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Short Paper

Routine Vaccine Simulation for Infants in a Mobile Environment

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Abstract

Purpose – This study aimed to develop and evaluate the Routine Vaccine Simulation for Infants. The routine vaccine simulation application was developed for the health workers and parents to provide basic information and press the importance of the vaccination to infants.

Method – The researchers used the fourth-generation technique (4GT) for the software development life cycle of the application. The technique adapted contains four major parts namely, requirements gathering, design strategy, implementation, and testing.

Results – The application was tested and evaluated by health workers, parents, and IT practitioners from the academe and the industry. The evaluation was based on criteria for core app quality. Descriptive and inferential statistics were employed for data presentation and interpretation. As a whole, the evaluation of the android-based routine vaccine simulation application was found excellent in most of its features. The finding asserts the adherence to the standards of android development applications and conforms to the expectations of the app's potential users.

Conclusion – The development of a routine vaccine app for infants serves as a new platform for immunization awareness and education. Once information given in the app is taken earnestly, infants will be protected against diseases. Thus, controversies surrounding vaccination hesitancies can be decreased.

Recommendations – A thorough information dissemination and education campaign regarding vaccine safety can be initiated in the local communities to address the issues on vaccine safety and hesitancy.

Research Implications – The healthcare system in the communities through the local government unit (LGU) will be able to benchmark and implement the information dissemination and education to mothers and health workers using the app.

Keywords – mobile vaccine application, immunization education, vaccine simulation, vaccine hesitancy, vaccine-preventable diseases

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INTRODUCTION

A routine vaccine was developed to offer protection against diseases. These are given to infants from birth and are recommended up to 18 years of age. This process is also known as immunization. World Health Organization (WHO) reported as mentioned by Chen et al. (2016) stated that the incidence of serious infectious diseases in infants and young children has decreased through immunization. However, WHO has long success stories on saving millions of lives every year (WHO, UNICEF & World Bank, 2009). WHO in 2019 claimed about 85% of infants worldwide received 3 doses of the diphtheria-tetanus-pertussis (DTP3) vaccine. Through its establishment of the Expanded Program on Immunization (EPI) in 1974, it ensures that all children have access to four routinely recommended vaccines that protect against tuberculosis, diphtheria, tetanus, pertussis, polio and measles, Bacillus Calmette-Guerin vaccine (BCG), DTP, polio vaccine (Pol), and MCV (Vanderende et al., 2018). In congruence to the program of WHO, it was also established in the Philippines in 1976 which initially recommended 6 vaccine-preventable diseases. It then transitioned in the same year to the National Immunization Program which included immunizations of senior citizens, school-age, and adolescents (Department of Health, Cordillera Center for Health Development, n.d.).

The vaccination rates decline has been associated with an increase in the outbreak of preventable diseases in many countries (De Cock et al., 2020). According to Katib (2013), millions of infants born worldwide still do not receive proper vaccination especially in developing countries, and emphasized that vaccine-preventable diseases can be prevented through strengthening surveillance and monitoring of programs. The Philippine government's efforts through the DOH in partnership with WHO and United Nations Children's Fund (UNICEF) can be seen in the promotion of the implementation of vaccines in protecting people of all ages from certain diseases (DOH, 2019). Campaigns highlight the benefits of immunization stressing the millions of lives saved by immunization. In 2000, the Philippines has declared a polio-free country and eliminated maternal and neonatal tetanus in 2017. These successes however challenged the DOH's National Immunization Program in reaching every child for vaccination covering 95% national target (Philippine News Agency, 2020). This is in response to the call of WHO during the World Health Assembly in 2012 on all countries to reach ≥ 90% national coverage with all vaccines in the country's national immunization schedule by 2020 (Peck et al., 2019). The 5% remaining gap to cover that all Filipino children shall receive proper immunization can be attributed to the inadequacy of health care facilities and public services available in the remote or far-flung areas of the country.

