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The Effects of a Smartphone-Based Education Program Designed to Help Mothers Safely Administer Medication to Their Children

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This study aimed to determine the effect of a smartphone-based medication education program to help mothers safely administer medication to their children at home. A quasi-experimental, non-equivalent control group, pretest-posttest design was utilized. There were 33 participants in the experimental group and 30 in the control group. The experimental group participated in the *KidsMedi* program for 6 weeks. The experimental group, receiving the *KidsMedi* program, had a statistically significant higher perception of antipyretic analgesics and higher eHealth literacy than the control group. The medication education program developed in this study is a mobile Web-based program. It is an effective program for mothers to improve their knowledge about administering drugs to children at home. This program is not affected by time and place, allowing repetitive self-directed learning. Nurses can utilize this program in daycare centers, schools, hospitals, communities, and public institutions to educate parents about safe medication for children.

KEY WORDS: Caregivers, Child, Education, Knowledge, Medication errors

Children's health may vary according to the actions of their primary caregivers. Caregivers should administer medication to their children for health maintenance, disease prevention, and symptom relief based on accurate medication-related knowledge. The potential risk of dosing errors is higher for children than it is for adults.[1] This is because doses given to children may vary based on age, weight, and body surface area.[2,3] An analysis of pediatric medication error reports conducted by the Korea Adverse Event Reporting System found that the side effects due to medication errors in children were 2.73 times higher than those in adults; the most frequently reported medication errors among children were accidental overdosing and drug maladministration.[4] Compared with adults, children also have less mature gastrointestinal, liver, and kidney functions, and these organs are responsible for metabolizing and excreting drugs, which may otherwise remain in the body for longer periods.[5] This increases the risk of side effects, even when the drugs are taken in small amounts and children who experience side effects may be limited in their ability to express symptoms.[6]

The most commonly used medicines for children include antipyretic analgesics, cough/cold medicines, and antibiotics. In particular, antibiotics must be administered exactly according to their prescribed doses and time. Antibiotic resistance in the body increases if the dose is arbitrarily reduced or stopped prior to treatment completion. This makes proper education on medication compliance a highly important area of concern among caregivers. A study on the at-home medication experiences of parents with children under 6 years of age found that 85.5% of respondents had discontinued medication when symptoms were no longer present.[7] Further, 26.8% had implemented other medicines along with the prescribed drugs, whereas 26.3% had used leftover medicines when their children exhibited the same symptoms during later episodes, and 13.4% had administered medications to the siblings of the child with the prescription.[7] Moreover, 96.1% of respondents expressed the need for education aimed at helping them properly administer drugs to their children.[7] To our knowledge, no intervention studies have been focused upon parents who administer medication to their children for the purpose of increasing medication knowledge and preventing drug misuse.

A previous study investigating the amount and frequency of antipyretic analgesics administered to children at home prior to visiting the emergency room found that 51% did not receive the correct doses; in this context, 34.8% of parents or caregivers actually administered higher doses than recommended.[8,9] It should be ensured that caregivers fully understand what constitutes drug misuse because they consider over-the-counter (OTC) medicines, such as antipyretics and cough/cold medicines, as safe even if they are taken in a dose beyond prescription.

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Health literacy refers to the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions.[10] Low health literacy among parents contributes to the difficulty in understanding and implementing medication instructions; it is also reported to be related to medication errors.[11] Low health literacy among parents has been associated with poor adherence among children with diseases.[10,12] Therefore, it is necessary to consider parents' health literacy when administering medication to their children.

eHealth literacy is defined as "the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem."[13] Currently, parental education is increasingly being issued in an individual online education format that does not require attendance at a specific time or place. However, it is still necessary to ensure professional and systematic education rather than merely providing information through online resources. Continual advancements in wireless Internet applications and mobile-communication technologies have increased the popularity of devices such as tablet PCs and smartphones that provide convenient ways to offer official Web-based education programs, as they can be accessed without time and space constraints. This enables mutual information exchanges, formation of interpersonal relationships, and continuous repetitive self-directed learning.

