The online version of this article can be found at:
https://www.asianinstituteofresearch.org/

The Asian Institute of Research *Journal of Health and Medical Sciences* is a peer-reviewed International Journal. The journal covers scholarly articles in the fields of Medicine and Public Health, including medicine, surgery, ophthalmology, gynecology and obstetrics, psychiatry, anesthesia, pediatrics, orthopedics, microbiology, pathology and laboratory medicine, medical education, research methodology, forensic medicine, medical ethics, community medicine, public health, community health, behavioral health, health policy, health service, health education, health economics, medical ethics, health protection, environmental health, and equity in health. As the journal is Open Access, it ensures high visibility and the increase of citations for all research articles published. The *Journal of Health and Medical Sciences* aims to facilitate scholarly work on recent theoretical and practical aspects of Health and Medical Sciences.

ASIAN INSTITUTE OF RESEARCH
Connecting Scholars Worldwide

Integrated Dental Health Monitoring using Smart Tooth Brush and Application

Salikun[1], Supriyana[2], Suwarsono[1], Aan Kusmana[2], Yuwono Setiadi[3]

[1] Department of Dental Health, Poltekkes Kemenkes Semarang, Semarang, Indonesia
[2] Department of Dental Health, Poltekkes Kemenkes Tasikmalaya, Tasikmalaya, Indonesia
[3] Department of Nutrition, Poltekkes Kemenkes Semarang, Semarang, Indonesia

Correspondence: Salikun, Department of Dental Health, Poltekkes Kemenkes Semarang, Semarang, Indonesia 50268. E-mail: salikun62@gmail.com

Abstract

Dental and oral health is the main need of people, including to children. Since, about 60 – 90% of children are suffering from dental caries. The prevention of dental caries is an important part of conducting. The digitalization era has influenced the dental and oral health education. Tooth brushing is one way to keep dental and oral health. However, the proper tooth brushing has not been achieved by children. Our objective is to conduct dental and oral health programs for children by creating a smart tooth brush named TOMON (Tooth Monster Hunter) and an application of monitoring named SIMOGI (*Sistem Monitoring Kesehatan Gigi* / Dental Health Monitoring System). We undertook this study by planning the monitoring system. The monitoring system is divided into three parties: dental therapist, parent and children. Dental therapists and parents are collaborated to handle and educate children about proper tooth brushing. Second, is the analysis of the requirement. The analysis stage consists of application program content. The last is the prototyping stage. In the prototyping stage, the smart toothbrush TOMON and application SIMOGI were made. The results of the research are the smart toothbrush TOMON and SIMOGI application can be used for health promotion for the children.

Keywords: TOMON, SIMOGI, Tooth Brushing, Children

1. Introduction

Regular plaque removal is a central part of dental and oral health prophylaxis. Without dental and oral health, there will be a high risk of caries and cavities. Therefore, the behavior of maintaining dental and oral health is very important for everyone and must be started from childhood, because the behavior of maintaining health must be applied in everyday life. Providing counseling and learning behavior to maintain dental and oral health to children is a must so that they can implement efforts to maintain dental and oral health from an early age (Gibson and Williams, 1999) (Lam, 2014) (Baginska and Stokowska, 2013).

Poor oral and dental health can lead to consequences that make children feel uncomfortable to move and inhibit growth. Toothache and loss of the integrity of a single tooth can have immediate consequences. Because teeth and gums that are damaged and not treated can cause dental and oral diseases such as pain, dental caries, and interfere with other body health. The potential for social rejection can also occur when a child is socially ostracized because of a visible disability, impaired articulation or bad breath. Thus, dental disease prevention measures not only maintain healthy teeth, gums and mouth, but also prevent children from somatic disorders, psychology and unpleasant social experiences. However, one cannot fully depend on the ability of parents to be able to provide dental health education without any assistance from those who are experts in the field of dental nursing. Lack of knowledge and skills in oral health in adults and strong social gradients suggest that society must also take responsibility. Therefore, many dental and oral disease prevention programs have been developed. Knowledge of oral health and routine application are important predictors of tooth brushing frequency. The role of parents also affects the development of health behavior in children (Craig, Baker and Rodd, 2015) (Ueno *et al.*, 2012) (Berzinski *et al.*, 2019).

