Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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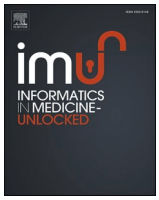

Effectiveness of an educational mobile-app intervention in improving the knowledge of COVID-19 preventive measures

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Patient education plays an essential role in the modern digital era when the spread of COVID-19 can be prevented using smartphone apps as an alternative learning medium. Although previous studies have shown that the app provides more benefits than any conventional media, its implementation in learning has not been evaluated in hospitalized patients in Indonesia. Therefore, this study aimed to determine the effectiveness of an educational mobile app intervention in improving the knowledge of COVID-19 preventive measures. This quasi-experiment included a pretest-posttest control group design involving 140 participants from various backgrounds. The comparison and treatment categories were randomly selected before and after each educational intervention. Based on the mode of data collection, an EduCovid-19® app and a knowledge-based questionnaire were utilized, with the total pre-test and post-test scores being statistically analyzed descriptively and hypothetically (Mann-Whitney and Wilcoxon). The comparison between pre-test and post-test scores of control and treatment groups were to determine the impact levels of the mobile app-assisted educational intervention for subsequent development. The results confirmed that this intervention significantly improved the knowledge of COVID-19 preventive measures. The mean value of the pre-test and post-test of the treatment group was found to increase as many as 3.46, and the difference of the test scores was significant at a 0.001 significance level. For both hypothetical tests (Mann-Whitney and Wilcoxon), the p-values were smaller than 0.001. From the study results, the mobile app-assisted educational intervention significantly improved patients' knowledge, suggesting that the implementation of the mobile apps as a learning medium needs to be part of the educational environment to teach about COVID-19 preventive measures.

1. Introduction

A coronavirus belongs to a group of viruses causing various diseases in humans. It is shaped like a crown, corresponding to the Latin term "corona". Several types of the virus cause respiratory tract infections, ranging from colds to more serious illnesses, such as MERS (Middle-East Respiratory Syndromes) and SARS (Severe Acute Respiratory Syndromes) [1]. COVID-19 is a new infectious variant known to cause a zoonotic disorder due to its transmissible capabilities between animals and humans. However, the occurrences of transmission among animals are unknown. Based on scientific evidence, COVID-19 was transmitted among humans through coughing or sneezing droplets, with the most vulnerable individuals often in close contact with infected patients. Irrespective of the variations in this infection's common signs and symptoms, several acute respiratory distress, such as fever, cough, and shortness of breath, are still involved. In severe cases, pneumonia, acute respiratory syndrome, kidney failure, or death are also observed [2–5].

One of the factors contributing to the rapid spread of the COVID-19 disease is the lack of public knowledge, which is needed to avoid significant risks, such as anxiety, panic, and stress [6,7]. These psychological conditions also affect professional health workers, including general practitioners, pharmacists, nurses, and others [8]. The term "anxiety" is characterized by somatic, vegetative, and cognitive symptoms involving a lack of security or an inability to cope with a problem. "Panic" is the sudden appearance of excessive fear or anxiety for an unknown reason, generally characterized by accelerated heart rate, shortness of breath, dizziness, muscle tension, or shaking. Meanwhile, physical and emotional stress describes a person's reaction when

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environmental changes require adjustments [9,10]. During the COVID-19 pandemic, increased numbers of people experienced these conditions, the severity of which needs to be minimized by various counselling services. In this case, the spread of the virus tends to be uncontrollable due to the public's ignorance of the symptoms and preventive measures [11–13]. Therefore, this fundamental knowledge is very important in decreasing the number of infectious cases. Education is one of the effective methods to improve public knowledge. Therefore, an attractive and interactive learning medium is highly required. According to previous studies, many users, ranging from teenagers to adults (19–34 years), demanded a mobile app-assisted medium because of its simplicity, attractiveness, and comprehensibility [14–16]. Many positive literature reviews reported that mobile apps are effective for patient education due to their efficient multimedia-based educational materials that inspire and trigger users' imagination and understanding [17–19]. Despite these descriptions, app utilization in patient education has not been widely evaluated in Indonesia. Therefore, this study aimed to determine the effectiveness of mobile app-assisted educational interventions in increasing users' COVID-19 knowledge. The results were expected to support using mobile apps as an alternative, effective, attractive, and innovative learning medium. No prior studies were identified on the effectiveness of app usage as an alternative educational medium for Indonesians, supporting the novelty of this study.

