

Development of a mobile application focusing on developmental support care for Korean infants born prematurely: a methodological study

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Purpose: This study aimed to develop and evaluate a mobile application focusing on developmental support care for infants born prematurely. **Methods:** An application was developed using the analysis, design, development, implementation, and evaluation model. In the analysis phase, previous research was evaluated through big data text-mining and a literature review. In the design phase, the preliminary content of the application was designed, and the content validity and comprehension were verified. A hybrid application was developed and used by eight experts and ten users, who evaluated the layout of the mobile application and their satisfaction with it. **Results:** The content of the designed application comprised a diary, customized information, developmental play, and community. The mean scores for layout were 3.73 ± 0.47 and 3.43 ± 0.68 out of 4 points among the experts and users, respectively. Users' mean satisfaction score was 3.70 ± 0.70 out of 5 points. **Conclusion:** The information provided by the mobile application was evaluated as consistent and systematic. The application was also found to be satisfactory by infants' parents. The mobile application developed through this study is expected to be effective in supporting the development of children born prematurely.

Key words: Child development; Growth and development; Infant, premature; Nursing methodology research; Mobile applications

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INTRODUCTION

Although the survival rate of premature infants is increasing due to advances in medical technology, active treatment and care, and the expansion of government support, care focusing on the development of premature infants after their survival is relatively insufficient [1]. Premature birth can negatively affect language, social-emotional, motor, cognitive, and behavioral development in infancy, with impacts extending to later in childhood [2]. After discharge from the neonatal intensive care unit (NICU), most premature infants have developmental inadequacies, and many experience difficulties in catching up [2,3]. Therefore, it is important to promote the development of infants born prematurely.

Interactions with the caregiver are important in infants' development because their development is influenced by the ex-

ternal environment [4-6]. After NICU discharge, parents of preterm children experience difficulties in physical and psychological aspects, self-efficacy, interactions with their babies, and parenting behavior [1,7,8]. Parents who lack knowledge regarding infants born prematurely are afraid and anxious about caring for their preterm children [8]. In addition, since preterm infants often require specialized healthcare or readmission after NICU discharge, their parents need systematic and long-term interventions for child-rearing and development after discharge from the NICU [4]. Therefore, to promote and support the long-term development of preterm children, parents should be included in developmental support care [4-6].

Altimier et al.[3] reported that it is necessary to observe the full range of children's responses, including physical and behavioral responses, and to provide appropriate stimuli in-

dividually to support the development of preterm children. Therefore, integrative and individual development should be considered when providing developmental support care for children born prematurely [1,3]. However, previous studies [9,10] have focused only on fragmentary aspects of the development of premature infants, limiting the degree to which optimal development can be promoted based on their results.

Previous domestic and international research related to the development of preterm infants includes a study on the parenting experiences of parents with premature infants [8] and intervention studies for parents with premature infants in the NICU [5,7,11-14]. Previous studies have mainly focused on the period of hospitalization or the time of discharge. Although an earlier study conducted a program to improve parents' quality of life through text messages after NICU discharge [15], studies related to developmental support care for preterm children after NICU discharge are lacking. For this reason, there is a need for programs that promote ongoing care for preterm children after NICU discharge by providing the necessary information on rearing preterm babies at home and developmental support care.

Mobile applications have the advantage of being used anytime and anywhere depending on the user's circumstances without restrictions of time and space [15,16]. Thus, mobile applications are currently being used in various fields. Non-face-to-face education is also emerging owing to the global outbreak of coronavirus disease 2019 (COVID-19)[17], and remote education can be applied as an effective intervention for parents with preterm children who cannot attend in-person educational sessions. Therefore, this study aimed to develop a mobile application for developmental support care that would provide information required at home after discharge and promote various developmental activities for infants born prematurely, and to evaluate its actual usefulness.

METHODS

Ethics statement: This was a methodological study for the development of a mobile application and was therefore exempt from institutional review board approval.

1. Study Design

In this methodological study, a mobile application focusing on developmental support care for infants born prematurely was developed through Seels and Richey's [18] process of analysis, design, development, implementation, and evaluation (ADDIE) for instructional design.

2. Analysis

The analysis step is the basic step of the instructional design model, in which the needs of learners are analyzed [18]. In this study, a literature review was conducted, and previous research using big data text-mining [1] was reviewed to determine the program content.