The present study developed, applied, and evaluated a mobile Web-based medication education program (*KidsMedi*). The purpose of this study was to verify the effects of this program on the perception of antipyretic analgesics and antibiotics, knowledge of medication safety, and eHealth literacy.

METHODS

Study Design

This study used a quasi-experimental, nonequivalent control group, pretest-posttest design to investigate the effect of the *KidsMedi* program.

Participants and Setting

This study was approved by the institutional review board (IRB-SBR-SUR-17-441) at the hospital. Before the research commenced, participants were informed of the study purpose and procedure; they also provided written informed consent. A convenience sampling method was adopted to recruit participants. Inclusion criteria were as follows: mothers (1) living in the area of Gyeonggi-do, to enable the use of an accessible population; (2) with a child/children under the age of 6 years; (3) with experience administering medicine to a child at home; and (4) who use smartphones. For the recruitment process, we ensured that residential environments were similar; however, the experimental group and control group were allocated based on geographically separate locations. Specifically, the experimental group was selected from a kindergarten and a daycare center located in "S city," whereas the control group was selected from a kindergarten and a daycare center located in "K city." We first visited the kindergartens and daycare centers to ensure cooperation from the institutional heads. We then sent letters to the homes of eligible individuals with an explanation of the study purpose. Consent forms were obtained from the mothers who volunteered to participate. Participants included the mother's name, their child's name, and the mother's mobile number in the consent form.

The sample size was estimated using the G*Power 3.1 program (Heinrich Heine University, Dusseldorf, Germany), based on a significance level (α) of .05, a power ($1 - \beta$) of .80, and an effect size of .80.[14] Accordingly, 26 participants were required for each group. Ultimately, 33 and 30 participants were recruited for the experimental and control groups, respectively; two participants dropped out from the control group, resulting in a withdrawal rate of 6.3% (Figure 1).

Measures

The perception of antipyretic analgesics was measured through a questionnaire developed from a review of the relevant literature. After composing the test items, content validity was assessed by an expert group (including pediatricians, pharmacists, and child nursing professors) and finally completed through supplementation and revision. The final 14 items were each answered on a 5-point Likert scale ranging from 1 ("not at all") to 5 ("very much"), with higher scores indicating a higher perception of antipyretic analgesics. The reliability in this study was a Cronbach's α of .84.

Perception of antibiotics was measured using the Parental Perception on Antibiotics Scale[15] consisting of 25 items that are rated on a 5-point Likert scale ranging from 1 ("not at all") to 5 ("very much"). Higher scores indicate higher levels of parental perception about antibiotics. The reliability of the scale at the time of development was a Cronbach's α of .78, and in this study, it was .71.

Knowledge of medication safety was measured using the questionnaire relating to knowledge of medication safety[16] consisting of 15 items that are rated on a 4-point Likert scale ranging from 1 ("always") to 4 ("not at all"), with higher scores indicating higher levels of knowledge about medication safety. The reliability of the scale at the time of development was a Cronbach's α of .77, and in this study, it was .72.

eHealth literacy was measured using the eHealth Literacy Scale (e-HEALS),[13] consisting of eight items that are rated on a 5-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree"), with higher scores indicating higher eHealth literacy. The reliability of the scale at the time of