2. Material and methods

This quasi-experiment utilized a pretest-posttest control group design. The comparison and treatment classes were randomly selected and administered tests before and after the educational intervention. Fig. 1 shows the systematic design of this study, while Fig. 2 shows the screenshots of the Educovid-19 app user interface.

2.1. Study participants

A quota sampling technique was used to recruit the potential participants. The sample size was estimated according to a sample size formula developed by Lemeshow and Lwanga [20]. The eligible criteria included (1) living in the Special Region of Yogyakarta, Indonesia, (2) being 19–34 years old, (3) owning a smartphone, (4) not being a professional health worker or a potential candidate, and (5) willing to fill out the consent form. Meanwhile, those who could not complete questionnaires and resigned due to technical troubles related to smartphones or apps were excluded. A public announcement was distributed through social media, such as Facebook, Instagram, WhatsApp, and direct calling, to recruit the participants.

2.2. Procedures

These study procedures followed three steps: preparation, implementation, and data processing. The preparation phase involved (1) submitting a permit application to the KEPK (Health Research Ethics Committee) of the Faculty of Medicine and Health Sciences, Universitas Muhammadiyah Yogyakarta, Indonesia, (2) seeking potential participants through social media, such as Facebook, Instagram, and WhatsApp, and (3) preparing data collection instruments, such as the EduCovid-19® mobile app and COVID-19 preventive-measure questionnaire, which includes validation and reliability tests. In the implementation phase, the recruited participants were divided into control and treatment groups. The treatment group was asked to download and use the educational mobile app, while the control class could use only printed materials (e.g., books, leaflets, posters, etc.) or other learning sources. A pre-test and post-test analyses were conducted before and after a 1-month treatment period to determine the participants' preventive measure knowledge. The obtained data were then statistically analyzed with a descriptive and hypothetical analysis to evaluate the effectiveness of mobile app-based educational interventions in improving the quality of users' knowledge.

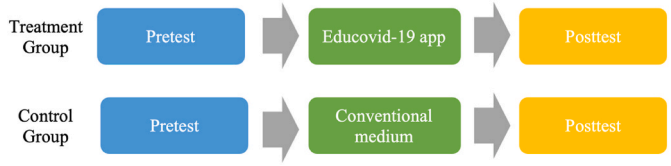

Fig. 1. Study systematic design.

2.3. Instruments

The instruments included the EduCovid-19® app and a COVID-19 knowledge questionnaire. This educational app contained several learning materials sourced from the Decree of the Indonesian Minister of Health (HK.01.07/Menkes/413/2020), which serves as a guideline for the prevention and control of COVID-19 [21]. Meanwhile, a previously developed questionnaire containing 30 preventive measure items was utilized to determine public knowledge [22], as shown in Table 1. In this instrument, a good, moderate, and low level emphasized the correct answers at values $\geq$ 75%, between 56 and 74%, and $\leq$55%, respectively. The mobile apps' effect on users' knowledge levels was analyzed using the IBM SPSS Version 22.0. In this case, the hypothesis was accepted (rejected) when its p-value was smaller (greater) than 0.05.

2.4. Data analysis

Data were collected from July to December 2021 using a COVID-19 questionnaire. In this process, the participants were instructed to complete this data instrument, which measured COVID-19 knowledge and demographic characteristics, such as gender, age, and educational level. After a 4-week intervention period, all the participants were instructed to complete the post-test analysis. Subsequently, the obtained data were statistically compared to determine the level of COVID-19 knowledge in the control and treatment groups. The comparison was also conducted to effectively prove the study hypothesis. Before the descriptive analyses and hypotheses testing, a normality test was performed to determine whether the obtained data were normally distributed. The data were considered to be normally distributed if their p-value was greater than 0.05 (a confidence level of 95%). With the involvement of 140 participants, a Kolmogorov-Smirnov model was used in this analysis, with the results shown in Table 2.

2.5. Ethical consideration

This study was officially approved by the KEPK (Health Research Ethics Committee) of the Faculty of Medicine and Health Sciences, Universitas Muhammadiyah Yogyakarta, Indonesia (no. 238/EC-KEPK FKIK UMY/VIII/2021).