To compose the content of the mobile application, we reviewed Korean and international literature related to developmental support care for children born prematurely. The literature search was conducted from December 23, 2019 to January 2, 2020. The inclusion criteria of the analyzed papers were as follows: 1) the topic was developmental support care for children born prematurely, 2) the publication date was between 2015 and 2019, 3) the publication was an original article, and 4) the study population comprised caregivers or children born prematurely who were at developmental stages ranging from infancy to adolescence. The exclusion criteria were as follows: 1) a descriptive study design that simply evaluated the developmental status of preterm children and 2) papers written in languages other than English or Korean. KISS, RISS, CINAHL, and PubMed were searched using natural language and Boolean operators, as well as major indexes for each database, with concepts and terms including "premature", "children", "infant", "toddler", "preschooler", "school age", "adolescent", "growth", "development", "support", "intervention", and "care". The initial search yielded 1,251 Korean and international papers, from which 1,213 duplicate papers were excluded. Based on the inclusion and exclusion criteria, 24 articles were dropped. Finally, 14 papers were analyzed. Based on the findings, we confirmed that developmental support care should be able to promote integrated development, including motor, cognitive, sensory, and language domains, and that caregivers should participate as providers of care and play.

To determine the needs of parents with preterm children, we reviewed the previous study by Park et al.[1]. Park et al.[1] conducted a text-mining study using 628 online news articles and 1,966 social network service (SNS) texts. Based on their results [1], the following four topics were identified: "1) a vague fear of caring for a baby upon imminent NICU discharge, 2) real-world difficulties encountered while caring for preterm children, 3) concerns regarding growth and development problems, and 4) anxiety regarding possible complications."

3. Design

1) Preliminary content

The conceptual framework of this application relates to the critical period as a core principle of human development [19].

Based on the principle that infants who do not receive the appropriate stimuli to achieve developmental tasks in infancy may be less successful in achieving proper development (or may do so only with difficulty), this program was designed to promote and maintain the aspects of growth and development that prematurely born infants must achieve in the infant stage. The preliminary content consisted of a diary, information related to the growth and development of infants born prematurely, developmental play, and community. The storyboard was designed using image data, text, and images. The purpose of the mobile application was to provide information on developmental support care for preterm children and encourage activities to promote development. Meanwhile, considering the results of previous research [1], the goal was set that the parents of preterm children would be able to explain information related to child-rearing, provide information on children's development, perform childcare, and engage in play that promotes development. The mobile application was named "Todak-Todak" (literally, "Pat-Pat" - an expression used to provide reassurance). The title was selected as an option that would be easy to remember for users due to the repetition of words and was not previously registered on the App Store and Google Play. The mobile application was designed based on the content identified in the design stage.

2) Content validity

To verify the content validity of the application, input from six experts was requested: three professors of pediatric nursing, one nurse with more than 20 years of NICU work experience, one professor of pediatrics specializing in high-risk newborns, and one professor of occupational therapy specializing in child development. The expert group consisted of six individuals according to the recommendation by Lynn [20] that it is appropriate to use 3-10 experts. The first round of content validation was conducted from March 11 to 25, 2021, and the second round was conducted from March 29 to April 2, 2021. The content validity was measured on a 4-point scale: 1 point, not relevant; 2 points, relevance cannot be assessed without modification; 3 points, relevant but needs some modification; and 4 points, very relevant and concise. Comments for improvement were also provided. The content validity index (CVI) was calculated as the proportion of items rated by the experts as 3 or 4 points. According to the recommendation by Lynn [20], a CVI of .80 or higher was set as the standard for ensuring content validity, with appropriate revision according to the experts' opinions. The first CVI was 1.0; the gestational age was changed to the corrected age; and diapering guide and methods of coping with constipation and diarrhea were added. In addition, milestones for each age in months

were added to the childcare and developmental play section. The second CVI was 1.0. In response to the opinions presented in the additional round of revision, recipes were deleted from baby weaning foods, and oral rehydration therapy as a method of coping with diarrhea was deleted. Complications were deleted according to the opinion that they would be discovered in the NICU or screened during the pre-discharge examination. Modifications were performed so that both parents could participate by emphasizing the role of the father in developmental play in addition to that of the mother. The illustrations were also modified to avoid portraying a specific sex.

3) Content comprehension

To determine the comprehensibility of the application's content, we provided storyboards to a fifth-grader in elementary school and a student in middle school from March 29 to 30, 2021. Children were selected because adults would be certain to easily comprehend expressions that children understood [21].

To confirm the comprehensibility of the content on developmental promotion activities, two adults with no play experience with infants participated from March 29 to 30, 2021. After they reviewed the text and illustrations of the storyboard, we checked whether developmental play could be performed on the basis of the content alone. The adults described and performed developmental play without difficulty.

