# MOBILE APPLICATION GIGIKU SIHAT TO IMPROVE DIETARY HABIT AND ORAL HYGIENE AMONG CHILDREN AGED 4 TO 6 YEARS AND DIETARY AND ORAL HEALTH KNOWLEDGE, ATTITUDE AND PRACTICE AMONG PARENTS: A COMMUNITY INTERVENTION STUDY IN KELANTAN

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# MOBILE APPLICATION GIGIKU SIHAT TO IMPROVE DIETARY HABIT AND ORAL HYGIENE AMONG CHILDREN AGED 4 TO 6 YEARS AND DIETARY AND ORAL HEALTH KNOWLEDGE, ATTITUDE AND PRACTICE AMONG PARENTS: A COMMUNITY INTERVENTION STUDY IN KELANTAN

**by**

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*In the Name of Allah, The Most Gracious, The Most Merciful*

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## LIST OF ABBREVIATION

**AAPD** American Academy of Paediatric Dentistry

**CD** Compact disc

**CFFFQ** Cariogenic Food Frequency Questionnaire

**CONSORT** Consolidated standards for reporting trials

**DE** Design effect

**dmft** Decay, missing and filled teeth

**ECC** Early childhood caries

**iOS** iPhone Operating system

**KAP** Knowledge, attitude and practice

**NOHP** National Oral Health Programme

**OHI-S** Simplified oral hygiene index

**SD** Standard deviation

**SMS** Short messaging system

**TIP TOP** Toddler intervention package for total oral health program

**WHO** World Health Organization

**WTP** Water Treatment Plan

**APLIKASI MUDAH ALIH GIGIKU SIHAT UNTUK MENINGKATKAN TABIAT PEMAKANAN DAN KEBERSIHAN MULUT DALAM KALANGAN KANAK-KANAK BERUSIA 4 HINGGA 6 TAHUN SERTA PENGETAHUAN, SIKAP, DAN AMALAN BERKAITAN PEMAKANAN DAN KESIHATAN MULUT DALAM KALANGAN IBU BAPA: KAJIAN INTERVENSI KOMUNITI DI KELANTAN**

## ABSTRAK

Penjagaan kesihatan mulut yang baik pada kanak-kanak memerlukan kombinasi tahap pengetahuan ibu bapa, sikap, dan amalan (KAP) yang berterusan terhadap pemakanan dan kesihatan mulut kanak-kanak. Keupayaan telefon pintar untuk mengatasi halangan yang terdapat dalam kaedah pendidikan konvensional amat diperlukan memandangkan lebih ramai ibu bapa bergantung kepadanya pada masa kini. Bagi meningkatkan tabiat pemakanan dan kesihatan oral, aplikasi Gigiku Sihat (GS) telah dibangunkan khusus untuk ibu bapa kanak-kanak prasekolah. Tujuan kajian ini adalah untuk menilai keberkesanan aplikasi kesihatan mudah alih Gigiku Sihat dalam meningkatkan tabiat pemakanan dan kesihatan oral dalam kalangan kanak-kanak berusia 4 hingga 6 tahun di pra-sekolah KEMAS di Tumpat dan Pasir Mas, Kelantan serta pengetahuan, sikap, dan amalan (KAP) berkaitan pemakanan dan kesihatan mulut ibu bapa mereka. Percubaan rawak kelompok telah dijalankan. Sepanjang tempoh kajian, peserta dalam kumpulan intervensi (IG) menerima aplikasi GS yang dipasang pada telefon mudah alih mereka, manakala kumpulan kawalan (CG) menerima TIP TOP yang

disampaikan sekali semasa lawatan pertama. Saiz sampel adalah 60 bagi setiap kumpulan IG dan CG. Ukuran hasil yang utama adalah KAP ibu bapa berkaitan pemakanan dan kesihatan mulut dan kekerapan pengambilan makanan kariogenik (CFF) kanak-kanak yang dinilai melalui soal selidik kendiri yang disahkan, serta status kesihatan mulut yang dinilai melalui pemeriksaan klinikal menggunakan *Simplified Oral Hygiene Index* (OHI-S). Pengukuran pembolehubah dilakukan pada permulaan, 4 minggu (Penilaian 1) dan 8 minggu (Penilaian 2) selepas intervensi. Analisis deskriptif, *independent t-test*, dan *repeated measure* ANOVA dilakukan dengan tahap signifikan ditetapkan pada $p<0.05$. Seramai 116 pasangan ibu bapa-anak (IG:56, CG:60) telah menyelesaikan kajian ini. Kedua-dua kumpulan mempunyai lebih ramai kanak-kanak perempuan berbanding lelaki. Kebanyakan ibu bapa dalam kedua-dua kumpulan berumur 30-39 tahun (IG:73.2%, CG:53.3%); telah menamatkan sekolah menengah sebagai tahap pendidikan tertinggi mereka (IG:48.2%, CG:66.7%); merupakan suri rumah atau tidak bekerja (IG:41.1%, CG:68.3%); mempunyai kurang daripada 6 ahli keluarga (IG:62.5%, CG:55%) dan mempunyai pendapatan isi rumah bulanan sebanyak RM1,000 - RM1,999 (IG: 32.1%, CG:45.0%). Kebanyakan ibu bapa dalam IG (35.7%) telah membelanjakan RM500-RM599 sebulan untuk makanan, manakala kebanyakan ibu bapa dalam CG (31.7%) mempunyai perbelanjaan bulanan RM700-RM799. Bekalan air utama bagi kedua-dua kumpulan adalah daripada AKSB (air paip) (IG:69.6%, CG:73.3%). Pada Penilaian 1, IG menunjukkan skor min CFF yang ketara lebih rendah dalam kategori biskut ($p=0.017$), kerepek ($p=0.024$, 0.003), susu berasaskan kacang soya ($p=0.007$) dan minuman bergula/susu pekat ($p=0.042$). Pada Penilaian 2, didapati skor min CFF dalam IG juga lebih rendah untuk kuih tradisional ($p=0.006$), coklat ($p<0.001$), kerepek ($p=0.003$), gula-gula ($p=0.047$), buah-buahan proses ($p=0.002$), susu berasaskan kacang soya ($p<0.001$)