The Childhood Immunization Schedule for the Philippines contains 13 vaccinations that Filipino children need from age 0 to 18 years available for free at health centers (Business Mirror, 2019). In 2019, the childhood immunization schedule was updated. Due to the measles outbreak, the usual administration of the measles vaccine from 9 months old can be given as early as 6 (Elicay, 2019). The update on schedule is claimed as the ideal vaccination routine for children. The dengue vaccine, which is still surrounded by controversy, is no longer **in** the immunization schedule. The schedule is prepared annually by the Philippine Pediatric Society (PPS), the Pediatric Infectious Disease Society of the Philippines (PIDSP), and the Philippine Foundation for Vaccination (PFV).

The controversy about the dengue vaccine came into the light of the Philippine health care system after allegations on Dengvaxia were linked to the death of children which had been used in a widespread school vaccination program (Lo, 2019). According to Fatima and Syed (2018), the vaccination campaign involved more than 80 000 school children. Flasche et al. (2019), stated that there were 830 000 age 9-10 year-old-school children living in areas highly endemic for dengue received at least 1 of 3 recommended doses of vaccine. Elicay (2019) also reported from the obtained data from Philippine Statistics Authority (PSA) and UNICEF that the vaccination rate has gone down from 77% in 2013 to 70% in 2017 for children 12-23 months who received all basic vaccinations. Moreover, UNICEF (2020) reported that childhood immunization coverage has been declining sharply in recent years from 87% percent in 2014 to 68% in 2019, exposing children to vaccine-preventable diseases such as measles and polio. Along with this, the WHO included vaccine hesitancy on its annual list of global health threats in January 2019. The widely circulating media reports and the halt of the dengue immunization campaign in 2019 created fear in the public to get their children vaccinated. Owen (2017) stated that WHO warned the Philippines in July 2016 about the threat that Dengvaxia may pose to people who had never been infected with dengue. For this, concern over vaccine safety is one of the dominant reasons for vaccine hesitancy (Fatima & Syed, 2018).

It is through proper vaccination that prevented a child from acquiring preventable diseases which, if not to be taken seriously could result in serious complications and even death. Numerous studies mentioned its safety, efficacy, and importance. However, there is a lack of research focusing on mobile integration of information campaigns on health care issues in the country with simulation features. Wilson, Atkinson, and Deeks (2014) assert mobile applications offer an excellent opportunity for public health due to their distribution capability which is higher than simply posting on other platforms. Android-based applications provide convenience, and a fast user experience, which shifted to mobile platforms of hardware and software platforms (Holla & Katti, 2012). The advantages to the users in terms of portability, location awareness, and accessibility are provided significantly by mobile devices (Nayebi, Desharnais & Cheung, 2012). Bednarczyk et al. (2017) assert the promotion of routine vaccine activities which are typically educational in nature, informing the target population about vaccines, vaccine-preventable diseases, and populations indicated for vaccination. Atkinson et al., (2016) explored the potential of mobile technologies to influence vaccination behavior which is critical to protect against preventable diseases.

Zaidi (2019) reported the increasing number of health-related applications using mobile technology. It tackles health care issues in low- and middle-income countries (LMICs) where 97 per 1000 people used mobile phones in reaching remote communities. Applications available and can be downloaded in the Google play store are listed in Table 1.

As listed in Table 1, there are numerous android-based applications showcasing similar features and functions. Most of the focus of the application is on the vaccination schedule, vaccine administration, vaccine reminder, and vaccine tracking. Other apps emphasize medication, food tracking, parenting, and baby care tips. None of the apps was found featuring vaccine simulation for infants.