4. Development

The development step is the stage in which the data and content determined in the analysis and design stages are converted into a program or product [18]. In this study, the design, development environment, and application screen layout were developed, and beta testing was conducted. The researchers informed the application development programmer about the content of the application. Based on the developed storyboard, a professional programmer was commissioned to develop the mobile application. A hybrid application was developed, including Android and iOS mobile applications and a website. Before launching the developed mobile application, we conducted a beta test using TestFlight (Apple Distribution Ltd., Hollyhill, Ireland).

5. Implementation

The implementation step is the stage in which developed materials are used [18]. The developed mobile application was used by experts and users from May 22 to 26, 2021. The number of participants in this study was determined by referring to the sample size of a previous study [22], in which ex-

perts and user groups evaluated a developed mobile application. The expert group consisted of eight experts, including three professors specializing in pediatric nursing with NICU clinical experience, a registered nurse with more than 20 years of NICU work experience, a professor specializing in pediatric care for high-risk neonates, a professor of occupational therapy specializing in child development, and two mobile application-related programmers. The user group consisted of 10 parents of infants or premature infants.

6. Evaluation

The evaluation step is used to assess the adequacy of instructional design [18]. In this study, the experts and users evaluated the appropriateness of the layout, and the users reported their satisfaction with the developed mobile application.

1) Mobile application layout

The evaluation tool for healthcare smartphone applications developed by Jin and Kim [23] was modified and supplemented to assess the layout of the mobile application. The original tool is composed of three factors: content, interface design, and technology. Technical factors related to security were excluded, as they did not fall under the scope of this study. In this study, 6 items from the content factor dealing with accuracy, understandability, and objectivity and 10 items from the interface design factor related to consistency, the suitability of the design, and the accuracy of wording were used. In the evaluation of the content validity of the revised tool by the six professors of pediatric nursing, the average CVI was .95, while the CVI for all items was .80 or higher. Each item was measured on a 4-point Likert scale. Higher scores indicated a better layout of the mobile application. The Cronbach's α value, as an indicator of reliability, was .85.

2) Satisfaction with the mobile application

The researchers developed a six-item tool for evaluating users' satisfaction with the mobile application. The content validity of the developed tool was tested by the expert group consisting of six professors of pediatric nursing. The average CVI was .93, and the CVI for all items was .80 or higher. Each item was measured on a 5-point Likert scale, with higher scores indicating higher satisfaction. The Cronbach's α value for evaluating reliability was .89.

3) Data analysis

The collected data were analyzed using IBM SPSS version 24 (IBM Corp., Armonk, NY, USA) and presented as means and standard deviations.

RESULTS

1. Design

As shown in Table 1, the content of the mobile application was designed to provide information on developmental support care for infants born prematurely. The menus consisted of a login menu, a diary, customized information, developmental play, and community. The login menu included a login screen, infant birth history (date of birth, gestational age, and height, weight, and head circumference at birth), and membership registration. The diary menu included a calendar for recording intake and output (I/O), and developmental play. The customized information menu consisted of information related to rearing, including breastfeeding, bathing, diapering, and attachment, as well as information related to growth and development, including growth standards in the Korean national growth charts, developmental milestones, and characteristics according to corrected age. The information provided was based on the characteristics of the infants born prematurely. In the developmental play menu, play activities that promote attachment formation and movement, language, and sensory development were presented for each corrected age of infants. Finally, the community menu was composed of bulletin boards and a question-and-answer (Q&A) portion. A diagram of the developed mobile application is shown in Figure 1.

The application included a function where the corrected age was presented based on the baby's birth history. This was designed so that parents with infants could check the information and development promotion activities for each corrected age. It was also designed to enable individual consultations for each infant born prematurely using the data stored in the admin mode, such as I/O, weight, height, and play activities.

2. Development

1) Application design

The developed mobile application was designed with illustrations drawn by the first author. The illustrations were created on an iPad using the Procreate® application (Procreate® for iPad, Savage Interactive Pty. Ltd., Hobart, Australia). Since the main users of the developed mobile application were expected to be parents raising premature infants, the background and icon colors were made in pastel tones for a warm feeling. According to the programmer's recommendation that the Jua font (Woowa Brothers Corp., Seoul, South Korea) has good readability and stability, it was used as the font for the mobile application.