dan minuman bergula/susu pekat (p=0.004). Pada Penilaian 2, terdapat penurunan skor OHI-S yang ketara lebih rendah (p=0.023) dan peningkatan skor sikap yang ketara lebih tinggi (p=0.041) dalam IG berbanding CG. Tiada perbezaan yang signifikan dalam skor pengetahuan dan amalan ibu bapa antara IG dan CG. GS berkesan dalam meningkatkan skor sikap ibu bapa, tahap kesihatan mulut kanak-kanak, serta skor CFF kanak-kanak pra-sekolah dalam beberapa kategori. Aplikasi mudah alih, tabiat pemakanan, kebersihan mulut, KAP, pra-sekolah dan ibu bapa.

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## ABSTRACT

Maintaining good oral health in children involves a combination level of parental knowledge, attitude, and persistent behavioral routines towards children's nutrient and oral health. The ability of smartphone to overcome barriers in conventional education method is needed since more parents depend on it nowadays. In order to improve dietary habits and oral health, app of Gigiku Sihat (GS) was developed targeted to parents of preschool children. Aim of this study was to evaluate the effectiveness of mHealth apps Gigiku Sihat for improving dietary habits and oral health among 4- to 6-year-olds children at KEMAS preschool in Tumpat and Pasir Mas, Kelantan and their parents' nutrition and oral health knowledge, attitude, and practice (KAP). A cluster randomized trial was done. During the study period, participants in the intervention group (IG) used GS installed in their mobile device, while the control group (CG) received TIP TOP which was delivered once during the first visit. The sample size was 60 for each IG and CG. Primary outcome measures including parental nutrition and oral health KAP and children's cariogenic food frequency (CFF) were evaluated through validated self-administered questionnaires, and OH status was determined through clinical examination using Simplified Oral Hygiene

Index (OHI-S). Measurement of variables were done at baseline, 4- (Evaluation 1) and 8-weeks (Evaluation 2) post-intervention. Descriptive analysis, independent t-test, and repeated measures ANOVA were performed with significance level set at $p<0.05$. A total of 116 parent-child pairs (IG:56, CG:60) completed the study. Both groups have more girls compared to boys. Majority of parents in both groups aged 30-39 years old (IG:73.2%, CG:53.3%); had finished secondary school as their highest education level (IG:48.2%, CG:66.7%); were housewife or not working (IG:41.1%, CG:68.3%); had less than 6 family members (IG:62.5%, CG:55%) and had monthly household income of RM1,000 - RM1,999 (IG: 32.1%, CG:45.0%). Most of parents in IG (35.7%) had spent RM500-RM599 monthly for food, while most of parents in CG (31.7%) had monthly expenditure of RM700-RM799. The main water supply for both groups was from AKSB (pipe water) (IG:69.6%, CG:73.3%). At Evaluation 1, IG showed significantly lower mean CFF score in the categories of biscuits ($p=0.017$), crisps ($p=0.024$, 0.003), soya bean-based milk ($p=0.007$) and sugared drinks /condensed milk ($p=0.042$). At Evaluation 2, significantly lower mean CFF scores was also observed in IG for traditional *kuih* ($p=0.006$), chocolate ($p<0.001$), crisps ($p=0.003$), sweets ($p=0.047$), processed fruits ($p=0.002$), soya bean-based milk ($p<0.001$) and sugared drinks /condensed milk ($p=0.004$). There was a significantly lower OHI-S score ($p=0.023$) and higher attitude score ($p=0.041$) at Evaluation 2 in IG as compared to CG. There was no significant difference in parental knowledge and practice scores between the IG and CG. GS was effective in improving parental attitude score, children's oral health, as well as some categories of CFF of the preschool children. Mobile application, dietary habits, oral hygiene, KAP, preschool and parents.

# CHAPTER 1

# INTRODUCTION

Oral health is vital for children's lives and future growth and development. Untreated ECC does not only cause infection and pain (S. S. Gao and Chu, 2020) but will also interfere with biting and eating (Schmoeckel *et al.*, 2020) and affect the child's oral-health-related quality of life (Shahnaz *et al.*, 2019). Beyond physical health, poor oral hygiene can impact a child's cognitive and academic performance, as studies suggest that untreated dental issues lead to lower school attendance and performance in school due to persistent pain. Furthermore, visible decay or tooth loss can contribute to low self-esteem and mental stress (Bramantoro *et al.*, 2021). Unfortunately, unattended tooth caries remains a major problem in preschool children throughout the globe especially in low- and middle-income countries where oral care systems are often limited, unavailable, underdeveloped, and unaffordable for the majority of their citizens, particularly to the poor in the rural area (Watt *et al.*, 2019).

Chen *et al.* (2019) stated that dental caries in preschool children or known as early childhood caries (ECC) remains a significant health problem worldwide. According to American Academy of Pediatric Dentistry (AAPD), ECC was defined as the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries) or filled tooth surfaces that occur in any primary tooth of child age ≤71 months old (American

Academy of Pediatric Dentistry, 2016). However, at the recent Bangkok Declaration, a group of international experts has redefined ECC as “the presence of a primary tooth with one or more carious (non- cavitated or cavitated lesions), missing (due to caries), or filled surfaces in a child under the age of six years” (Pitts *et al.*, 2019).

Once a child is exposed to ECC, their teeth are prone to decay as they start to erupt and can lead to an increment of new carious lesions if left untreated. Research also shows that poor oral health in childhood can have long-term consequences, increasing the risk of chronic conditions such as malnutrition (Folayan *et al.*, 2019; Soares *et al.*, 2017). Therefore, it is suggested that preventive measures should be taken as early as within the first year of life to improve the child’s oral and overall health, and to prevent childhood caries from becoming more severe (AAPD, 2016).