The proportion of dental and oral problems in 2018 in Indonesia was recorded at 57.6% and the proportion of proper tooth brushing behavior was only 2.8% (Kementerian Kesehatan RI, 2018). Pre-school age or kindergarten is a good age to train children's motor skills. Dental caries affects 60 to 90%, including school-age children in developing countries and is common in several Asian countries, including Indonesia (World Health Organization (WHO), 2020). The risk of dental disease in children, can cause problems or difficulties in mastication, reduced nutritional intake so that body weight decreases and the end result is that the child's growth and development are not optimal (Al-Darwish, 2016). A comprehensive dental health education program for children and parents is needed to achieve the goal of maintaining dental health (Vishwanathaiah, 2016).

Toothbrush is an equipment that is always used in maintaining dental and oral health. Maintaining good and correct toothbrushing behavior can help reduce the risk of caries (Atarbashi-moghadam and Atarbashi-moghadam, 2018). Mobile apps are software programs that run on smartphones and other mobile devices. Mobile health apps can help people take care of their own health and promote useful information to others and remove time and place limits for patients and healthcare workers (Underwood, Birdsall and Kay, 2015) (Byambasuren, Beller and Glasziou, 2019) (Id, Norman and Robinson, 2020). Therefore, TOMON (Tooth Monster Hunter) which produces applications and toothbrushes based on wearable devices (Salikun *et al.*, 2021) will be developed with an Internet of Healthcare Things (IoHT) approach in terms of applications with parent, and dental therapist features. The dental therapist can monitor the progress of brushing children's teeth based on a smart toothbrush that has been integrated with motion sensors and attracts children's attention to maintain dental health, so that it can be a solution even in the conditions of the Covid-19 pandemic.

2. Method

2.1 Planning

The planning and initial requirements data collection is the phase carried out in the first year of the study. The results in this phase will obtain primary data regarding the data on the number of students, as well as the application requirements needed to be input for the analysis phase and start making monitoring features.
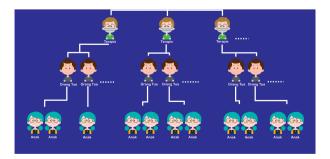

Figure 1: Monitoring System

Figure 1 shows the monitory system planning. In the first line is the dental therapist. The dental therapist handle the parent as the supervisor of the child at home. Because this is the remote monitoring, the application and the smart tooth brush named TOMON were made.

TOMON or Tooth Monster Hunter is the smart tooth brush in our research. It is a smart tooth brush with the sensor to track a tooth brushing motion on the game TOMON (Salikun *et al.*, 2021). While for monitoring system is done by creating an application according to Figure 1 model named SIMOGI.

2.2 Analysis

In the analysis phase, the researcher analyzes alternative solutions based on the initial system requirements and analyzes based on user feedback reactions. The initial needs-based analysis phase was carried out in the first year of the study. Outputs in the planning phase and initial requirements gathering are inputs in this phase. In this phase, an analysis of alternative solutions will be developed. The results of this phase are in the form of model analysis and design. The analysis phase is based on user reactions. The results of the design based on user feedback will be input in this phase. The target in the analysis stage is dental nursing practitioners, namely students of the dental and oral therapy study program Bachelor of Applied Health from Poltekkes Kemenkes Semarang.

Table 1: Menu Features of Application

Menu	Content
Home	Greeting for the user and application manual
Reminder	Dental Health Action:
	1. Brush your teeth 2 times a day after breakfast and at night before going to bed
	2. Using toothpaste the size of a corn seed
	3. Brush your teeth regularly every morning and night following the directions from the TOMON game
	4. Avoid excessive sugar consumption
	5. Brush your teeth after eating sweet foods so that sugar doesn't stick to your teeth
	6. Chewing food using the right and left sides of the teeth alternately
	7. Drink plenty of water every day at least 6-7 glasses for children aged 4-8 years, and 8-10 glasses for children aged 9-13 years
	8. Parents accompany their children to brush their teeth
	Children's Dental Dangerous Signs
	1. Child has toothache and difficulty chewing
	2. A hole appears in the child's tooth
	3. Blood appears on the child's gums or teeth
	4. There is a broken tooth
	5. Children's teeth look dull and have white spots/stains
	6. The child's teeth are black on the chewing side
Counseling	Counseling menu based on text and photo upload

2.3 Prototyping

At the prototyping stage, the researcher develops the system based on the initial requirements analysis and the system development for the next stage is based on the analysis of user feedback reactions. At this prototyping stage, implementation of the results of system development is also carried out.