Table 1. Content of the Mobile Application Focusing on Developmental Support Care for Infants Born Prematurely

Menu	Categories	Contents		
Login	Login	ID, password		
	Membership registration	Parent's nickname, baby's nickname, date of birth, gestational age, corrected age, height, weight, and head circumference at birth		
Diary	Calendar for recording	Amount of feeding		
		Frequency of urination and defecation		
		Growth and development		
		Performance of developmental play		
Customized information	Rearing	Feeding	- How to breastfeed	
			- How to feed formula	
			- How to feed weaning food	
		Bathing	- How to perform bathing - Precautions for bathing	
	Diapering	- Type and pattern of defecation - How to cope with constipation and diarrhea		
	Attachment	- Importance of attachment - How to form an attachment		
	Growth and development	Growth	- Growth standards in the Korean national growth charts for children and adolescents	
			Development	- Definition of corrected age - Developmental milestones - Motor, cognitive, language, and social-emotional developments by corrected age
		Developmental play		Information
	How to promote development by corrected age			
Toy by corrected age in months				
1-3 months corrected age	Finger spider web, holding mom and dad's hands, mimicking sounds, home navigation, baby ear massage			
4-6 months corrected age	Sky bike, grab mobile, peek-a-boo, head shoulder knee foot, looking in the mirror together			
7-9 months corrected age	Swinging with dad, jaemjaem with mom and dad, removing Velcro, touching the rice noodles, jjakjjakkung			
10-12 months corrected age	Moving water, drumming with a bowl, walking barefoot on various paths, throwing animal dice, bye-bye			
Community	Bulletin board	Rearing concerns, growth concerns, developmental concerns, question and answer ID, identification.		

2) Developmental environment

A hybrid smartphone application was developed, including Android and iOS applications. The Android application was developed using Android Studio (Google LLC, Mountain View, CA, USA & JetBrains s.r.o., Prague, Czech Republic), while the iOS application was developed using iOS Xcode 13 (Apple Inc., California, USA). The Java Development Kit and Software Development Kit were used for Android Studio, and the Swift language was used for Xcode. Intel® Core™ i7 processors (Intel Corporation, Santa Clara, CA, USA) and 16 GB of RAM were used for application development. The applica-

tion was designed to be used in Android 4.1.1 or higher and iOS 12 or higher operating systems.

For the α test, the Android application was tested using V40 (LG Electronics, Seoul, South Korea) for Android v8.0, Note 8 (Samsung Electronics Co., Ltd., Suwon, South Korea) for Android v9.0, and Wing (LG Electronics) for Android v10.0. The iOS application was tested using iPhone 6 (Apple Inc.) for iOS v12, iPhone XS (Apple Inc.) for iOS v13, and iPhone 11 (Apple Inc.) for iOS v14. The website was tested using Chrome and Microsoft Edge browsers.