Hence, the objectives of the study were to develop an android-based routine vaccine simulation for infants, assess the functionality of the android-based routine vaccine simulation based on the perception of health workers, IT experts, and mothers, and determine the differences of evaluation from the three groups of app evaluators. The android-based routine vaccine app for infants was designed for immunization awareness and education. Vaccinations chart were defined to help parents see when their infants will be scheduled for the next immunization, type of immunization vaccine, and how they are given. It will be useful for first-time mothers for they will be enlightened through the app's information on vaccines, possible side effects, and after-care. Moreover, the content of the apps was presented for information dissemination and education purposes only.

Table 1. Comparative Analysis of Vaccine Applications

Application	Short Description
CDC Vaccine Schedules	CDC immunization schedules for clinicians recommending or administering vaccines
Vaccine Reminder & Booking – Kidcare	A vaccine reminder app like none other which reminds tracks baby's vaccination
Vaccine Reminder	Track Vaccine Schedule
CANImmunize	Vaccination tracking app
Child Vaccination Schedule	Track child vaccination schedule
Immunization App	Immunization basic knowledge with immunization table and child immunization plan
Growth Chart, Development Milestone, and Vaccination	Parenting app, baby care tip, diet chart, baby tracker, vaccination, and food tracker
Vaccination Record	Vaccination record, growth chart, and medication reminder
Immunize India (Early Access)	Immunization reminds caregivers to completely vaccinate their children on time
Immunization Planner	Vaccination reminder for the newborn child
Vaccine on the Go	Vaccine information app
Vaccination Chart for Children	Immunization chart based on age

Source: Play Store (as of March 2021)

HYPOTHESES

The assessment result of the study was founded on the assumption that the three groups of evaluators would find the developed application adherent to the principles of the core app quality standards. Inferential statistics were used to test the hypotheses.

H_{oa}: There are no significant differences in the assessment of three groups of app evaluators of the routine vaccine simulation for infants in terms of visual design and user interaction.

H_{ob}: There are no significant differences in the assessment of three groups of app evaluators of the routine vaccine simulation for infants in terms of functionality.

H_{oc}: There are no significant differences in the assessment of three groups of app evaluators of the routine vaccine simulation for infants in terms of compatibility, performance, and stability.

H_{od}: There are no significant differences in the assessment of three groups of app evaluators of the routine vaccine simulation for infants in terms of security.

METHODOLOGY

Design of routine vaccine simulation for infants

Based on the information from the identification of the routine vaccines, a design of the information system was created in a form of a context diagram.

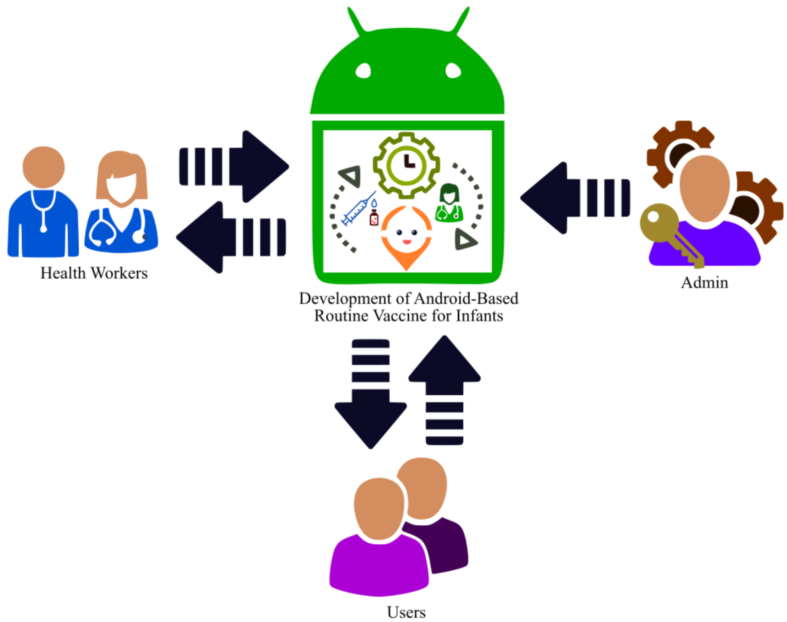

Figure 1. Context Diagram of the Android-Based Routine Vaccine for Infants

Figure 1 shows how the application works. The three users are health workers, mothers or other users, and the administrator. App users can view the different types of vaccines, how it is administrated to the infants, schedule of vaccine, vaccine information, and aftercare. App users are also allowed to simulate the application to see the immunization process.