### 1.1 Dietary Habit and Oral Hygiene Practice of Preschoolers and their Oral Health

Dental caries is an active pathological process which need three principal components to be present in its formation: fermentable carbohydrates, cariogenic bacteria, and a vulnerable tooth surface or host (Lui *et al.*, 2023). In addition to the three components above, dental caries is also influenced by multifactorial risk factors, with dietary habit and oral hygiene practice as two of the many elements that influence its formation. Therefore, understanding this association is critical for developing effective preventative interventions to protect the oral health of this vulnerable population.

Dietary habits contribute to ECC prevalence through the interaction between sugars on the tooth surface with microorganisms in the mouth. The process of caries production starts when bacteria consume and ferment the ingested carbohydrates. At the

exposure and process of breaking down the carbohydrate, biofilm such as *Streptococcus mutans (S.mutans)* will convert fermentable carbohydrates into organic acids, causing a fall in dental plaque pH from 7.0 to 5.0 and below, which subsequently leads to demineralization of enamel (Hujoel and Lingstrom, 2017; Lui *et al.*, 2023; P. Moynihan and Petersen, 2004a). At a longer exposure or increased frequency of consumption of the fermentable carbohydrates in between meals, there will be continuous acid production in the oral cavity, which subsequently leads to a continuous cycle of enamel demineralization (Sukumaran Anil and Anand, 2017; Lui *et al.*, 2023). Later, tooth decay will develop and lead to the formation of the cavity if they are left untreated (Morozova *et al.*, 2016).

A study by Yadav *et al.* (2022) reported a statistically significant association ($p<0.01$) between the prevalence of ECC and children's dietary pattern. In the study, the highest prevalence of ECC was observed in children who have the habit of consuming sweets, cakes, biscuits, and chocolates, as well as soft drinks twice a week in rural areas and daily in urban areas in Jaipur. This indicates that eating sucrose containing food at higher frequency may raise the risk of developing ECC as it causes increase in the acidogenicity of plaque, which fosters the growth of the caries-causing bacteria, *Streptococcus mutans* (Yadav *et al.*, 2022). Similar findings regarding association between dietary pattern and oral health outcomes were also found in other studies (Branger *et al.*, 2019; Lam *et al.*, 2022).

There are significant association between diet, sugar consumption and caries development had long been established in the classical studies since more than 50 years ago, for example, the Vipeholm study (1954) and Turku sugar study (1976) The Vipeholm study, conducted in a Swedish mental institution after World War II, investigated how the

consumption of sugary foods with different levels of stickiness (affecting their retention time in the mouth) and at various times influenced the development of dental caries (Gustafsson et al., 1954; Scheinin et al., 1976). The study assessed caries progression in participants who consumed refined sugars either during meals, between meals, or at varying times. Results showed that even when consumed in large amounts, sticky sugary foods had a minimal impact on the increase of dental caries if eaten up to four times a day during meals. However, consuming sugary foods frequently between meals significantly increased the risk of developing dental caries (Gustafsson *et al.*, 1954; P. Moynihan and Petersen, 2004).

On the other hand, the Turku Sugar Study in Finland in the 1970's investigated the effects of almost total substitution of sucrose with xylitol and fructose in the diet. Overall, the Turku Study concluded that xylitol, as opposed to sucrose, significantly reduced dental caries for both carious cavities and precavitation lesions, indicating that sugar alternatives might be useful in lowering tooth decay (P. Moynihan and Petersen, 2004; Scheinin *et al.*, 1976). Both research studies made a substantial contribution to our knowledge of how sugar affects dental health. Therefore, the current recommendation by World Health Organization (WHO) (2015) is to limit the intake of added sugar to less than 10% of total energy as a preventive strategy to reduce ECC, with a further reduction to <5% is believed to be more effective (WHO, 2015; Moynihan, 2016; Sheiham and James, 2014).

On the other hand, children's oral hygiene behavior is also positively associated with their oral health outcomes (Lam *et al.*, 2022; Yadav *et al.*, 2022). For example, A systematic review by Lertpimonchai *et al.* (2017) suggests that prevalence of periodontitis may be lowered with regular toothbrushing. Similarly, another study by Yadav *et al.*

(2022) also shows significant association between oral hygiene habit and oral health outcomes, where high prevalence of ECC was found in children who consumes bottles and breast milk, drinking milk at night, snacking between meals without brushing teeth.

Undeniably, children's dietary and oral hygiene habits can be influenced by their parents. Literature has shown that poor parental knowledge, attitude, and practice towards nutrition and oral health may lead to inappropriate feeding and oral hygiene practices towards the child. For example, they may practice prolonged breastfeeding than necessary (Branger *et al.*, 2019), higher frequency of bedtime sweet consumption (Zhang *et al.*, 2020), and feeding their children with baby bottle with milk to fall asleep, a baby bottle with sugary beverages, and a pacifier with sugary substances (Colombo *et al.*, 2019). Improper feeding practice will consequently increase the unnecessary contact time, duration, and frequency of fermentable carbohydrates with the children's teeth, which will interact with biological risk factors that lead to higher ECC prevalence (S Anil and Anand, 2017).

Since preschool children also have limited ability to practice appropriate oral hygiene independently, they are particularly more prone to dental caries. The parents', especially mothers' knowledge, attitude, and practice (KAP), has a profound influence on children's use of dental care services, oral health behavior, and dental outcomes (Bodhale *et al.*, 2014; Elamin *et al.*, 2018). For example, a study from Abbass *et al.* (2019) found a positive correlation between the dmft (decayed, missing, and filled teeth) score of children in the primary and mixed dentition stages and both the parent's brushing frequency and how often the parent brushed the child's teeth. Similarly, Yadav *et al.* (2022) also reported lower prevalence of ECC in children who performed oral hygiene

practices under parental supervision, and higher in children who has less parental monitoring during oral hygiene practices.