The initial prototype phase was carried out in the first year of research. The output from the analysis phase based on initial needs is input for the initial prototype which will later be processed and built to produce TOMON (Tooth Monster Hunter) and SIMOGI applications. The results of this phase are the final results of the first year of research in the form of system prototypes and scientific research articles.

3. Results

The activity carried out at the beginning of the realization was to form a team of dental therapists to assist the implementation of this research activity at SD Al Azhar 14 Semarang. The dental therapists appointed were 6 students of the Bachelor of Applied Dental Therapy study program, Department of Dental Health, Poltekkes Kemenkes Semarang. The next activity is in a smart toothbrush with the TOMON application. This TOMON application stands for Tooth Monster Hunter. This application is a teaching game to brush teeth with visualization on the Android screen. In addition, there is also a toothbrush paired with an IMU (Inertia Measurement Unit) sensor and a Bluetooth module so that the toothbrush can be connected to the TOMON game on Android. Table 5.1 is the contents of the TOMON game which consists of brushing teeth from the top left, bottom left, top right, bottom right, left side, right side and front teeth. The way this TOMON game works is that the image of the monster on the TOMON game display represents germs, so that the toothbrush must be done according to the position of the germ. If it's true, the germs will disappear and if it's false, the germs will still be there. At the end of the TOMON game, a dental report will appear. The white teeth represent the correct brushing and the yellow teeth represent that the tooth brushing movement is still wrong, according to the yellow color position. If the yellow color is on the upper right tooth, then brushing the teeth is not correct in the upper right tooth.

Figure 2: TOMON Smart Tooth Brush

Figure 2 is the realization of a smart toothbrush that will be used in the implementation. The toothbrush is adjusted to the needs, namely by installing a bluetooth module, arduino nano and an IMU sensor in the toothbrush handle. The bluetooth module aims to enable the toothbrush to be connected to the TOMON game wirelessly. The IMU (Inertia Measurement Unit) sensor is a sensor that detects the movement of the toothbrush. Arduino nano is a microcontroller that regulates the work of bluetooth and IMU sensors. The handle of the toothbrush is shaped through a 3D Printer with PLA (Polylactic Acid) 3D Printer filament as raw material.

Besides TOMON, this research also creates the SIMOGI (*Sistem Monitoring Kesehatan Gigi or Dental Health Monitoring System*) application. The SIMOGI application is a Dental Health Monitoring System that is used to support monitoring of children's dental health between parents and therapists. The application has two versions for parents and dental therapists. The making of this application is based on pandemic conditions where face-to-face contact still has to be maintained and limited even. SIMOGI is divided into two login features, namely for dental therapists and parents.
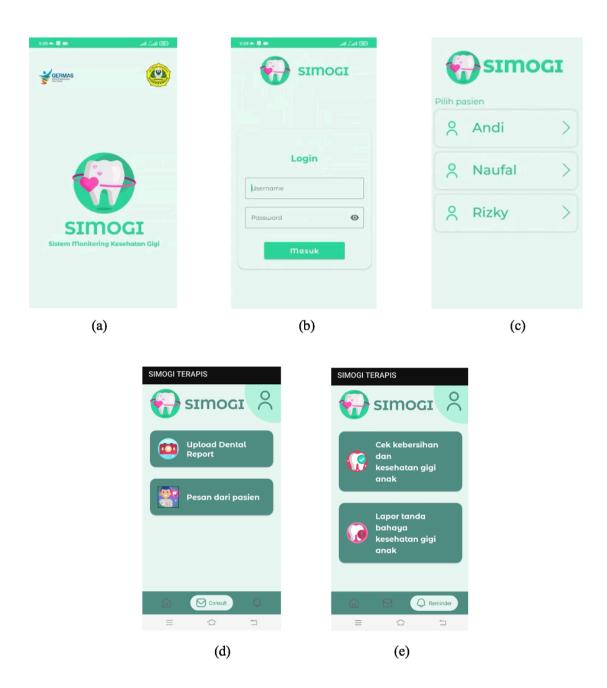
Figure 3: SIMOGI Application for Dental Therapist (a) Homepage (b) Login page (c) Client page (d) Consult menu (e) Reminder menu