Materials

For the development of the application, the researchers used the following hardware specifications: Windows 10 64-Bit Operating System, 4GB RAM, and Android Phone. The software that was used in the development of the system was UNITY 2018 and Adobe Photoshop for the design. The developers used an android device for the alpha testing of the application. During the testing process, the app was installed in different android devices running different versions of operating systems. The objective was to ensure that the app would work properly once installed by its targeted users. In order to run the application, the following hardware and software requirements were determined. The app's technical specifications were also stated.

Table 2. Hardware and software requirements and technical specifications of the routine vaccine simulation app

Hardware Requirements		**Software Requirements**		**Routine Vaccine Simulation Technical Specifications**
Minimum CPU or processor speed:	Intel Atom Z3560 Quad-core 1.8	Operating system:	Android 2.3 (Gingerbread) to 6.0 (Marshmallow)	An app that can be installed directly on a smartphone or tablet running Android operating systems.
Minimum GPU or video memory:	PowerVR G6430			Once in the play store, information content will be available even with no network connection.
Minimum system memory (RAM):	2 GB			Updated information will be downloaded automatically when an app is used on a network connection
Minimum free storage space:	256 MB			Information content will be tailored to specific user groups.
Audio hardware (sound card, speakers,):	Smartphone Speaker or earphone			User type specifications: Healthcare provider, Parent.

Table 2 shows the minimum hardware requirements, range of software requirements, and technical specifications of the routine vaccine simulation application.

Development Process

The methodology used in the development of the application is the Fourth Generation Technique (4GT) was comprised of four major parts namely: requirements, gathering, design strategy, implementation, and testing. In the 4GT model, a program is constructed according to the specification of the developers while the source code is generated automatically (Yu, 2018).

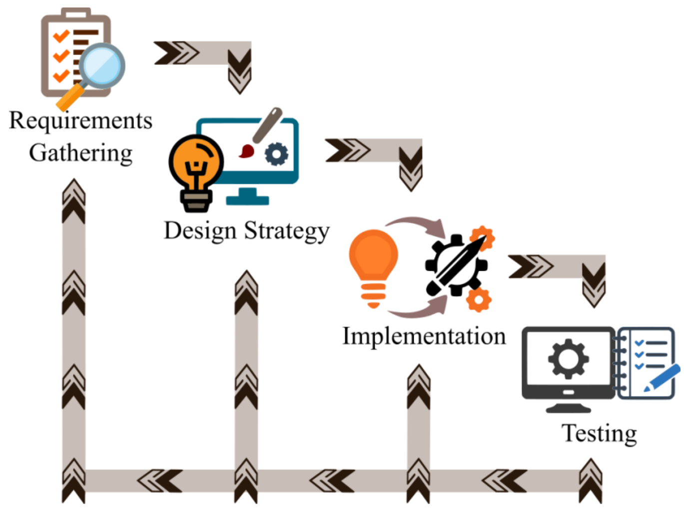

Figure 2. Fourth Generation Technique Paradigm

As illustrated in Figure 2, the fourth-generation technique (4GT) approach requires the requirement analysis step. Once the requirement analysis is done up to the expectations, its translation into the operational prototype begins. The most important phase in the 4GT approach is the customer developer approach where all the major decisions regarding the implementation, costs, and functioning of the system were taken in this phase.

Requirements Gathering. This is where the definition of requirements is necessary for the development of the app. The developers used different methods in acquiring the information needed such as research, interview, and observation. The developers conducted interviews with health workers from different barangay to gather required information in the development of the application. Likewise, random observations during the administration of vaccines to infants were conducted. The Rural Health Unit (RHU) of the research locale played a big role in verifying the accuracy of information gathered and content integration in the application development.