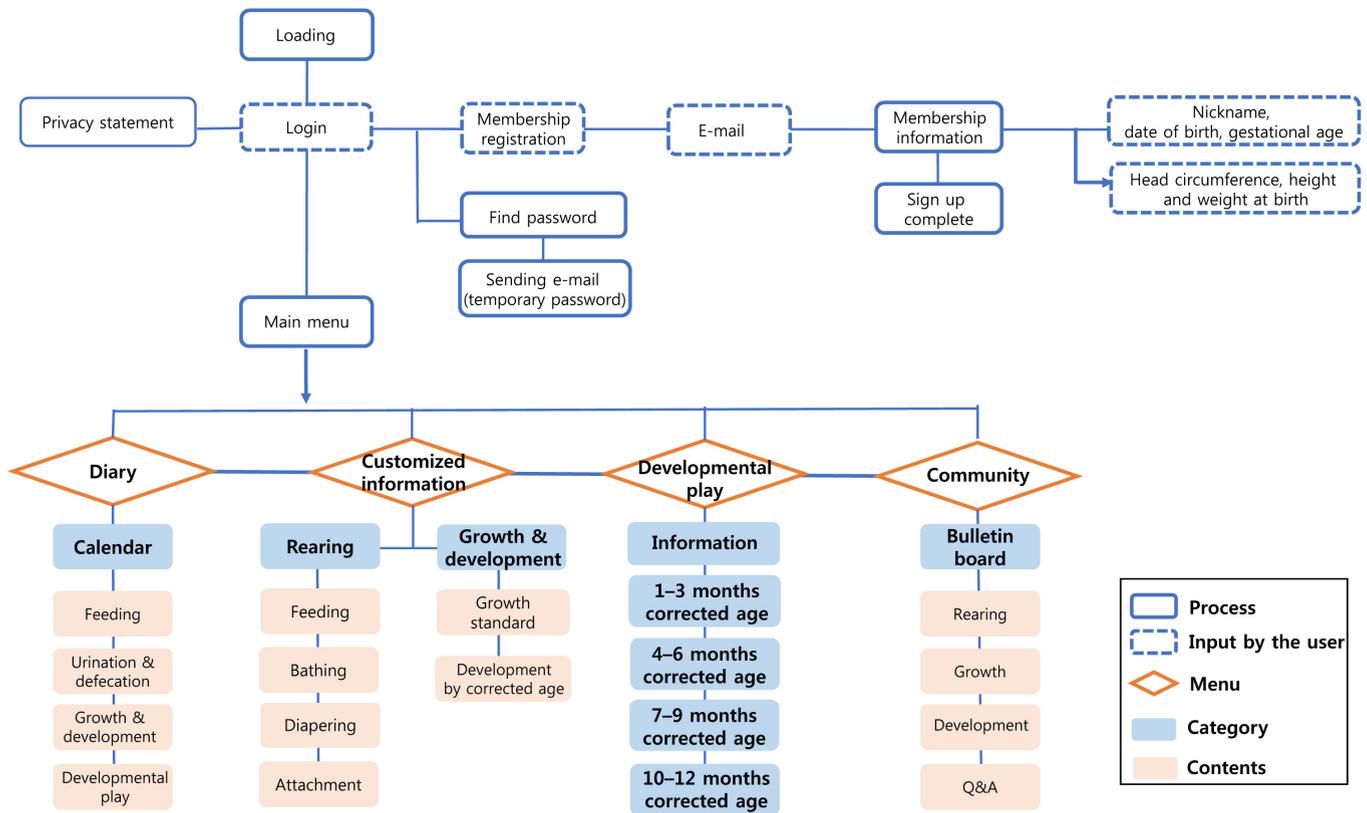


Figure 1. Diagram of a mobile application of developmental support care for infants born prematurely. Q&A, question and answer.

3) Application screen layout

The title of the developed mobile application was “Todak-Todak,” and the slogan of this application was “Raising my baby to be healthy-Todak-Todak.” The diary was structured to record the amount of feeding, frequency of urination and stool passage, performance of developmental play, development checks, and growth-related information, including height, weight, and head circumference (Figure 2-A). In the calendar, simple icons were arranged to record feeding, diapers, growth and development, and developmental play by date, and the results were posted. For customized information, icons were organized in the categories of childcare and growth/development, and screens were separated for each item to prevent too much information from being presented on one screen (Figure 2-B). Each screen presented text, images, illustrations, and sources for content. Developmental play was organized by dividing the screens by corrected age (months), and the types of development supported by different play activities were presented.(Figure 2-C). In developmental play, example images, materials, descriptions of how to play and how to communicate, information on other play activities that can be applied, and sources were presented. The community section was de-

signed to encourage two-way communication between parents and operators, as well as between parents themselves, and was structured with posts divided into parenting, growth, development, and Q&A items (Figure 2-D). To enable more detailed and specific communication, users could submit questions or opinions according to the corrected age (months), and images could be attached. The operators could answer posts, and the users could reply to those answers. Q&A messages from users were sent to the operator's e-mail, and the operator's answers could be conveniently checked in the application. The developed website is shown in Figure 2-E.

4) Beta test

The developed mobile application was registered with the iOS service and Google Play. The content modified based on the beta test was as follows. For a brief explanation of the mobile application, an “ABOUT US” section was added at the bottom of the main screen to provide a description of Todak-Todak. A “CAUTION” button was also added at the bottom of the main screen to allow users to easily view the disclaimer. The letter spacing was adjusted for readability. Each source was linked to a source of additional information. Finally, a “Click” icon was added to easily navigate to each menu.