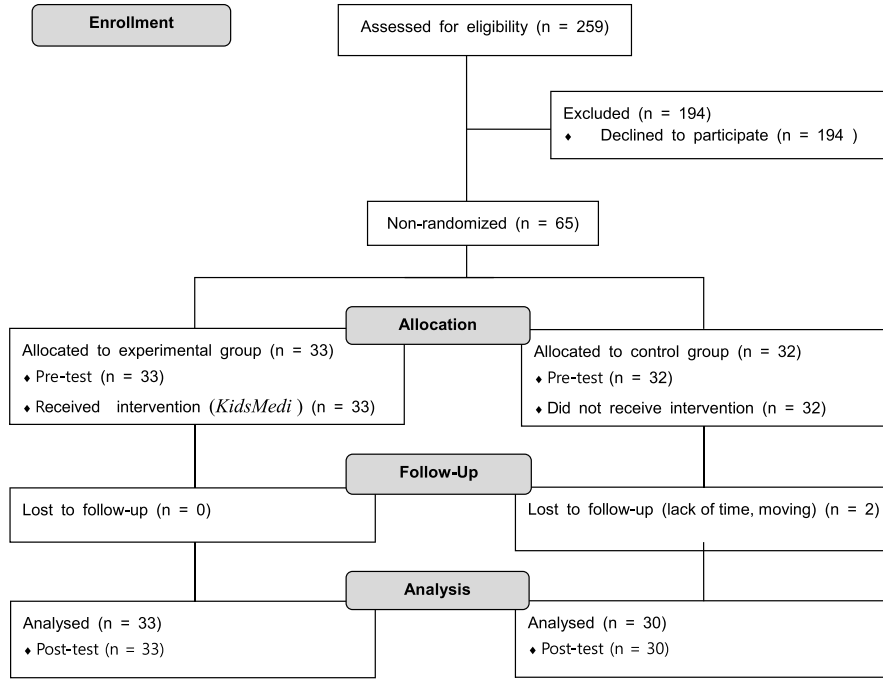

FIGURE 1. Flowchart of the study.

development was a Cronbach's α of .88, and in this study, it was .94.

Development of KidsMedi Program

The *KidsMedi* program was designed and developed as follows: First, a literature review was conducted to gain information on both domestic and international research regarding children's medication. The program's contents were then compiled using Web-based data and drug-related books. We also collected and analyzed the dosage containers from the various types of antipyretic analgesics and other medications for children at pharmacies near a general hospital and local pediatric clinics. In-depth one-on-one interviews were then conducted with five mothers of infants/young children. Interview questions were designed to gain information about children's medication experiences at home. We analyzed the interview contents to revise the primary educational contents of the intervention. These were also supplemented based on advice received from a panel of five experts (ie, a pediatrician, a pharmacist, a child nursing professor, a child ward nurse, and a professor with extensive research experience related to medication).

The final program consisted of six weekly sessions in which participants were supposed to watch an educational video lasting 15–20 minutes each, on their smartphones. They were asked to complete quizzes after each session concerning the contents. The topics for each week were as follows: week 1: understand the child (growth and development, common diseases in children); week 2: understand the drugs (OTC drugs, antipyretic analgesics, written description of medicine); week 3: understand the drug information (prescription drugs, antibiotics, online drug information); week 4: understand how to administer drugs (dosing methods for each drug); week 5: understand what you need to know about drugs (side effects, drug storage); and week 6: summary and evaluation. Finally, the mobile Web-based program (*KidsMedi*) was completed in cooperation with Web program development experts (Figure 2).

Data Collection and Procedures

For pretest of the control group, structured questionnaires were sent to each participant's home through their child. For pairing the pretest and posttest questionnaire, we sent the questionnaire envelope, filled out with their child's name, to participants. A researcher collected completed questionnaires after the participants returned the questionnaire envelopes to their respective kindergarten or daycare center. There was no contact between the experimental and control groups because they were in geographically far locations. After the 6-week period, wherein the experimental group was provided the intervention but the control group was not, the control groups were administered the posttest. After this study was done, we provided the *KidsMedi* program to the control group.