Design Strategy. After gathering all the required information, the researchers developed a context diagram to represent the process and direction of the application function flow involved in developing the app. The gathered data was translated into a set of presentations that describes the data structures, architecture, algorithmic procedure, and inter-phase characteristics.

Implementation. The design presentation was translated to an artificial language that results in instruction that could be executed by the computer. The gathered requirements and design were put into a machine-executable form. The developers implemented using 4GT which enables a representation of desired output in a manner that results in automatic generation of code to generate the output. The program coding was created with the Fourth Generation Technique (4GT). Modifications were made based on the recommendation of the target app users.

Testing. The application was evaluated and tested to determine if the objective of the application development had met the needs of the health workers and users and to ensure that it is free from any error. Alpha testing was made to check the compatibility of the application in different versions of android-based platforms.

Data Analysis. The data were collected, classified, tabulated, and coded for analysis. Descriptive and inferential statistics were employed for data presentation and interpretation.

Population Frame and Sampling Technique

The study used non-probability sampling in selecting the app evaluators. In this sampling design, the researcher selected the health workers who were conveniently available (Almeida, Gaerlan & Manly, 2016). The functional acceptability of the system was evaluated by thirty (30) Information Technology (IT) experts randomly selected from the academe and the industry. The subject matter experts were the health workers in the community where the study was conducted. Thirty (30) health workers were randomly selected. The potential users were mothers and parents comprising thirty (30) samples from different barangays. Their fitness and qualifications to evaluate the app were taken into consideration.

Instrument

The questionnaire used in the evaluation of the app was based on core app quality (Core app quality, n.d.). The questionnaire was modified based on the requirements of the study and was subjected to expert validation and reliability testing. The 5-point Likert scale was used.

Table 3. Arbitrary scale in interpreting the data.

Scale Value	**Mean Range**	**Descriptive Scale**
5	4.20-5.00	Excellent
4	3.40-4.19	Very Good
3	2.60-3.39	Good
2	1.80-2.59	Fair
1	1.00-1.79	Poor

RESULT AND DISCUSSION

Routine Vaccine Simulation

The developed application was intended for the community health workers, parents, or mothers to provide basic information about the vaccines that their infants needed and help them know the things they need to do after the vaccine is given. The main menu and the different vaccines were provided in the following figures.

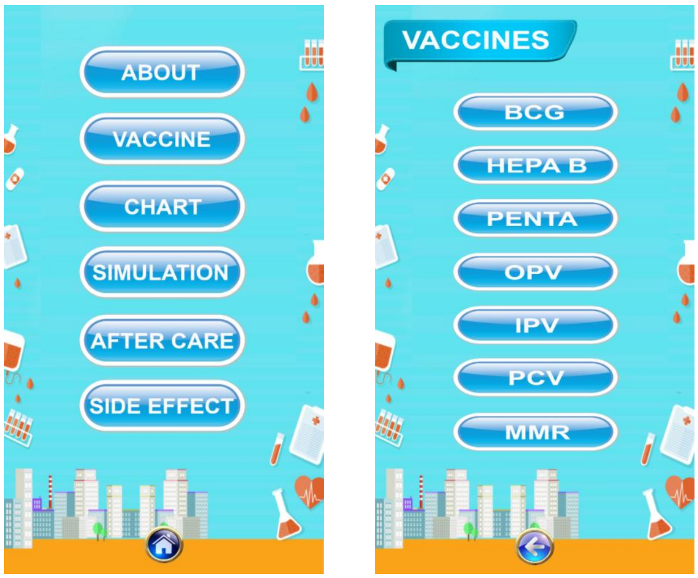

Figure 3. (a) Main Menu and (b) Vaccine Menu

Figure 3a above contained the different buttons of the application. The summary of the application can be viewed on the about button. As seen in Figure 3b, the vaccine button contained the different vaccines, chart button contains the view of the vaccine chart or schedule of the different vaccines. Simulation buttons contained the different vaccine simulation procedures and the aftercare button contained the different practices for taking care of the infants after immunizations.