3. Results

3.1. Study participants

The quota sampling technique led to the recruitment of 140 participants categorized into two groups. As seen in Table 2, most participants were female (45.29%; n = 77) aged between 19 and 23 years (71.746%; n = 122) with undergraduate degrees (71.17%; n = 121). Almost half of them (47.64%; n = 81) had medium knowledge of COVID-19 preventive measures (56–74% of correct answers). Meanwhile, all participants (100%; n = 100%) had experience in using mHealth apps. Table 3 shows the background data of these participants.

Fig. 2. Screenshots of the EduCovid-19® app user interface.

3.2. Validity and reliability of the questionnaire

The validity test is often used to ensure the accuracy of the questionnaire regarding the measurement of variables and data collection. The reliability, commonly expressed in numbers (coefficients), refers to whether the test produces the same results consistently across time and situations. In this analysis, 4 experts validated the content validity, two general practitioners and two public health experts. Based on the results, the average score of all questions (100%; n = 30) was 3 out of 4 on the Likert scale, indicating a relevant categorization. For construct validity, more than half of the questions (63.33%; n = 19) were had a strong correlation with the content of the question items, with 30% (n = 9) having a very strong correlation. Meanwhile, only 2 questions (6.67%; n = 2), CO10 and CO23, had moderate correlations with the content of the question items. Table 4 shows the content and construct validity results obtained from the COVID-19 knowledge questionnaire.

Regarding the reliability, shown in Table 5, the Cronbach's Alpha value was 0.971, indicating that the questionnaire is a highly reliable measuring tool.

3.3. Inferential statistical analysis

The results of the inferential statistical analysis of this study found a significant decrease of 0.09 observed in the control group's mean value (21.43–21.34) at a 0.05 level ($p = 0.471$) after intervention period. Meanwhile, an increase of the questionnaire scores (pre-test and post-test) of 3.46 was found in the treatment group, with a significance of 0.001. These results explained that the utilization of the EduCovid-19® app helped improve participants' knowledge of COVID-19 preventive measures. This analysis is summarized in Table 6.

3.4. Hypothesis test

3.4.1. Mann whitney

Since the obtained data were not normally distributed, the Mann-Whitney approach was adopted to prove the study hypothesis. This non-parametric test determines the presence or absence of a difference between two independent samples. The results shown in Table 7 support the proposed hypothesis, as indicated by the p-value of 0.001.

3.4.2. Wilcoxon

Wilcoxon statistical method is used to test the difference between two paired data. In this analysis, a p-value of less than 0.001 confirmed the study hypothesis (Table 8).

Table 1
A questionnaire on the knowledge level of COVID-19 preventive measures.

No	Statements	Answers	
		True	False
CO1	COVID-19 is a new type of infection transmitted from one person to another.		
CO2	The cause of COVID-19 is a newly mutated virus known as SARS-CoV-2.		
CO3	SARS-CoV-2 is also known as Severe Acute Respiratory Syndrome Coronavirus 2.		
CO4	SARS-CoV-2 is not more contagious than SARS-CoV and MERS-CoV.		
CO5	In Indonesia, COVID-19 was first discovered in January 2020.		
CO6	The cause of COVID-19 is a bacterium belonging to the coronavirus family.		
CO7	SARS-CoV-2 can survive up to 72 h on plastic, stainless steel, or iron surfaces.		
CO8	SARS-CoV-2 cannot last for 4 h on copper.		
CO9	SARS-CoV-2 can last for 24 h on cardboard.		
CO10	SARS-CoV-2 is a zoonotic disease transmitted between animals and humans.		
CO11	The average incubation period for COVID-19 is 5–6 days, ranging between 1 and 14 days.		
CO1	SARS-CoV-2 spreads through droplets or contact with contaminated objects.		
CO13	Transmission of the COVID-19 virus can occur directly and indirectly through infected people and contaminated surfaces or objects, respectively.		
CO14	Some people infected with SARS-CoV-2 do not show any symptoms and still feel healthy.		
CO15	The most common symptoms of COVID-19 include fever, tiredness, and dry cough.		
CO16	Some patients infected with SARS-CoV- 2 always have aches and pains, nasal congestion, runny nose, headache, conjunctivitis, sore throat, diarrhea, loss of smell, and nose or skin rash.		
CO17	Older adults are an age group susceptible to infection with SARS-CoV-2.		
CO18	Someone suffering from high blood pressure, heart and lung disorders, diabetes, and cancer is at greater infection risk.		
CO19	Swab Test-PCR is the most accurate method to identify infected people.		
CO20	A rapid test is carried out by taking blood samples from infected patients.		
CO21	Anti-bacterial drugs can be used to cure infected patients.		
CO22	Patients recovering from SARS-CoV-2 are unlikely to be re-infected due to their body's immunity formation to fight the virus.		
CO23	Improvement in body immunity is an effort to avoid being infected with SARS-CoV-2.		
CO24	Regular exercise can increase the body's immunity, which can help prevent being infected with the virus.		
CO25	Injecting a vaccine is the best approach to ensure someone is not infected with the SARS-CoV-2 virus.		
CO26	Physical distancing is an action to maintain a distance from one person to another to prevent transmission of SARS-CoV-2.		
CO27	The recommended safe distance in the practice of physical distancing is 1 m.		
CO28	Maintaining hand hygiene is not effective in preventing the transmission of SARS-CoV-2.		
CO29	Using a mask is a preventive effort against the infection of SARS-CoV-2.		
CO30	Restrictions on external activities cannot limit the spread of SARS-CoV-2.		