For the experimental group, the same procedure as the control group was followed for the pretest. The experimental

FIGURE 2. Screenshots of *KidsMedi* Web page. (A) Main screen, (B) learning objectives, (C) videos list, (D-E) examples screen of video, (F) quiz, and (G) individual results of the quiz.

group was given an informational manual a week prior to the *KidsMedi* commencement. This allowed participants to learn how to use the program while providing early opportunities to inquire about portions they did not understand. The researchers administered the *KidsMedi* for 6 weeks to participants. The researcher, as the mobile Web manger, uploaded the educational videos, sent weekly text messages to participants to inform them about upcoming program contents, encouraged the participants to access the entire educational contents from the Web site, and monitored the time and frequency of Web site access. The total running time for the 6 weeks, on an average, was 2 hours and 29 minutes, and the average number of participants who accessed the Web site was 10.5. After finishing the *KidsMedi* program, the experimental group was asked to complete the same questionnaire as in the pretest. They were also asked to complete program satisfaction evaluation sheets. All participants were compensated with a $25 reward whenever they completed the survey.

Data Analysis

Data were analyzed using the IBM SPSS Statistics version 25 (IBM Inc., Armonk, NY, USA). The homogeneity in general characteristics and dependent variables between groups was analyzed using the χ^2 test or independent t test. Descriptive statistics were utilized to assess the general characteristics of participants, whereas the normality of the dependent variables was verified using the Shapiro-Wilk test. An independent t test was used to analyze the difference between the experimental and control groups. A paired t test was used to analyze the difference between pretest and posttest scores. For the two-tailed tests, statistical significance was achieved at $P < .05$.

RESULTS

Participants' General and Baseline Characteristics

The average ages of the mothers participating in this study were 36.85 years and 35.67 years in the experimental and control groups, respectively. Regarding education, 84.8% and 90% of the experimental and control groups, respectively, had attended college or above, whereas 63.6% and 53.3%, respectively, were employed. There were no significant differences in the general characteristics between the groups prior to study participation (Table 1). In the pretest, there were no significant differences between the two groups in the perception of antipyretic analgesics, perception of antibiotics, knowledge of medication safety, and eHealth literacy (Table 2).

Effects of the Intervention (KidsMedi Program)

The experimental group showed a statistically significant higher perception of antipyretic analgesics when compared with the control group ($t = 2.27$, $P = .027$). There was a significant increase in the perception of antipyretic analgesics of the experimental group (from 4.28 points to 4.50 points; $t = 2.97$, $P = .006$). However, there were no significant differences in the control group (from 4.30 points to 4.33 points; $t = 0.33$, $P = .745$). The experimental group showed statistically significant higher eHealth literacy than the control group ($t = 2.60$, $P = .012$). eHealth literacy also significantly increased for the experimental group (from 3.08 points to 3.65 points; $t = 3.42$, $P = .002$). However, there were no significant differences for the control group (from 3.19 points to 3.20 points; $t = 0.50$, $P = .619$) (Table 2).

There were no statistically significant differences in the perception of antibiotics between the study groups ($t = 1.54$, $P = .130$). However, there was a significant increase in the perception of antibiotics for the experimental group (from 3.55 points to 3.85 points; $t = 3.48$, $P = .001$) and the control group (from 3.57 points to 3.70 points; $t = 2.21$, $P = .035$). There were no statistically significant differences in the knowledge of medication safety between the study groups ($t = 1.72$, $P = .093$). However, there was a statistically significant increase in the knowledge of medication safety for the experimental group (from 3.39 points to 3.61 points; $t = 3.44$, $P = .002$). There were no significant differences in the control group (from 3.31 points to 3.44 points; $t = 1.33$, $P = .195$) (Table 2).

DISCUSSION

This study developed and evaluated the effect of a smartphone-accessible Web-based education program designed to help mothers administer medication to children aged under 6 years.