### 1.2 Parental Oral Health Knowledge, Attitude, and Practice

Parental knowledge, attitudes, and practices regarding nutrition and oral health are crucial in shaping the dietary habits and oral health outcomes of their children. Parents are expected to become role models and primary influencers to their children during their early years. Either good or bad routines that the children learned from their parents will determine their dietary habit and oral health in a long time (Khalid *et al.*, 2020).

Study showed that children had lower risk of caries when their parents had higher levels of nutrition and oral health knowledge (Khalid *et al.*, 2020; Scaglioni *et al.*, 2018). This may be due to better attitudes of the parents towards use of dental care services and better oral health behavior (Bodhale *et al.*, 2014; Elamin *et al.*, 2018). Meanwhile, parental knowledge regarding nutrition may have possible influence in the children's dietary habit through food choices, meal patterns, and nutritional environment that they introduced at home (Scaglioni *et al.*, 2018).

In general, well-informed parents regarding nutrition and oral health tend to have more positive attitude towards the matter, which encourages them to practice the recommended dietary and oral health behaviors and provide a good example for their kids to follow (Khalid *et al.*, 2020; Scaglioni *et al.*, 2018). Therefore, in order to reduce the prevalence of ECC, strategies must be developed by involving parents, to facilitate them to possess accurate knowledge about good nutrition and oral health (e.g. importance of fluoride in preventing dental caries and good feeding practice) and foster good parental

attitude and practice regarding nutrition and oral health (American Academy of Pediatric Dentistry, 2016; Zhang *et al.*, 2021).

### 1.3 Mobile Health Application (mHealth) in caries prevention

Mobile health applications or mHealth apps can be defined as "medical and public health practice supported by mobile devices such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices" (Aitken and Jennifer, 2015). It focuses on the use of mobile technologies like phones and wearables to support healthcare delivery and individual health management (Choe *et al.*, 2021). There are numerous capabilities available with mHealth apps, such as the ability to track physical activity, monitor diet and nutrition intake, manage chronic diseases, schedule medical reminders, and even put users in touch with medical professionals (Choe *et al.*, 2021).

With mHealth playing a critical role in modern oral healthcare, advancements in digital technology have also transformed dentistry**.** Teledentistry has gained prominence, particularly during the COVID-19 pandemic (2020-2022), when remote consultations became essential to maintain access to dental care. Additionally, the integration of AI-powered diagnostic tools, wearable devices, and mHealth applications in recent years has enhanced diagnostic precision, patient engagement, and preventive treatment in dentistry. These innovations enable real-time monitoring, personalized treatment plans, and interactive patient education, making current dental services more patient-centered**,** effective, and accessible (Eddhaoui *et al.*, 2025).

The increment of smartphone usage as well as mobile health (mHealth) applications being produced in the marketplace has turned mobile devices into a targeted tool for health promotion and individual disease management (Lee *et al.*, 2018). With mHealth apps, users can take charge of their health, enhance their wellbeing, and encourage healthier lifestyle choices by providing easy access to health information and tools (Grundy, 2022; Mendiola *et al.*, 2015). The conventional method is no longer the only way to convey oral health-related knowledge to parents and children to improve their dental health outcomes.

### 1.4 Problem statement

Children with early childhood caries (ECC) are more likely to develop cavities in their permanent teeth, which can negatively affect their quality of life as they grow older (Ministry of Health Malaysia, 2019). This chronic disease raises concern for its unfavorable health impact on preschool children such as infection, swelling, pain, and fever. ECC also causes disturbed sleep, frequent absenteeism from school, difficulty in speaking and eating as well as psychological effects like poor ability to communicate and lower self-esteem, although these effects are found to be significantly more frequent in severe ECC cases (Shahnaz *et al.*, 2019).

Regardless of the efforts by the government, however, although a steady reduction in caries prevalence in Malaysia was observed from 76.2% in 2005 to 71.3% in 2015, the rate is still far from National Oral Health Programme (NOHP) target to achieve 50.0% caries-free among 5 years-old by 2020. According to state-specific data, Kelantan consistently reports the highest caries prevalence among the states, with a caries-free rate

of only 7.0% among 6-year-olds in 2021, a decrease from 15.5% in 2020 (Oral Health Division Ministry of Health Malaysia, 2021). Unfortunately, specific caries reduction targets for 2025 and beyond have not been clearly stated in the publicly accessible documents. Detailed caries-free prevalence for other states and more recent data on caries prevalence in this age group also not publicly available, thus consequently, additional comparisons are not feasible. However, the Ministry of Malaysia has developed the National Oral Health Strategic Plan (NOHSP) 2022-2030 in response to ongoing oral health challenges, focusing on strategies such as community empowerment, preventive care, and digital transformation to address oral health issues (Oral Health Division Ministry of Health Malaysia, 2025).

Additionally, although oral health education talk was given to the children to promote positive behavior, Kelantan preschoolers were reported to consume high added sugar in their diet which is 205.1% times higher than the recommended WHO value (ie. <10% of total energy intake) (Hasan, 2012). Additionally, the unmet treatment needs among the preschool children in Kelantan is also still high, although a recent study by Dolah *et al.* (2020) in Kelantan preschoolers reported a statistically significantly lower mean dmft for deciduous dentition (5.27) than the national study in 2019 (7.56).

Furthermore, in 2021 there's still less than 50% of Water Treatment Plant (WTP) producing fluoridated water in Kelantan. Kelantan also appears to have the highest non-compliance of reticulation reading according to the standard lower limit of fluoride level in public water supplies (<25% of the reading below 0.4ppm), with 100% non-compliance. Regarding the Fluoride Varnish program, caries free status in 6 years old in Kelantan has shown improvement from 2012 until 2019. However, due to the restriction

on continuing oral health services for preschoolers during COVID-19, their dental health status was deprived to some extent. The compliance rate of the children to the programme was also low, with only 3.3% of the children completed 4 times applications. (Oral Health Division Ministry of Health Malaysia, 2021).