As illustrated in Figure 4a, the vaccine chart contained a routine immunization schedule for infants. The app user may choose the vaccine to see the different vaccines and their information. The app user may also choose simulation to see how the process goes on. Figures (4b), (4c), (4d), (4e), and (4f) show the simulation process for BCG with instructions given for the user to perform such. Processes for simulations on Hepa B, Penta, OPV, IPV, PCV, and MMR were also available for app users once the simulation option is chosen.

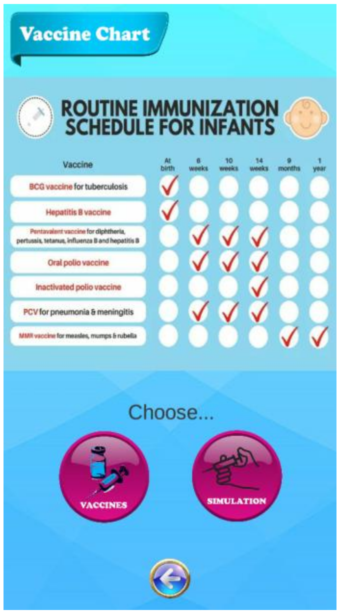

Figure 4. (a) Vaccine Chart

Figure 4. (b) Step 1 for BCG Simulation

Figure 4. (c) Step 2 for BCG Simulation

Figure 4. (d) Vaccine Chart

Figure 4. (e) Step 1 for BCG Simulation

Figure 4. (f) Step 2 for BCG Simulation

The functional requirements of the app included (a) the user can put a check on the immunization chart for every vaccine that is needed by the baby, (b) the user can practice the immunization of babies by a series of steps in the simulation, and (c) the user can choose any vaccine to use for the simulation. The non-functional requirements of the app included (a) checked schedules are saved even the app is not active (b) making a wrong step in the simulation will trigger a warning to the user, and (c) for every vaccine chosen, the app can provide clear and concise information of the side effects.

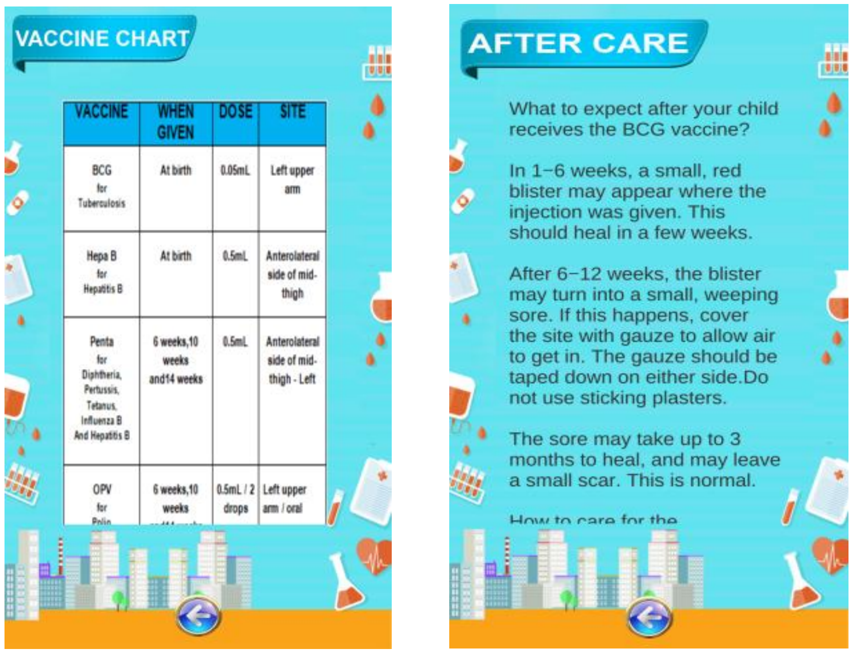

Figure 5. (a) Vaccine Chart and (b) After Care Screen

The chart button contained the Routine Vaccine Chart of the Infants as seen in Figure 5a. The aftercare button contained the information about how the user takes care of the infants after immunization as seen in figure 5b.