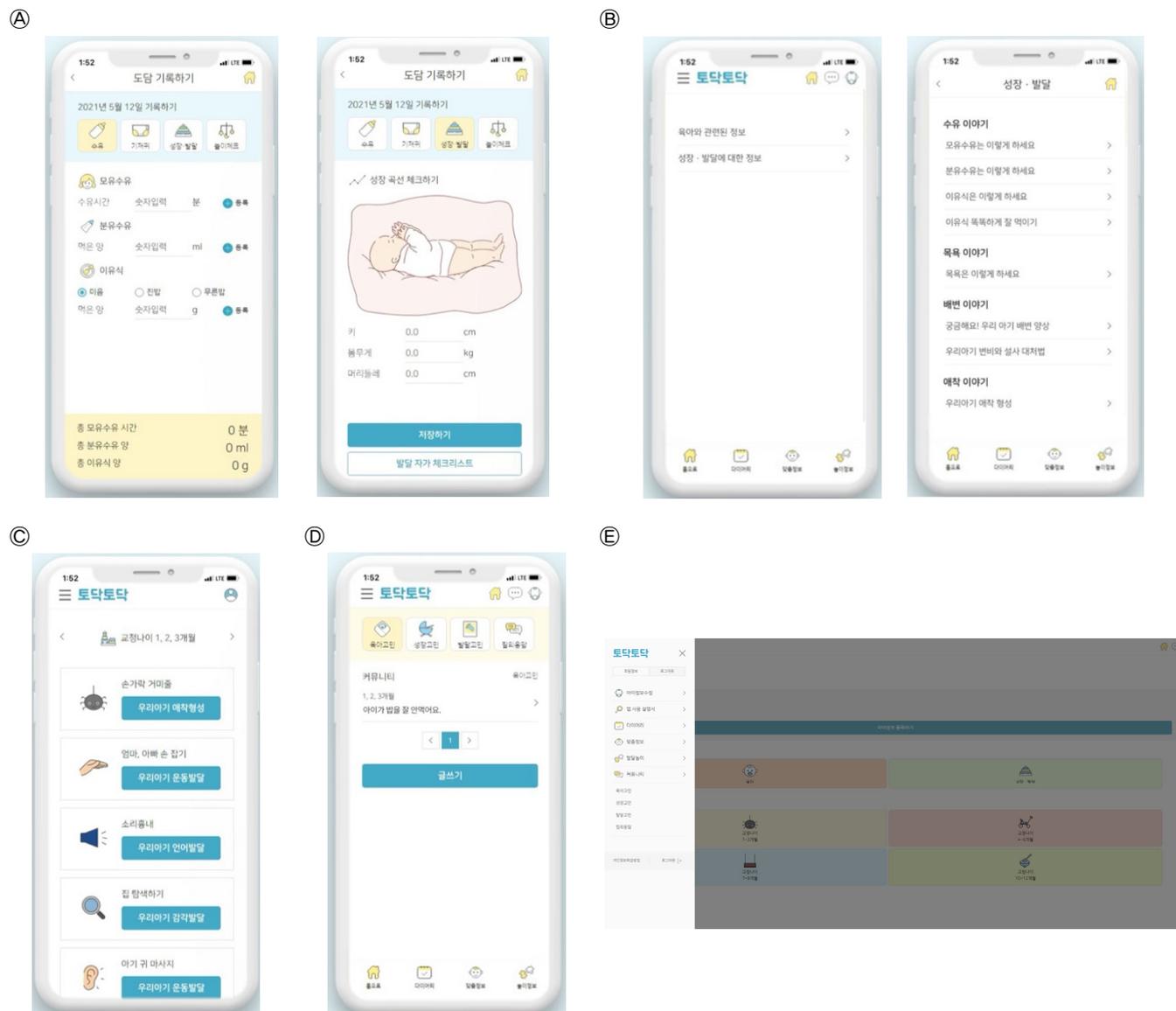


Figure 2. Hybrid application focusing on developmental support care for infants born prematurely. (A) Diary. (B) Customizing information. (C) Developmental play. (D) Community. (E) Website.

3. Evaluation

1) Evaluation by the experts

The score for the developed mobile application layout was 3.73 ± 0.47 out of 4 points among the experts (Table 2). The highest score for the content factor was found for accuracy (3.88 ± 0.34 points), followed in descending order by understandability (3.69 ± 0.60 points) and objectivity (3.63 ± 0.50 points). The highest score for the interface design factor was for consistency (3.79 ± 0.42 points), followed in descending order by suitability of design (3.72 ± 0.46 points) and accuracy of wording (3.67 ± 0.48 points).

2) Evaluation by the users

The users' score for the developed mobile application layout was 3.43 ± 0.68 out of 4 points (Table 2). The highest score for the content factor was found for understandability (3.70 ± 0.48 points), followed in descending order by accuracy (3.55 ± 0.51 points) and objectivity (3.50 ± 0.51 points). The highest score for the interface design factor was for accuracy of wording (3.50 ± 0.57 points), followed in descending order by consistency (3.47 ± 0.63 points) and suitability of design (3.15 ± 0.89 points).

The mean score for satisfaction with the developed mobile application was 3.70 ± 0.70 out of 5 points (Table 3). The highest scores were found for the items stating that the information on developmental support care was interesting (3.80 ± 0.63 points) and the item indicating that the application

was helpful for obtaining information on developmental support care (3.80 ± 0.63 points).

DISCUSSION

To analyze the content of our mobile application of developmental support care for infants born prematurely from various perspectives, we used the results of a previous big data analysis [1] and conducted a related literature review. Kim et al.[5] and Shin et al.[12] conducted a literature review and in-

terviews in the analysis stage to develop a program for parents of premature infants. The methods used in this study are different from those used in previous studies. A big data analysis is an effective research design to understand what the target population thinks in detail and to analyze their actual needs [24]. Since insufficient studies have analyzed the need for developmental support care for preterm children after NICU discharge, rather than during hospitalization or at the time of discharge, the use of previous big data analysis results was an appropriate methodological choice.