We found that the experimental group had a significantly higher perception of antipyretic analgesics than the control group. Further, the perception of antipyretic analgesics scores for the experimental group increased in the posttest compared with the pretest; however, there was no significant difference in the control group. Fever is the most common symptom among children and a chief complaint upon hospital visitation. In a previous study on parents' fever-related beliefs and behaviors, 59% of parents gave antipyretic analgesics to a comfortable-appearing child with a temperature between 37.4°C and 37.8°C.[17] Although acetaminophen is a primary at-home drug for managing diseases and injuries, intentional and unintentional overdosing may cause liver toxicity.[18] Studies on parental medication errors that threaten children's health and safety have also shown that some parents believe it is safe to take more than the recommended dose of acetaminophen, with some even believing it is acceptable to take unlimited amounts; others may also wake sleeping children for the purpose of administering antipyretic analgesics.[19] Many parents rely on written information from labels or package inserts when administering OTC antipyretic analgesics to their children. However, this kind of information can often be difficult to understand due to brand-based variations in drug concentrations and dosages.[20] Previous studies have also shown that parents may be unaware of the importance of bodyweight when determining drug dosages for children.[9,21]

In the present study, an educational video was composed and shown to mothers in the experimental group. Specifically, contents included the definition of a fever, thermometer types,

Table 1. Homogeneity Test of the General Characteristics of Participants

Characteristics	Experimental Group (n = 33) n (%)	Control Group (n = 30) n (%)	χ^2 or t	P
Age, y	36.85 ± 5.11	35.67 ± 3.98	1.02	.313
Education				
High school	5 (15.2)	3 (10.0)		.710[a]
College	28 (84.8)	27 (90.0)		
Occupation				
Yes	21 (63.6)	16 (53.3)	0.69	.407
No	12 (36.4)	14 (46.7)		

[a]Fisher's exact test.

Table 2. Comparison of Knowledge of Antipyretics, Perception on Antibiotics, Knowledge of Medication Safety, and eHealth Literacy Between the Two Groups

Variables	Groups	Pretest		Posttest		Difference		Paired t (*P*)
		Mean (SD)	t (*P*)	Mean (SD)	t (*P*)	Mean (SD)	t (*P*)	
Knowledge of antipyretics	Exp.	4.28 (0.30)	−0.38 (.706)	4.50 (0.28)	2.27 (.027)	0.23 (0.44)	2.02 (.048)	2.97 (.006)
	Con.	4.30 (0.28)		4.33 (0.34)		0.02 (0.36)		0.33 (.745)
Perception on antibiotics	Exp.	3.55 (0.36)	−0.16 (.871)	3.85 (0.38)	1.54 (.130)	0.30 (0.50)	1.61 (.113)	3.48 (.001)
	Con.	3.57 (0.43)		3.70 (0.43)		0.13 (0.32)		2.21 (.035)
Knowledge of medication safety	Exp.	3.39 (0.31)	0.99 (.329)	3.61 (0.26)	1.72 (.093)	0.22 (0.36)	0.77 (.446)	3.44 (.002)
	Con.	3.31 (0.33)		3.44 (0.50)		0.13 (0.53)		1.33 (.195)
eHealth literacy	Exp.	3.08 (0.85)	−0.21 (.832)	3.65 (0.64)	2.60 (.012)	0.57 (0.95)	2.19 (.032)	3.42 (.002)
	Con.	3.19 (0.84)		3.20 (0.73)		0.08 (0.82)		0.50 (.619)

Abbreviations: Exp., experimental group (n = 33); Con., control group (n = 30).

methods of measuring body temperature, and the normal range of body temperature for each measurement site. Different types of antipyretic analgesics were also shown in detail, thus providing participants with an easy way to understand the types of drugs they have actually purchased. They also gained crucial information about the drug instructions (eg, ingredients, formulations, and dosages according to bodyweight) that are often placed on labels or package inserts, including administration precautions. We found that participants in the experimental group showed an increase in their level of knowledge about antipyretic analgesics after going through the informational videos and taking a quiz to test their understanding.

