Using Flashlight/Headlamp

From the questionnaire above, it was found that 43% of respondents often use a flashlight or headlamp during dental procedures, while only 9% have never used a flashlight or headlamp during procedures. In general, 91% of the respondents have used a flashlight or headlamp at some point during dental procedures. After obtaining this data, the researcher further explored what factors influenced the satisfaction level of users when using a flashlight or headlamp during dental procedures. The information from this data was used for the design and development of a prototype for the illumination device. The results from this extended questionnaire are presented in Table 2 and visualized in Figure 3 below (Zhu et al., 2019).

Table 2. Data on Dissatisfaction with Flashlights and Headlamps Available in the Market

Reason	Number of people
Non-ergonomic design	10
Lack of flexibility	25

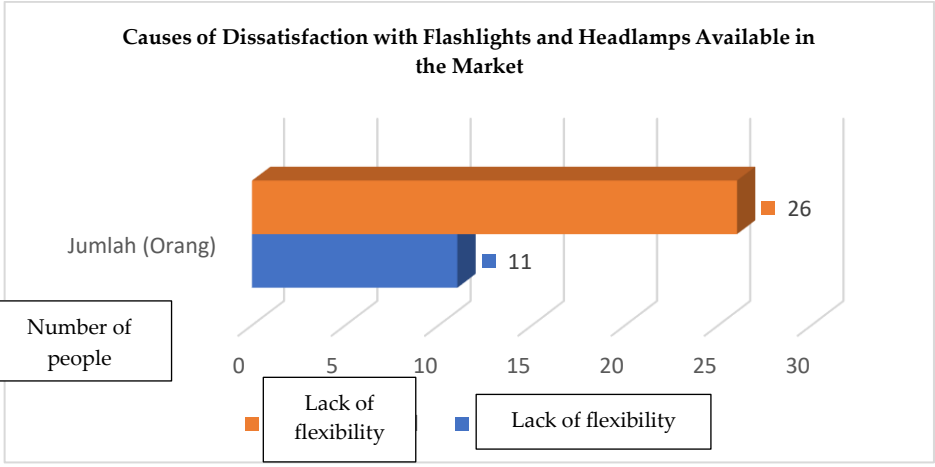

Figure 3: Visualization of Dissatisfaction with Flashlights and Headlamps Available in the Market

From the data above, it was found that the majority, 71%, or 26 individuals, were dissatisfied with the use of flashlights or headlamps because the devices were not flexible enough for use, while the remaining 29%, or 11 individuals, were dissatisfied due to non-ergonomic design. Therefore, an innovation in an alternative light source for dental examinations was developed, featuring a more compact and ergonomic design for more accurate and efficient dental inspections.

Based on the literature and questionnaire results from users, the user assessments include the use of fiber optic projection lighting to reduce the doctor's workload, optimize the design for the doctor's eyes so they don't easily get tired, avoid patient discomfort due to lighting, and reduce patient operating time to maintain the doctor's health. From the results of the literature review and user interviews, several conclusions were drawn for the product development, which are succinctly visualized in Figure 4 below.

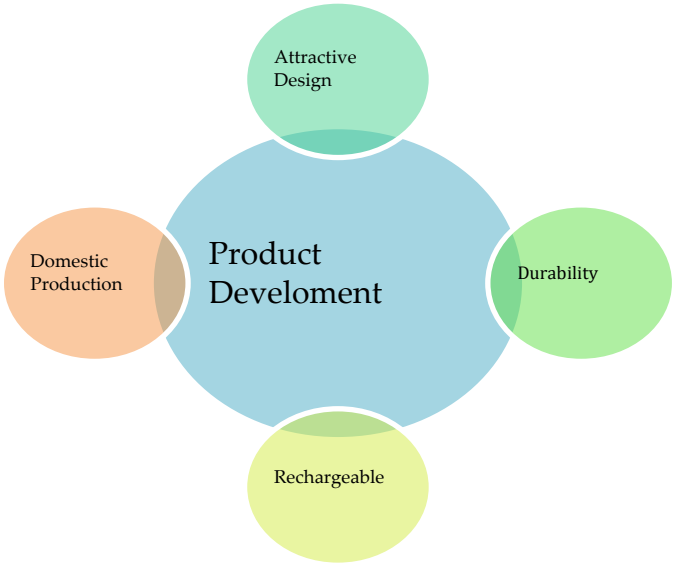

Figure 4 : User Needs

a. Attractive design

Attractive design is one of the keys to promoting and providing comfort for users when using the device. It also makes users feel modern even when using the tool. This attractive design can be achieved by creating a portable device with suitable coloring.

b. Durability

Durability is something that needs to be enhanced in product development because the long-lasting strength of the tool will have an impact on dental procedures (Starr et al., 2020).

c. Rechargeable

Rechargeable battery refers to a battery that can be recharged, eliminating the need for a connection to electrical power when the device is in use, making it more straightforward.

d. Domestic Production

it is crucial at present to undertake the development of domestic healthcare devices because domestically produced products are competitive in terms of quality with foreign healthcare devices, ensuring safety, quality, and benefits while also contributing to the national economy by achieving self-sufficiency in healthcare equipment.