Table 2. Evaluation of the Mobile Application Layout ($N=18$)

Categories	Items	Experts (n=8)	Users (n=10)	
		M±SD	M±SD	
Contents	Accuracy	3.88±0.34	3.55±0.51	
	1. The information provided in Todak-Todak is accurate.	3.88±0.35	3.50±0.53	
	2. Clear information is provided in Todak-Todak.	3.88±0.35	3.60±0.52	
	Understandability	3.69±0.60	3.70±0.48	
	3. The information provided in Todak-Todak is easy to understand.	3.75±0.46	3.50±0.71	
	4. The information provided in Todak-Todak is described in everyday language.	3.63±0.74	3.70±0.48	
	Objectivity	3.63±0.50	3.50±0.51	
	5. Professional information is provided in Todak-Todak.	3.63±0.52	3.50±0.53	
	6. Information is provided in Todak-Todak systematically and objectively.	3.63±0.52	3.50±0.53	
	Interface design	Consistency	3.79±0.42	3.47±0.63
		7. Todak-Todak is consistent in color, layout, and presentation.	3.88±0.35	3.20±0.79
		8. The icon arrangement in Todak-Todak is in harmony with the overall application design.	3.75±0.46	3.50±0.53
		9. The icons in Todak-Todak are categorized consistently across the application.	3.75±0.46	3.70±0.48
		Suitability of design	3.72±0.46	3.15±0.89
		10. It is easy to understand logically because the contents of Todak-Todak are arranged sequentially.	3.63±0.52	3.00±0.67
		11. The meaning of each icon in Todak-Todak is clearly expressed.	3.75±0.46	3.20±1.03
12. The letters used in Todak-Todak are in an easy-to-read size and font.		3.75±0.46	2.90±1.10	
13. The visual elements of Todak-Todak are comfortable for users.		3.75±0.46	3.50±0.71	
Accuracy of wording		3.67±0.48	3.50±0.57	
14. The phrases used in Todak-Todak are concise.		3.63±0.52	3.50±0.71	
15. The phrases used in Todak-Todak are precise.		3.63±0.52	3.60±0.52	
16. The phrases used in Todak-Todak are grammatically correct.		3.75±0.46	3.40±0.52	
Total			3.73±0.47	3.43±0.68

"Todak-Todak" (literally, "Pat-Pat") is the title of the application developed in this study.

Table 3. Users' Evaluation of their Satisfaction with the Mobile Application ($N=10$)

Items	M±SD
1 The data and information provided in Todak-Todak are enough to understand my child's development.	3.70±1.06
2 The information provided in Todak-Todak is interesting.	3.80±0.63
3 Todak-Todak helped me obtain information on the development of my child.	3.80±0.63
4 I am satisfied with Todak-Todak overall.	3.60±0.63
Total	3.70±0.70

"Todak-Todak" (literally, "Pat-Pat") is the title of the application developed in this study.

The mobile application developed in this study provides specific information on child-rearing based on previous research [1] reporting a high degree of demand among parents with premature babies for guidance on how to raise their children. Existing programs related to the care of premature infants have focused on cross-sectional aspects of parenting, such as breastfeeding [13] and attachment [5]. Because infants and toddlers develop through interactions with their parents, it is important to provide appropriate information on parenting [1,3]. The study by Kim et al.[16] investigating the effects of development knowledge and parenting knowledge on maternal confidence among mothers with premature infants found a low level of knowledge on child-rearing. Similarly, Park et al.[1] reported that parents of children born prematurely felt afraid of parenting. Therefore, the mobile application developed in this study makes a meaningful contribution by information on rearing in infancy, including feeding, bathing, diapering, and attachment.

Children born prematurely experience several types of developmental difficulties [2]. In this study, we intended to help the parents of premature infants acquire development knowledge by providing developmental information and milestones by corrected age. Park and Bang [6] reported that the provision of accurate knowledge on development promoted the development of premature infants and minimized developmental difficulties, thus supporting our study results. In addition, a care program is necessary to promote the integrated development of premature infants [9]. However, the focus of previous studies on fragmentary aspects of development limits the degree to which their findings can be used to promote optimal development [9,10]. Therefore, it is noteworthy that our study focused on integrated development, including language, cognition, sensory, and motor development and attachment, so that children born prematurely can achieve optimal development.

Play in infancy is an essential activity for holistic development and provides an opportunity to get to know the world [25,26]. Yognam et al.[26] emphasized that infants need to play for their physical, cognitive, social, and linguistic development. Additionally, because developmental characteristics differ according to the corrected age in months, the method of play should also change over time. Based on this evidence, the developed mobile application in this study comprised a play section that included various tools and activities that can be easily used at home, where both infants and their parents spend most of their time. The developed mobile application provided the corrected age for infants born prematurely and presented support for play activities that promote language, cognition, sensory, and motor development, as well as attachment, according to the corrected age.