In this study, there were no significant differences in perception on antibiotics between the study groups. However, the perception on antibiotics scores of both groups increased in the posttest compared with the pretest. Antibiotics are widely used and commonly prescribed drugs in infectious diseases. There is also a high likelihood of overdose and misuse among children that can lead to both antibiotic resistance and a variety of side effects. This also increases the overall cost of healthcare services. In addition to over-prescription by doctors, antibiotic misuse is also related to certain misconceptions held by parents or caregivers.[22,23] A study on caregiver perceptions found that only 19.7% knew that antibiotics were not effective for colds, whereas 80.2% did not know about the importance of medication adherence during a course of antibiotics.[24] Another study on parents' knowledge and attitudes regarding antibiotic usage showed that 68% thought they should be administered for colds, 26% had stopped administering antibiotics early, 15% had kept the remaining antibiotics, and 24% had given leftover antibiotics to other children with similar symptoms.[25] Studies have shown that educational interventions targeting acute respiratory tract infections and antibiotic use can reduce the rate of inappropriate administration and usage.[23,26]

In this study, an educational video was composed and shown to mothers in the experimental group. Specifically, contents included the causes, treatment options, management of respiratory diseases, and information on which diseases require antibiotic treatment. The video also showed drugs that require prescriptions and explained how to confirm information such as the drug name, dosage guidelines, administration procedures, and treatment duration. Some sections also focused on different methods of antibiotic treatment, especially concerning adherence and duration. In this context, participants were given clear information regarding the causes of antibiotic resistance. The reason for no significant difference in perception on antibiotics scores between the experimental and control groups in the posttest may be due to a recent focus on evaluating the use of major drugs such as antibiotics, including the need for doctors to carefully consider prescriptions. This has been accomplished through educational campaigns targeted at the prevention of antibiotic misuse. In addition, the video contents provided in this study were not individualized and consisted of general antibiotic information, which may have resulted in no difference between the two groups. Hence, future programs should include individualized and customized interventions, thus providing specific information on misunderstood contents while excluding information that participants already know. As many parents obtain drug information via the Internet,[24] it is highly necessary to ensure they have access to programs such as the *KidsMedi*, which was professionally developed to ensure information accuracy and reinforce proper antibiotic usage by increasing overall awareness.

We found no significant differences in the knowledge of medication safety between the study groups. However, the experimental group showed significantly higher knowledge of medication safety in the posttest compared with the pretest, whereas the control group showed no differences. To prevent accidents related to medication at home, it is first necessary to increase knowledge of medication among parents or caregivers. It is particularly important to ensure an adequate understanding of proper drug administration and

storage methods.[16] The contents of the educational video provided in this study to the experimental group included reasons for correct drug administration to children; the process of absorption, delivery, and excretion of drugs; definition of drug misuse; examples of misuse cases; the "five rights" (right child, right medication, right dose, right time, and right route); and how to administer drugs to children considering their age—all using many images and pictures to help participants understand.

It is essential to provide education on safe medication storage and administration procedures to prevent unintentional overdosing.[5] The contents of the video regarding this included detailed information on drug storage procedures, including proper storage containers, medication duration, storage locations, and how to dispose of drugs. Drugs are usually administered to young children in liquid form, which often requires specialized instruments. Generally, these instruments are provided by the pharmacy or enclosed in OTC packaging, or instruments that are already available at home are used to measure liquid drugs. In South Korea, standard instruments are provided for OTC liquid medications, but this may vary according to the drug manufacturer; for instance, some provide oral syringes, whereas others provide droppers, dosing cups, and dosing spoons. Previous studies on medication instruments have shown high error rates when using dosing cups, whereas the oral syringe was found to ensure the greatest accuracy.[19,27,28] However, a study found that participants thought the oral syringe was inconvenient; many measured liquid doses by placing the measuring devices on countertops in order to examine calibration markings from above or below rather than doing so at eye level, which is the appropriate method.[29] For this reason, this study aimed to enhance medication safety in the experimental group by presenting real photos of the types, relevant procedures, and characteristics of various medication instruments. To ensure medication safety, it is crucial that caregivers who administer medications to children at home do so appropriately. In this study, the program was solely provided online, so the parents' actions could not be directly observed. Hence, additional research should supplement the program with a videoconferencing platform through which caregivers can interact directly.