Table 2
The normality test (Kolmogorov-smirnov).

Groups	Test	p-Value	Information
Control	Pre-test	0.025	Non-normal distribution
	Posttest	0.007	Non-normal distribution
Treatment	Pre-test	0.001	Non-normal distribution
	Posttest	0.001	Non-normal distribution

Table 3
The participants' background.

Demographics	Value (%)		p-value
	Control (n = 70)	Treatment (n = 70)	
Gender			
a) Male	32 (45.7)	31 (44.3)	0.73
b) Female	38 (54.3)	39 (55.7)	
Age (Years Old)			
a) 19–23	60 (85.7)	62 (88.7)	0.14
b) 24–28	6 (8.5)	5 (7.1)	
c) 29–34	4 (5.8)	3 (4.2)	
Level of Education			
a) Undergraduate Degree	62	59 (84.2)	0.47
b) Bachelor Degree	4 (5.8)	8 (11.6)	
c) Master Degree	4 (5.8)	3 (4.2)	
d) Doctoral Degree	0(0)	0 (0)	
Level of Knowledge			
a) Low	27 (38.6)	21 (30)	0.62
b) Medium	39 (55.7)	42 (60)	
c) High	4 (5.7)	7 (10)	
mHealth User Experience			
a) Yes	100 (100)	100 (100)	–
b) No	0 (0)	0 (0)	

Table 4
The content and construct validity tests.

Statement Code	Content Validity		Construct Validity	
	Value (Avg)[a]	Note	Value (r)[b]	Note
CO01	3.25	Relevant	0.78	Strong
CO02	3.75	Relevant	0.76	Strong
CO03	3.75	Relevant	0.75	Strong
CO04	3.5	Relevant	0.66	Strong
CO05	3.5	Relevant	0.75	Strong
CO06	3.25	Relevant	0.75	Strong
CO07	3.75	Relevant	0.93	Very Strong
CO08	3.5	Relevant	0.93	Very Strong
CO09	3.75	Relevant	0.93	Very Strong
CO10	3.25	Relevant	0.66	Moderate
CO11	3.25	Relevant	0.83	Strong
CO12	3.25	Relevant	0.76	Strong
CO13	3.5	Relevant	0.82	Strong
CO14	3.75	Relevant	0.80	Strong
CO15	3.75	Relevant	0.84	Strong
CO16	3.75	Relevant	0.76	Strong
CO17	3.75	Relevant	0.84	Strong
CO18	3.75	Relevant	0.93	Very Strong
CO19	3.75	Relevant	0.93	Very Strong
CO20	3.25	Relevant	0.83	Strong
CO21	3.5	Relevant	0.93	Very Strong
CO22	3.5	Relevant	0.93	Very Strong
CO23	3.5	Relevant	0.66	Moderate
CO24	3.5	Relevant	0.93	Very Strong
CO25	3.5	Relevant	0.92	Very Strong
CO26	3.75	Relevant	0.84	Strong
CO27	3.5	Relevant	0.79	Strong
CO28	3.5	Relevant	0.84	Strong
CO29	3.5	Relevant	0.77	Strong
CO30	3.75	Relevant	0.83	Strong

[a] Average value of 4-point Likert Scale (4 = highly relevant; 3 = relevant; 2 = irrelevant; 1 = highly irrelevant).