A previous study that investigated the effect of fathers' rearing on the development of infants found that fathers' participation in childrearing had strong direct and indirect effects on the overall development of their children [27]. Jung et al.[28] also reported that play activities with fathers are important for children's development because attachment is formed through physical contact. This evidence supports the significance of including fathers as primary caregivers along with mothers in the mobile application developed in this study.

A meaningful component of the mobile application developed in this study is that it applied multi-pronged communication channels using bulletin boards and a Q&A function. Users with common interests, such as pregnancy, childbirth, and childcare, could communicate in the online community and share common experiences, which is an important factor influencing user intention and satisfaction [29]. Furthermore, communication channels related to child-rearing reduce parenting stress [30]. The programs developed by Lee and Kim [13] and Seo [11] also focused on communication between users and healthcare providers. The mobile application developed in this study provided multi-faceted communication channels between users and other users as well as between users and operators are provided so that information and opinions can be exchanged. Therefore, the mobile application can improve emotional support, reduce parenting stress, and improve the satisfaction and self-confidence of parents with preterm children.

The mobile application was developed in a hybrid form that can provide information on post-discharge care to parents with preterm children who find it difficult to visit public health centers or clinics owing to practical limitations. Since a hybrid application can be used in a variety of ways, including through a smartphone or on a computer, it can be more conveniently accessed than existing smartphone applications [16]. Therefore, parents who prefer smartphones can use those devices to access the application developed in this study, while parents who have difficulty using smartphones can use this program through the website. A study examining the relationship between an early intervention using smartphone text messages and the quality of life among parents of premature infants after NICU discharge [15] found that parents of preterm children who owned smartphones had higher emotional support and fewer difficulties in preparing for rearing at home after NICU discharge than those who did not. Therefore, a hybrid application is expected to be effective in enhancing the readiness and efficacy of parenting among parents of preterm children.

In the evaluation step in this study, the application layout was evaluated by the expert and user groups, while the application satisfaction was evaluated by the user group. We found

that both groups evaluated the application as useful and stated that the information provided was consistent and systematic. The application was also found to be satisfactory. This positive evaluation is attributed to the fact that concerns on parenting and development experienced while raising a baby after discharge were addressed through reliable information checked by an expert content validity evaluation, as in the study by Park and Bang [6]. In addition, the fact that the application was developed on the basis of the results of a big data study [1] and that comprehension of the content was confirmed by testing with a range of subjects also contributed to ensuring the validity and satisfactoriness of the layout. In light of the favorable evaluations by the expert and user groups, the mobile application developed in this study is considered to be feasible for further interventional studies.

In summary, the usefulness of our mobile application was enhanced by combining technical functions to help parents and caregivers provide developmental support care for infants born prematurely. The development of this hybrid application for parents who have difficulties in continuing in-person follow-up care owing to the realistic limitations of raising infants or the COVID-19 pandemic is expected to contribute positively to the development of preterm children in the future. An important aspect of our mobile application is its provision of developmental support care that is not one-sided or fragmentary, but interactive and comprehensive. However, this study did not verify its effectiveness. Therefore, further studies are needed to evaluate the effects of this mobile application on parenting knowledge, parenting efficacy, and infant development.

CONCLUSION

This study was conducted to develop and evaluate the usefulness of a mobile application focusing on developmental support care for infants born prematurely. The conclusions drawn from the main results are as follows. Our mobile application was developed systematically according to the ADDIE model. This application included a diary; information on child-rearing, growth, and development; developmental play according to corrected age; and a bulletin board. It used colors and fonts that are friendly to infants and their parents. Additionally, it was configured to be accessible and convenient to use by implementing an uncomplicated and systematic structure and icons. Both mothers and fathers are included as primary caregivers, and the sex of the caregiver presented in the illustrations and phrases of the developed mobile application is expressed as neutral. That is, in accordance with the recent trend of joint parenting in which both partners in a couple participate, the intention was to increase fathers'

participation in child-rearing and enhance fathers' attachment.

This study is meaningful in that the mobile application developed provides practical information for the rearing and development of infants born prematurely based on the results of a previous study using SNS posts of parents raising preterm children. The application also provides overall information on the development of infants born prematurely, provides multi-faceted communication channels, and has an appropriate and satisfactory layout. Therefore, the study findings may be used as a basis for further interventional research aiming to promote the development of children born prematurely.

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Authors' contribution

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Conflict of interest

No existing or potential conflict of interest relevant to this article was reported.

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Data availability

Please contact the corresponding author for data availability.

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