Apart from government's policy and action, one of the factors influencing these problems is related to parental involvement in nutritional education and caries prevention program itself (which can be closely associated with their KAP), because children mainly depend on their parents to do their daily activities (Nepaul and Mahomed, 2020; Xiao *et al.*, 2019; Zhang *et al.*, 2021). In Malaysia, a significant challenge in caries prevention is the lack of parental awareness and knowledge regarding early childhood oral health. Many parents are not fully informed about the cause of ECC, benefits of fluoride, proper brushing techniques, and impact of sugary diets on their children's oral health (R. Ahmad *et al.*, 2017). Additionally, many parents also delay their child's first dental visit, while many others depend on traditional beliefs and home remedies instead of seeking professional dental care, which can worsen oral health problems. Misconceptions, such as the belief that primary teeth do not require care because they will eventually be replaced, further exacerbate the issue (R. Ahmad *et al.*, 2017).

A study by R. Ahmad *et al.* (2017) also found that while many Malaysian parents have fair oral health knowledge and positive attitudes, their actual practices for preventing early childhood caries (ECC) remain inadequate. Despite understanding the importance of oral hygiene, parents often fail to implement consistent brushing, flossing, and cariogenic food reduction. Many do not supervise their children while brushing and tend to delay dental visits until issues arise, rather than prioritizing preventive care.

Additionally, although parents are aware of the risks, frequent consumption of sugary foods and drinks continues to be a major factor in the high prevalence of caries among children (R. Ahmad *et al.*, 2017). A systematic review by Khalid *et al.*, (2020) further supports this, highlighting a strong association between parental oral health practices and the development of ECC.

Expanding on this issue, a study in Kelantan by Hasan et al. (2012) on parental KAP regarding the oral health of preschool children found that only one-quarter of the proxy population have good knowledge (26.4%), less than one-quarter have a good attitude (17.1%), and more than one-third (39.4%) have good oral health practice. These gaps in parental knowledge, attitude, and practice in Malaysia, particularly in Kelantan, highlight the urgent need for this study to enhance parental dietary and oral health KAP, and therefore contributing to reducing ECC prevalence in the state in the future**.** A mobile health (mHealth) application can address these challenges by providing accessible, interactive oral health education to increase nutrition and oral health awareness and, as well as personalized reminders to reinforce good oral health habits among the parents.

### 1.5 Justification of the study

Improved oral health status of children will reduce the burden of disease and improve the quality of life (QoL) of the children. Therefore, it is crucial to ensure that oral health education is delivered to the community. With the rapid growth of mobile technology, the usage of mobile phones or smartphones specifically has become mainstream around the globe and makes the mobile phone a practicable platform to deliver health education content to the community. The positive effects of nutrition-related

mHealth applications have been acknowledged by many studies. It helps to reduce healthcare costs (Mendiola *et al.*, 2015), improve healthcare communication, efficiency, and quality of the services (Mikulic, 2019), and is convenient to the users (Kruse *et al.*, 2019).

The benefit of mHealth apps as a self-monitoring tool, specifically in managing gingivitis, improving oral hygiene, and acquiring health knowledge also has been supported by a recent systematic review (Toniazzo *et al.*, 2019a). The growing number of mHealth applications related to dietary and oral health available in the mobile play store, however, are ambiguous of their credibility because not all of them are developed in a research setting. Hence, the utility of those apps remains questionable as there are no prior reviews available regarding their overall content, usability, or quality (Sharif and Alkadhimi, 2019).

While mHealth apps are relevant to be used in the healthcare sector, it is important to develop an effective oral health program that fit the needs of the particular population since the cultural and social contexts of the Southeast Asians are different than that of another part of the world (Chen *et al.*, 2019). According to Muhamat *et al.* (2021), eighteen available mobile apps for oral health promotion designed for the iOS in the Google Playstore were studied in 2018, with findings that there was no locally developed mobile application that focuses on dietary and oral health and developed specifically for the guardians of preschool children in Malaysia yet. Therefore, this study will assess the effectiveness of the newly developed local dietary and oral health application Gigiku Sihat in improving the oral health KAP of the parents or guardians in Malaysia. In addition, it will also give knowledge by reporting further insight into its effectiveness on the local

population. Results from this study will also add to the knowledge about the current oral health KAP of Kelantan parents, oral hygiene status of Kelantan preschoolers and their dietary habits, as well as the effect of improved parental KAP on the child's dietary habit and oral hygiene.

The mobile application prototype Gigiku Sihat that will be used in this study was developed by Muhamat *et al.* (2019) according to TIP TOP module by Hasan (2012), the publication from the Malaysian Ministry of Health, and published journal and books by oral health experts. It had already passed its usability test. Responding to the Ministry of Health's call to adapt to new norms and start digitalization of healthcare services by Ministry of Health (2020), this mobile application is expected to serve as a new alternative to oral health education for parents and the public in childhood caries' prevention program in Malaysia. With more adjustments to the app in the future, this kind of educational app will be especially useful during times when delivery of oral outreach activities needs to be postponed, such as the MCO period due to COVID-19 pandemic.

Finally, with the implementation of this mHealth app educational method, it will benefit in terms of reducing the burden of the disease, increasing parental KAP towards oral health, and improving oral health status and overall quality of life of the children in the future. This study is also expected to help to provide researchers with resources and knowledge for future development and improvement of local mobile applications related to dietary and oral health. The findings can be utilized by various stakeholders, including researchers, healthcare or dental professionals, the media, and relevant authorities.

## 1.6 Conceptual framework

Figure 1.1 provides a summary of the conceptual framework for this study. ECC prevalence can be influenced by several factors, namely individual (dietary and oral hygiene habit), biological, and environmental risk factors. These factors interact with each other, with environmental factors like sociodemographic and socioeconomic characteristics as one of the biggest contributors to the development of ECC.