Figure 3 shows the application of dental health monitoring features for the dental therapist. The login page is based on the account given to the dental therapist. The client page contains the list of children handled by the dental therapist. The menu of consult has the feature to have a chat with the client, while the reminder menu contains the checklist according to table 2.

Figure 4: SIMOGI Application for Parents Handling Children at Home (a) Homepage (b) Login page (c) Dental Hygiene Video (d) Consult Menu (e) Dental Report (f) Consult menu with chat (g) Reminder menu (h) Checklist menu of dental health danger

Figure 4 shows the application for parents. The parents are given the account to connect to the dental therapist. The menu in the application consist of home menu, consult and reminder. On the home page, there is a video containing dental hygiene education. Second, the consult menu consists of chatting with dental therapist and upload dental reports. Meanwhile the reminder menu consists of checklist of dental hygiene and dental danger.

4. Discussion

Dental caries still becomes the global health challenge either in indigenous and geographically remote population. Dental caries affects 60 – 90% of children in the world. In fact, dental and oral health has an effect on children especially they under five years old because it can cause stunting (Rohanawati and Bachtiar, 2019). Thus, an integrated dental and oral health education and program are indispensable. Education to children regarding dental and oral health is important, especially to motivate them to carry out daily dental and oral hygiene. The involvement of schoolteachers can be one of solutions to educate the children. However, in the pandemic situation, the school is still closed for the activity. Thus, a dental and oral hygiene education in the pandemic situation needs an update by utilizing technology.

Industrial revolution 4.0 does impact on the daily life of people. Smartphone nowadays is used as if as primary need. The implementation of digital technology has spread in the world, including in health sector. Digitalization is proven great to offer dental education better in helping the dentist and patient (Zitzmann *et al.*, 2020). The interactive and intuitive learning can also impact on stimulation towards the patient, especially for the children. One of the biggest challenges in digital education is that to adapt and adjust to the development in technology and implement it in dental practice(Fernandez, Nimmo and Behar-Horenstein, 2016).

Our research has created TOMON (Tooth Monster Hunter) as the media to promote dental and oral health to children. This tool which is in the form of tooth brush with sensor and microcontroller inside that is able to detect tooth brushing motion. The toothbrush is connected to TOMON game which display a group of tooth brushing steps that should be followed by the player. This media is intended to attract the interest of the school children to practice dental hygiene especially tooth brushing. Because children follow what they see and record it. Thus, the media to teach tooth brushing is created as interesting as possible. Besides, the media is also intended to assess the children ability of tooth brushing in which it is expected their tooth brushing attitude is getting better (Cristina and Bezerra, 2002). This program is in line with the problem suffered by children that they have low efficiency in adopting the tooth-brushing recommendation in prevention program and therefore, effort is needed to improve their tooth brushing ability (Deinzer *et al.*, 2019). The program of dental health education is also intended to reduce dental plaque index in children. In (Setiawati *et al.*, 2020), the effort to reduce dental plaque of the children is not separated from parents. Once the knowledge of dental health ofparentst is good, the dental plaque index of the children is decreased. This shows a line that the attitude of preserving dental and oral health of the children is started by the knowledge of the parent and the role of the parent themselves. Our research has also created an application for the parent to involve in the dental and oral health program, i.e. giving parents an access to application to report to the dental therapist regarding their children's behavior of tooth brushing.

Acknowledgments

References

Al-Darwish, M. S. (2016) 'Oral health knowledge, behaviour and practices among school children in Qatar', *Dent Res J (Isfahan)*, 13(4), pp. 342–353.
Atarbashi-moghadam, F. and Atarbashi-moghadam, S. (2018) 'Tooth Brushing in Children', *Journal of Dental Materials and Techniques*, 7(4), pp. 181–184.