The experimental group showed significantly higher eHealth literacy scores than the control group in the posttest. Further, eHealth literacy scores of the experimental group increased in the posttest compared with the pretest, but there were no differences for the control group. Online medical information is often complex and requires high literacy levels, making it difficult for parents to understand issues concerning the health of their children. However, parents should be able to read and understand medication instructions prior to administration, especially to ensure correct dosages. Those with low health literacy may face more childcare obstacles and lack the communication and processing skills needed to access relevant information; they may also find it difficult to understand and follow written instructions.[30] Moreover, low literacy is associated with a poorer understanding of medication labels, dosing errors, decreased knowledge of diseases, and worse clinical outcomes.[31,32] This makes it highly important to increase eHealth literacy, especially regarding the proper identification and usage of online health information. In particular, parents should be able to understand and evaluate the information thus obtained, including whether it pertains to real-life health problems.[13] In cases of low eHealth literacy, parents may find it difficult to judge health information obtained through the Internet.[33,34]

In this study, contents of an educational video were provided to the experimental group to increase eHealth literacy, including how to classify OTC and prescription drugs, and read OTC packaging instructions and paper prescriptions by a doctor. We specifically increased eHealth literacy scores for the experimental group by explaining how to use national drug information sites (Ministry of Food and Drug Safety), conduct drug information searches (Health-iN), assess health supplements (Food Safety Information Portal), and search for information on drugs prescribed to children on national Web sites such as the Health Insurance Review and Assessment Service. Although the Internet is a good resource for information on children's health and development, a study among parents with children under 2 years of age found that a large percentage were skeptical about both the accuracy of health information and their understanding of it.[35] This makes it important to ensure that parents can locate and understand reliable sources of online health information, particularly regarding child health management. As low eHealth literacy makes it even more difficult to find relevant health information, the *KidsMedi* program was especially effective.

To our knowledge, this was the first study in South Korea to develop and verify an educational program designed to help mothers administer medication to their children at home via a smartphone, enabling repetitive learning. For participants in the experimental group, this increased their overall knowledge regarding medication and resulted in very high user satisfaction. To increase the rate of parental participation in this type of education, programs must be both fun and accurate. This can be accomplished through novel visual elements that provide benefits that cannot be easily obtained elsewhere.[36] As such, this study's *KidsMedi* program was not merely designed to simply provide information consisting of large amounts of text and redirections to Internet Web sites but was professionally and systematically developed to sustain synchronization by sequentially presenting a new topic each week.

This study has a few limitations that should be considered when interpreting the results. First, this study's results cannot be generalized, as we used convenience sampling to recruit mothers from a specific region. Future studies should therefore investigate fathers and/or other primary caregivers in a broader range of locations. Second, the experimental and control groups were not randomly assigned. Future studies should implement randomization procedures. Furthermore, longitudinal research is needed to determine the duration of the program's effects. Third, the majority of participants had high levels of education, including college and above. Further studies should evaluate program effectiveness among individuals with lower levels of education and/or eHealth literacy. Fourth, the reliability coefficients of the measures assessing perception on antibiotics and knowledge of medication safety were lower than .80. A more valid and reliable instrument should be developed to measure parents' knowledge and behaviors to antibiotics and medication safety.

CONCLUSIONS

This study confirmed that a 6-week smartphone-based medication program constituted an effective intervention to improve parental knowledge regarding antipyretic analgesics and eHealth literacy. The ongoing COVID-19 pandemic makes it difficult to provide offline parental education program, nor is it easy for parents with little free time to participate in offline interventions. This makes it important for health experts to expand the availability of Web-based educational offerings. The program developed in this study can be utilized as a strategy for parents to manage health problems and prevent drug misuse by safely administering drugs to children at home.

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