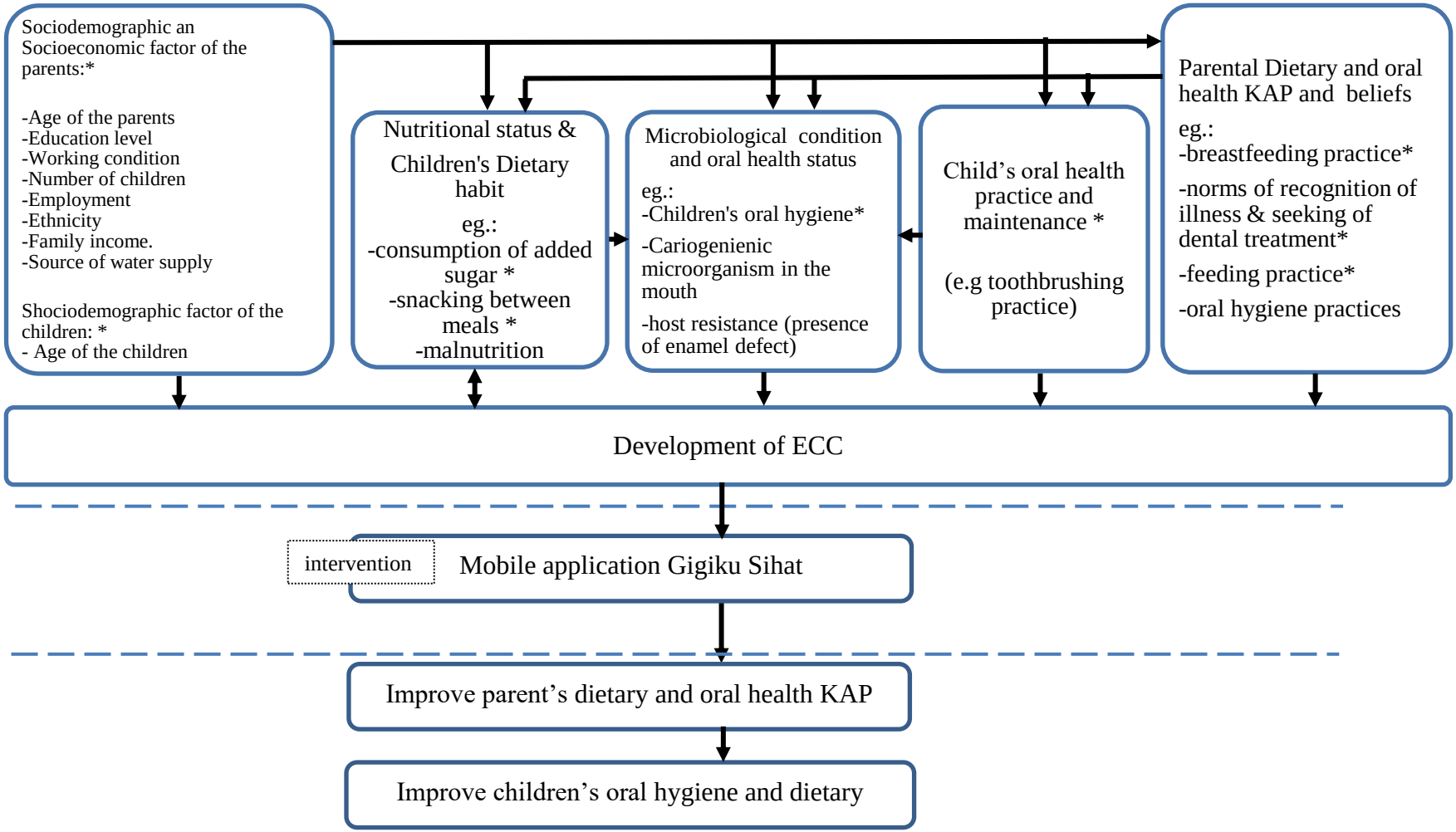
The association between sociodemographic factors and ECC was established in many literatures. For example, a study by Sathiyakumar *et al.* (2021) found that prevalence of ECC is higher in male children and that the risk increases with children's age (Pilbauerova *et al.* 2020, M. Zhang *et al.*, 2020). Sociodemographic factors were also associated with nutritional status (Angelopoulou *et al.*, 2019; Tanner *et al.*, 2022) and dietary habit of the children (Ravaghi *et al.*, 2020). Similarly, a positive association was also established between sociodemographic factors and oral health status of the children. For example, people with lower SES reported to have higher dmft and dental caries prevalence than those from higher SES (Lam *et al.*, 2022; T. Zhang *et al.*, 2021).

Additionally, sociodemographic factors such as employment status of the parents may also influence children's oral health practice (Law *et al.*, 2020). Other SES factors such as parental age, employment status, working condition, occupation, number of children, and ethnicity also have a significant correlation with parental knowledge, attitude and practice (KAP) towards dietary and oral health (Chala *et al.*, 2018; Law *et al.*, 2020; Zhang *et al.*, 2021).

Meanwhile, ECC development is associated with the dietary habit (i.e. high sugar consumption) of an individual (Colombo *et al.,* 2019). Dietary intake will interact with the cariogenic microorganisms inside the mouth, which is one of the biological risk factors for ECC (Hujoel and Lingstrom, 2017). On the other hand, toothbrushing practice and oral health maintenance of children also has an impact on their oral cavity status and ECC development. For example, caries prevalence are found to be lower in children who brushes their teeth under their parent's supervision (Yadav *et al.*, 2022), since they are not yet capable to clean their teeth properly.

Parental dietary and oral health KAP and beliefs may also significantly influence children's dietary (Branger *et al.,* 2019) and oral health habits and their oral health status (Abbass *et al.,* 2019). For example, literature have shown that children tend to have significantly better toothbrushing habits and are more enthusiastic about brushing their teeth when their caregivers, particularly their mothers, possess a strong understanding of oral health and demonstrate a positive attitude toward maintaining good dental hygiene (Nepaul and Mahomed, 2020). Children's food preferences may also be influenced by their parental dietary practice (Scaglioni *et al.*, 2018).