[b] Pearson's correlations (0–0.25 = very low; 0.26–0.49 = low; 0.5–0.69 = moderate; 0.7–0.89 = strong; 0.90–1.0 = very strong) (de Barros Ahrens et al., 2020).

4. Discussion

The coronavirus disease is capable of spreading and infecting anyone, regardless of the age group. A good understanding and knowledge of all related elements, including the community, are required to decrease its rapid spread. An understanding of this disease and its preventive measures can prevent the increase in the number of infectious

Table 5
The reliability test.

Statement Code	Cronbach Alpha[a]	Note
CO01– CO30	0.97	Very High

[a] Cronbach Alpha (0,81–1,00 = very high; 0,61–0,80 = high; 0,41–0,60 = moderate; 0,21–0,40 = low; and −1,00 - 0,20 = very low (not reliable) (Demir et al., 2021).

Table 6
The descriptive analysis.

Groups		Minimum	Maximum	Mean (SD)	Difference (p-value)
Control	Pre-test	15	27	21.43 (±2.65)	−0.09 (0.471)
	Posttest	17	25	21.34 (±2.23)	
Treatment	Pre-test	14	27	20.94 (±2.57)	3.46 (0.001)
	Posttest	21	30	24.4 (±2.68)	

Table 7
The mann-whitney statistical analysis.

Groups	Mean Rank	p-value
Control	50.41	0.001
Intervention	90.59	

Table 8
The wilcoxon statistical analysis.

Groups		Mean	p-value
Intervention	Pre-test	20.94	0.001
	Posttest	24.40	

cases. Therefore, education is vital for improving the patient's knowledge of COVID-19 preventive measures. Furthermore, educational media, such as smartphone apps, should stimulate patients' desire, interest, and motivation to learn. In several previous studies, these apps improved patients' disease management, including their knowledge. Based on the present report, 140 participants with different demographic characteristics, such as gender, age, and educational background, were selected. These subsequently included the knowledge levels on COVID-19 preventive measures and experience in mHealth app utilization. According to Table 2, differences between control and treatment groups in demographic characteristics were insignificant, as all p-values were greater than 0.05. A previously developed COVID-19 questionnaire was used to measure their knowledge [22].

The results also proved that the utilization of EduCovid-19® significantly improved the participants' knowledge of COVID-19 preventive measures compared to several conventional methods. This was reinforced by the significant increase in the mean patient's knowledge questionnaire score from pre-test to post-test for the treatment group. The Mann-Whitney and Wilcoxon tests were also significant, supporting the study hypothesis that the mobile-app educational intervention would significantly improve the participants' knowledge of COVID-19 preventive measures. These findings align with previous studies that reported statistically significant differences between the control and experimental groups [23]. Other reports have also found that implementing a mobile app as a learning medium significantly enhanced the quality of life, self-efficacy, and clinical outcomes [24,25]. In this modern era, digital-based patient educational interventions are being developed to improve knowledge and self-care skills to increase low health literacy [26]. These methods differ from the conventional methods using only printed educational materials (e.g., books, posters, pamphlets) or other traditional approaches, which provide minor benefits for those with limited medical understanding. According to several studies, information and communication technologies can support self-care skills and improve health outcomes. Moreover, a systematic review suggested that digital educational interventions positively enhanced patients' engagements and efficiently improved health status and self-management [27–30]. The findings of this study are aligned with many positive reports that have confirmed the significance of this patient education, emphasizing that the implementation of mobile apps as a learning medium should be part of the educational system that teaches about COVID-19 preventive measures.

4.1. Limitations of the study

Despite the positive results obtained, this study had some limitations. First, most participants were between the ages of 19 and 24 (71.76%; n = 121); therefore, the results do not fully represent the users below 19 or above 24 years of age. Second, the participants resided in the same area; therefore, their interactions during the intervention could not be controlled. Third, the educational intervention period was only one month, causing a high level of users' preventive-measure knowledge at the end of the treatment. Based on these limitations, subsequent studies should include larger sample sizes, diverse age groups, and smarphone app-assisted educational intervention periods for better results.

5. Conclusion

The results confirmed that mobile app-assisted educational intervention significantly improved the knowledge of COVID-19 preventive measures. This was reinforced by an increase of 3.46 in the mean knowledge value for the treatment group from pre-test to post-test, with a p-value of 0.001. Based on these results, implementing mobile apps as a learning medium needs to be part of the educational system for teaching COVID-19 preventive measures.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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