B. Design Planning to Improve the Efficiency of Dental Procedures

The product design is created using engineering design methods. Based on the data from the problem analysis found during interviews, product criteria are established for the development of a product to improve efficiency and utility in enhancing dental procedures. This led to the concept of working principles to create a product by addressing existing issues. The product design process uses the 3D design application Fusion and adheres to the tool's dimensions, resulting in the product design shown below.

Figure 5. Design of the Innovative Finger-Tip Illumination Device

The product design in Figure 5 was created with reference to literature and user experiences gathered through interviews with dentists, especially during dental procedures. In the design process, the light source will be placed at the fingertip of the dentist to facilitate illumination during dental procedures (Farah et al., 2022). Adequate lighting is crucial in dental procedures, as it can impact the quality of the dentist's work by improving accuracy, reducing the risk of errors, and increasing patient confidence. Placing a small light as the light source at the fingertip of the dentist is a recent innovation in dental procedure lighting. This is achieved by attaching a small light to the fingertip of the dentist's index finger, allowing the emitted light to be directly aimed at the area being treated.

A small'battery is placed in a compactly designed casing that can be worn on the wrist like a regular wristwatch, aiming to simplify its use with a simple principle. Additionally, the material used to secure it to the dentist's wrist is made elastic to accommodate various wrist sizes, ensuring comfort during use.

Figure 6. Usage of the Product Innovation

B. Product Testing

After the product was developed, it underwent testing once again with the 35 respondents who were previously involved. This testing was conducted to assess the level of user interest in the developed product. The results of this testing can be seen in Table 3 and visualized in Figure 7 below.

Table 3: Level of interest in the innovation

Scale	Number of people
1 (not interest at all)	1
2 (not interested)	1
3 (Neutral)	9
4 (interested)	15
5 (Very interested)	9

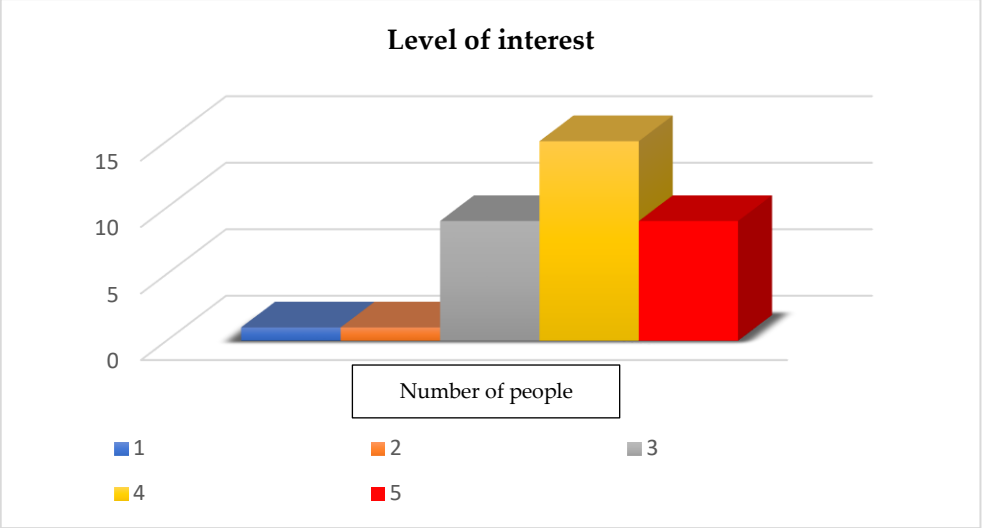

Figure 7. Visualization of the Level of Interest in the Innovation

From the experiment, it was found that the majority were interested in the developed innovation, which accounted for 69% or 15 individuals, while the rest were not interested. Among the majority who were interested, they provided reasons for their interest in the innovative product. From their feedback, it was concluded that they were interested because of the elegant design, bracelet-like appearance, detachable flashlight, focused light, practicality, and flexibility. On the other hand, those who were not interested had concerns about the durability of the product, the size of the cable design, and the size of the battery.

Figure 8. Experiment of the Innovation in Dental Procedure

In the group interested in using the product, they feel that the use of fingertip lighting provides a significant improvement in the required illumination during dental procedures. Dentists report that fingertip lighting is highly beneficial in visualizing the treatment area more effectively and enabling them to perform procedures with greater accuracy (Juliatri, 2020) . Furthermore, fingertip lighting allows dentists to identify and address smaller issues that may be overlooked without adequate illumination.

On the other hand, this innovation, according to them, indicates that fingertip lighting for dentists can provide a significant improvement in illumination during dental procedures. Fingertip lighting enables dentists to visualize the treatment area better and identify issues that may be overlooked without adequate lighting. Additionally, fingertip lighting offers additional advantages by allowing dentists to work with greater accuracy and efficiency.

5. Conclusion

The development of this lighting aid is an innovation that can help improve the accuracy and efficiency of dental and oral examinations of patients by dentists. This tool is designed to be operated easily and comfortably at the dentist's fingertips, making it easier to direct the illumination light to the required area. Apart from that, this tool also has a compact and portable design, so it can be used with flexibility in various inspection situations. Overall, the development of fingertip lighting tools for dentists is a breakthrough that can help improve the quality of dental and oral health services, as well as provide convenience and comfort for dentists in carrying out examinations.

However, further trials and evaluations regarding the performance and effectiveness of this tool in clinical practice are necessary to ensure its success.

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