Hence, taking advantage of the advancement of technology (Choe *et al.*, 2021), increment of smartphone usage (Müller, 2021), development of mHealth apps, and its usage, as well as the positive effect of mHealth especially in oral healthcare intervention program (Toniazzo *et al.*, 2019; Grundy, 2022; Mendiola *et al.*, 2015), Gigiku Sihat was developed to deliver the oral health education on ECC to parents. As suggested by AAPD (2016), focusing intervention action on the parents would be beneficial in improving children's dietary habit and oral hygiene, thus reducing the ECC prevalence.




NOTE: (*) are items that will be assessed in this study

**Figure 1.1 Conceptual framework of the study**

## 1.7 Research objectives

### 1.7.1 General Objective

To evaluate the effectiveness of the Gigiku Sihat mobile application prototype in improving dietary habits and oral hygiene among children aged 4 to 6 years in Tumpat and Pasir Mas, Kelantan, as well as dietary and oral health knowledge, attitude, and practice (KAP) of their parents to prevent early childhood caries (ECC).

### 1.7.2 Specific Objectives

1. To compare Cariogenic Food Frequency Questionnaire (CFFQ) scores and index plaque scores of 4 to 6-year-old children in Kelantan in the intervention group, before and after health education intervention.
2. To compare Cariogenic Food Frequency Questionnaire (CFFQ) scores and index plaque scores of 4 to 6-year-old children in Kelantan in the control group, before and after health education intervention.
3. To compare CFFQ scores and dental plaque index scores of 4 to 6-year-old children in Kelantan between intervention and control group after respective health education intervention.
4. To compare nutrition and oral health KAP scores among parents of 4 to 6-year-old children in Kelantan in the intervention group, before and after health education intervention.

5. To compare nutrition and oral health Knowledge, Attitude, and Practice (KAP) scores among parents of 4 to 6-year-old children in Kelantan in the control group, before and after health education intervention.
6. To compare nutrition and oral health KAP between parents of 4 to 6-year-old children in Kelantan between the intervention and control group, after health education intervention.

## 1.8 Research questions

1. Are there differences in the Cariogenic Food Frequency Questionnaire (CFFQ) scores and plaque index scores of 4 to 6-year-old children in Kelantan, within the intervention group, before and after health education intervention?
2. Are there differences in the Cariogenic Food Frequency Questionnaire (CFFQ) scores and plaque index scores of 4 to 6-year-old children in Kelantan, within the control group, before and after health education intervention?
3. Are there differences in the Cariogenic Food Frequency Questionnaire (CFFQ) scores and dental plaque index scores of 4 to 6-year-old children in Kelantan between intervention and control group following health education intervention?
4. Are there any differences in nutrition and oral health related KAP scores among parents of 4 to 6-year-old children in Kelantan in the intervention group, before and after health education intervention?
5. Are there any differences in nutrition and oral health related KAP scores among parents of 4 to 6-year-old children in Kelantan in the control group, before and after health education intervention?

6. Are there any differences in nutrition and oral health related KAP scores among parents of 4 to 6-year-old children in Kelantan between the intervention and control group, after health education intervention?

### 1.9 Research hypotheses

1. The mean Cariogenic Food Frequency Questionnaire (CFFQ) scores and index plaque scores of 4 to 6-year-old children in Kelantan in the intervention group are lower after health education intervention.
2. The mean Cariogenic Food Frequency Questionnaire (CFFQ) scores and index plaque scores of 4 to 6-year-old children in Kelantan in the control group are lower after health education intervention.
3. The decrease in mean CFFQ scores and dental plaque index scores of 4 to 6-year-old children in Kelantan in intervention group are lower than the decrease in control group after respective health education intervention.
4. The mean nutrition and oral health KAP scores among parents of 4 to 6-year-old children in Kelantan in the intervention group are higher after health education intervention.
5. The mean nutrition and oral health Knowledge, Attitude, and Practice (KAP) scores among parents of 4 to 6-year-old children in Kelantan in the control group are higher after health education intervention.
6. The increase in mean nutrition and oral health KAP between parents of 4 to 6-year-old children in Kelantan in the intervention group are more than the increase in control group after respective health education intervention.

# CHAPTER 2

# LITERATURE REVIEW

The literature review section of this paper delves into a comprehensive exploration of various aspects related to Early Childhood Caries (ECC) prevention. The following key topics will be discussed: First, an overview about oral health in children was presented. The focus then shifted to the prevalence of ECC among preschoolers worldwide as well as at the local settings and understanding its etiology. Dietary intake and its correlation with ECC development were explored, followed by the influence of socioeconomic status on the development of ECC. Further discussion regarding the function of fluoride in preventing ECC was also presented in the subsequent topic. Next, this section also discussed parental involvement and the impact of parental knowledge, attitudes, and practices (KAP) on children's nutrition and oral health outcomes. A thorough introduction to mobile health (mHealth) in the context of healthcare was also presented, with a focus on its applicability and relevance. This review also covered strategies for the prevention of ECC, followed by the effectiveness of utilizing mHealth Apps in this area. A detailed analysis of the opportunities and challenges related to implementing mHealth in ECC prevention was also explained, to provide an extensive understanding of the landscape. Finally, a case study on the Gigiku Sihat mHealth App will be provided at the end to provide an overview of its features, potential benefits for ECC prevention, and comparisons with other apps.

## 2.1 Oral health in children

Oral health is an important aspect of general health and well-being, especially in young children. Good dental health in early life is critical for proper development, including nutrition, speech, and socialisation (WHO, 2003). Additionally, teeth is also important for one's beautification (Rahman *et al.*, 2020). Research has consistently demonstrated that poor oral health in children can result in a variety of negative effects, including pain, infection, and trouble with eating and speaking (S. S. Gao and Chu, 2020; Shahnaz *et al.*, 2019). According to the World Health Organization (WHO), dental caries (tooth decay) is one of the most prevalent chronic conditions affecting children globally (Chen *et al.*, 2019; WHO, 2003). It affects children of all ages and can have long-term consequences if not addressed early.