Evaluation Result

The performance of the developed application was evaluated using the standardized requirements for android platform applications. The acceptability of the app was assessed in terms of visual design and user interaction, functionality, compatibility, performance and stability, and security by three groups of respondents; 30 app users, 30 subject matter experts, and 30 IT experts from the academe and the industry. The following results were illustrated in Table 4.

Table 1 shows the overall evaluation result of the potential users, subject matter experts, and IT experts of the Routine Vaccine Simulation for Infants based on standards for core app quality. It obtained an overall mean of 4.3498 from potential app users, 4.1707 from subject matter experts, and 4.1755 from IT experts with a verbal interpretation of excellent and very good, respectively. The grand mean obtained from the three groups of app evaluators was 4.2320 to denote an excellent rating.

Table 4. Overall Result of the Android-Based Application from the Perceptions of Potential Users of the App, Subject Matter Experts, and IT Experts

Indicators	**Potential User**		**Subject Matter Experts**		**IT Experts**		**Overall**	
	WM	**VI**	**WM**	**VI**	**WM**	**VI**	**WM**	**VI**
Visual Design and User Interaction	4.3730	E	4.1667	VG	4.0938	VG	4.2118	E
Functionality	4.3175	E	4.2171	E	4.1608	VG	4.2318	E
Compatibility, Performance & Stability	4.2442	E	4.1272	VG	4.1725	VG	4.1813	VG
Security	4.4625	E	4.1719	VG	4.2750	E	4.3031	E
Overall	**4.3498**	**E**	**4.1707**	**VG**	**4.1755**	**VG**	**4.2320**	**E**

Scale: 4.20 - 5.00 Excellent, 3.40 - 4.19 Very Good, 2.60 - 3.39 Good, 1.80 - 2.59 Fair, 1.00 - 1.79 Poor
Legend: WM - Weighted Mean, VI - Verbal Interpretation, TWM - Total Weighted Mean, E - Excellent, VG - Very Good, G - Good, F - Fair, P - Poor

The said findings complemented the features of the application developed gave the users the opportunity to appreciate the design, customized icons and not redefine or misuse Android UI patterns such that the user can understand easily the usability of the application. It allows the user to get the right permission that it needs to support the functionality which does not intend to any transactions that the app does not support. Convenience was also one of the features that allow app users to install the application on an SD card, without consuming a large amount of battery during its usage. The stability works properly without any problem when it is launched, thus its performance increases the usability of the user's experience, and attracts the user to the quality of the application without any crackle and shutter when in use. The app's standard development kit (SDK) was set through compiling SDK value supporting app restoration as closely as possible to the previous state. According to Holla and Katti (2012), Android SDK provides the tools and APIs necessary in the development of applications on the Android platform.

Overall, the findings adhered to the standards of Android Development. The design conformed to the expectation of the users of the app. The application showed user-friendliness, understandability, and attractiveness. Its functionality works accordingly to its intended purpose, works normally, and does not show unintended functions. The application components were appropriate to run properly. The performance of the app provided feedback to the user. Chen et al. (2016) assert the perceived benefits of using the mobile-based application could lead to better management of child immunization. For it reduces paperwork, more convenient and the detailed information are readily available at hand.

Table 5. Summary of Differences of Result of the Android-Based Routine Vaccine Simulation for Infants from the evaluation of App Users, Subject Matter Experts, and IT.