Baginska, J. and Stokowska, W. (2013) 'Pulpal involvement-roots-sepsis index: a new method for describing the clinical consequences of untreated dental caries', *Med Princ Pract*, 22, pp. 55–60.

Berzinski, M. *et al.* (2019) 'Parenting and child behaviour as predictors of toothbrushing difficulties in young children', *Ineternational Journal of Paediatric Dentistry*, (May), pp. 1–10. doi: 10.1111/ipd.12570.

Byambasuren, O., Beller, E. and Glasziou, P. (2019) 'Current Knowledge and Adoption of Mobile Health Apps Among Australian General Practitioners : Survey Study Corresponding Author ':, *JMIR MHealth and Uhealth*, 7(6), p. 313199. doi: 10.2196/13199.

Craig, S. A., Baker, S. R. and Rodd, H. (2015) 'How do children view other children who have visible enamel defects?', *Int J Paediatr Dent*, 25(6), pp. 399–408.

Cristina, A. and Bezerra, B. (2002) 'Effectiveness of Teaching Methods for Toothbrushing in Preschool Children', 13, pp. 133–136.

Deinzer, R. *et al.* (2019) 'Toothbrushing behavior in children – an observational study of toothbrushing performance in 12 year olds', *BMC Oral Health*. BMC Oral Health, 19(68), pp. 1–9.

Fernandez, M. A., Nimmo, A. and Behar-Horenstein, L. S. (2016) 'Digital Denture Fabrication in Pre- and Postdoctoral Education: A Survey of U.S. Dental Schools', *Journal of Prosthodontics*, 25(1), pp. 83–90. doi: 10.1111/jopr.12287.

Gibson, S. and Williams, S. (1999) 'Dental caries in pre-school children: associations with social class, toothbrushing habit and consumption of sugars and sugar-containing foods. Further analysis of data from the National Diet and Nutrition Survey of children aged 1.5-4.5 years', *Caries Res.*, 33(2), pp. 101–113. doi: 10.1159/000016503.

Id, D. L., Norman, R. and Robinson, S. (2020) 'Consumer preference to utilise a mobile health app : A stated preference experiment', *PloS One*, pp. 1–12.

Kementerian Kesehatan RI (2018) *Hasil Utama Riskesdas 2018*. doi: 10.1177/109019817400200403.

Lam, A. (2014) 'Elements in oral health programs', *N Y State Dent J*, 80(2), pp. 26–30.

Rohanawati, R. D. and Bachtiar, A. (2019) 'Effect of Dental and Oral Health in Under Weight Children Under Five Years of Age for Stunting Prevention: A Systematic Review', in *The 5th International Conference on Public Health*, pp. 209–218. doi: 10.26911/theicph.2019.02.37.

Salikun *et al.* (2021) 'Analysis On TOMON (Tooth Monster Hunter) - A Gaming Tooth Brush In Improving Dental Hygiene Status and Behavior Of Children', *International Journal of Dentistry and Oral Science (IJDOS)*, 08(04), pp. 2224–2229.

Setiawati, F. *et al.* (2020) 'Effectiveness of dental health education intervention using the 16-surface tooth brushing program among 7–9-year-old schoolchildren in Indonesia', *Pesquisa Brasileira em Odontopediatria e Clinica Integrada*, 20, pp. 1–7. doi: 10.1590/pboci.2020.144.

Ueno, M. *et al.* (2012) 'Effects of an oral health education program targeting oral malodor prevention in Japanese senior high school students.', *Acta Odontol Scand*, 70(5), pp. 426–431.

Underwood, B., Birdsall, J. and Kay, E. (2015) 'The use of a mobile app to motivate evidence-based oral hygiene behaviour', *British dental journal*, 219(E2). doi: 10.1038/sj.bdj.2015.660.

Vishwanathaiah, S. (2016) 'Knowledge , Attitudes , and Oral Health Practices of School Children in Davangere', *International Journal of Clinical Pediatric Dentistry*, 9(2), pp. 172–176.

World Health Organization (WHO) (2020) *What is the burden of oral disease?*

Zitzmann, N. U. *et al.* (2020) 'Digital undergraduate education in dentistry: A systematic review', *International Journal of Environmental Research and Public Health*, 17(9). doi: 10.3390/ijerph17093269.