Oral health encompasses more than just healthy teeth; it also involves the gums, soft tissues of the mouth, chewing muscles, palate, tongue, lips, and salivary glands, all of which play vital roles (WHO, 2003). While dental caries and gum disease (periodontal disease) are the most prevalent conditions affecting populations worldwide, other oral health issues such as tooth and jaw trauma, dental erosion, enamel developmental defects, and oral cancer are equally significant. The early loss of primary teeth can lead to misalignment of permanent teeth, impacting an individual's appearance. Tooth loss, especially in children, can affect their dietary intake and hinder proper growth and development (WHO, 2003).

Poor oral health in children can be influenced by many factors. Particularly dental caries, it is mainly affected by their diet, with sugary foods and beverages greatly contribute to the increased risk (P. Moynihan, 2016). Access to preventative care and

education is critical for children's oral health well-being, although discrepancies are expected, especially among low-income families. Regular dental check-ups, basic oral hygiene habits, the use of fluoridated water and toothpaste, and maintaining a healthy diet are all among beneficial strategies to maintain oral health (Morozova *et al.*, 2016; AAPD, 2016). Addressing these discrepancies and encouraging these key prevention practices is critical to reduce the children's risk of dental problems and promote their lifelong oral health.

### 2.2 Early Childhood Caries (ECC) among preschool children

Untreated dentine carious lesions in deciduous teeth remain the most common oral health problem, despite evidence showing that the severity and prevalence of dental carious lesions in children 5 to 12 years old is decreasing over the last decades (Global *et al.*, 2017). According to the latest global report, there has been no progress in oral health over the past 25 years, with an estimated 573 million children worldwide expected to have untreated dental caries in their primary teeth as of 2015 (Kassebaum *et al.*, 2015). A systematic review and meta-analysis by Uribe *et al.* (2021) regarding global prevalence of ECC discovered that almost half (48%) of preschool-aged children suffer from early childhood caries. This distribution is global with geographical variances. The ECC prevalence in North and Central America, Asia, and Oceania reported to have prevalence above the worldwide estimate, while in Africa, it is lower than the global pooled prevalence. Meanwhile, America and Europe are within the global estimate. In Malaysia, the prevalence of caries among 5-year-olds in Malaysia is also relatively high (71.3%) as reported by Malaysian National Oral Health Survey of Preschool Children (NOHPS) in 2015 (Ministry of Health Malaysia, 2019).

According to American Academy of Pediatric Dentistry (AAPD) (2016), two commonly accepted classifications for ECC are simple ECC and severe ECC. AAPD defines simple ECC as the presence of one or more decayed, missing, or filled tooth surfaces in any deciduous tooth in a child less than 6 years old, while severe ECC (s-ECC) is defined as any signs of smooth-surface caries in children < 3 years of age, and from ages 3 to 5, with 1 or more decayed, missing (due to caries) or filled smooth surfaces in the primary maxillary anterior dentition, or decayed, missing or filled scores of ≥ 4 (ages 3 to < 4), ≥ 5 (ages 4 to < 5) or ≥ 6 (ages 5 to < 6).

ECC results from complex, dynamic interactions between host, cariogenic microorganisms, range of social variables, and diet. The main bacteria that involve actively in the microbial etiology of ECC is *Streptococcus mutans* (*S. mutans)*, where can be found in high numbers in the plaque of children affected with ECC. Poor oral hygiene, genetic factors, and long-term immune changes are among the factors that will cause the shifting of biofilms in the mouth and lead to an increase in *S. mutans*. This condition will result in decreased pH and demineralization on the tooth surface (Luthfi *et al.*, 2019), which consequently promotes dental caries. *S. mutans* works together with other microorganisms such as fungus *Candida albicans (C. albicans)* in promoting the formation of cariogenic or tooth decay-causing dental plaque (Hajishengallis *et al.*, 2016).

Studies have shown that when *C. albicans* and *S. mutans* are exposed to a sucrose-rich diet, they develop a synergistic relationship which increases their ability to form dental plaque and subsequently leads to the onset of ECC (Hajishengallis *et al.*, 2016). Other acidogenic and acid-tolerant bacteria that can be detected in plaque from ECC-affected children include actinomyces, bifidobacteria, lactobacilli, and *Scardovia* species,

alongside other additional microbial genera/species which can also contribute to the pathogenesis of the disease. Meanwhile, lack of alkali production by specific members, such as *Streptococcus gordonii* of the plaque microbiome may also be the factor that can enhance the susceptibility of dental caries in children (Hajishengallis *et al.*, 2016).

### 2.3 Relationship between dietary intake and ECC development

The association between nutrients, foods, and dietary patterns has important consequences, especially for development and prevention of chronic diseases like ECC. There are many convincing evidence showing that overall dietary habit is one of the big key factors that influence dental caries formation, alongside other factors such as intra-oral environment, fluoride, and salivary flow. The effect of dietary intake on the formation of ECC depends on what is consumed at a specific time point and their current intra-oral environment. For example, prevalence and risk of ECC increases with bad dietary practices such as high frequency and high exposure to fermentable carbohydrates, or free sugars, such as disaccharides (sucrose, maltose, lactose) and monosaccharides (glucose, galactose, fructose) (Hujoel and Lingstrom, 2017; Winahyu *et al.*, 2019; P. Moynihan, 2016).

The cariogenicity of a food or beverage can be described as the food's potential to produce dental caries (Morozova *et al.*, 2016). It is determined by physical properties such as processing and refining, acidic properties, carbohydrate types and content, and the presence of protective elements like calcium, phosphate, and casein (Melekoğlu and Yilmaz, 2023). In addition to these physical characteristics, the amount, timing, and frequency of fermentable carbohydrate consumption, eating habits, and dietary