Indicators	Source of Variation	Sum of Squares	Mean Square	F	P	Decision
Visual Design and User Interaction	Between Groups Within Groups Total	0.17 0.04 0.21	0.08 0.00 0.08	20.73	0.00	Reject
Functionality	Between Groups Within Groups Total	0.14 0.94 1.08	0.07 0.02 0.09	3.05	0.06	Accept
Compatibility, Performance, and Stability	Between Groups Within Groups Total	0.06 0.62 0.68	0.03 0.01 0.04	2.32	0.11	Accept
Security	Between Groups Within Groups Total	0.20 0.06 0.26	0.10 0.00 0.10	18.19	0.00	Reject

For visual design and user interaction as well as security Table 2 shows that there are statistical differences in the evaluation of the app from the potential app users, subject matter experts, IT professionals between groups and within groups using one-way ANOVA. The computed value of visual design and user interaction, and security were both p = 0.00 which was greater than the 0.05 level of significance rejects the null hypothesis. The result of the rejection of the null hypothesis indicated the varied perceptions as seen by three groups of app evaluators.

Bencito, Dabu, and Santiago (2020) mentioned that adherence to visual design and user interaction is attributed to user experience (UX) functionality. When in use, the app users experience provided the intended function that is combined with the quality of the application's performance. The differences in the observation could be attributed to the app's component which provided provision to support the application right action that has nothing to do with other applications on the phone of the user and without overlaying the app with the other phone application.

For functionality, compatibility, performance, and stability, Table 2 shows that there were no differences in the evaluation of the app by three groups of evaluators. The computed value of p = 0.06 and 0.11 which was greater than the 0.05 level of significance fails to reject the null hypothesis. The result of the non-rejection of the null hypothesis indicates that the three groups of evaluators have similar perceptions of the app's performance as indicated by the variables. It could be attributed to the feature where the app is up to date and does not crash or force to close but it depends on the users' mobile phone versions, which the app evaluators found during testing.

CONCLUSION AND RECOMMENDATIONS

The application developed has seven (7) different vaccines that the infants will receive throughout his/her infant stage. The app also helps the parents to have enough information about the side effects of the vaccines and the after-cares they need to do. The developers used the Fourth Generation Technique Paradigm in the software development process. The system was developed using the following hardware specifications. Intel Core i3 at 2.00GHz, 4.00 GB RAM. For the software, the Windows 10 64-Bit as the Operating System, Unity 2018 2D for the development environment of the application, and Photoshop C6 for user interface design were used. The app was evaluated by three groups of evaluators, divided into 3 categories: thirty (30) potential users who are parents, thirty (30) subject matter experts who are the Barangay Health Workers and Midwives, and thirty (30) IT experts from the industry and the academe. The result of the evaluation denoted that the application would be effective once used or adopted as verified through the core app quality evaluation. The result of the overall mean from the evaluation of the application was 4.2352 to denote Excellent across all evaluators. The results proved that the application has been successfully constructed as designed. There were differences in the evaluation of the app in terms of security and of visual design and user interaction. There were no differences in terms of functionality, compatibility, performance, and stability in the evaluation of the app.

The development of routine vaccine simulation in a mobile environment provided opportunities for utilizing new technologies to increase vaccine confidence. The Android-Based Routine Vaccine App for Infants is designed for immunization awareness that helps tracking vaccination in an easy way along with tracking the development milestone of infants. It is useful for first-time parents who do not know much about immunization. In this app, information is given about vaccination to be taken at different ages for protection against diseases, and child health care after immunization. A vaccinations chart was provided to help parents see when their infants will be scheduled for the next immunization, the type of immunization vaccine, and how they are given. Thus, when the application is implemented it may contribute to address the problems in low vaccination rate, ease the issue on vaccine controversy and vaccine hesitancy. The application can be further explored by increasing immunization simulation regarding vaccination for school-age children, adolescents, adults, and seniors. To make the app a personalized one, adding a notification feature may be considered. A study on experimental design is also recommended.

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