

# Effect of Health Education via Mobile Application in Promoting Quality of Life Among Asthmatic Schoolchildren in Urban Malaysia During the COVID-19 Era: A Quasi-Experimental Study

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## Research Article

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# Abstract

**BACKGROUND:** Bronchial asthma among children is a common chronic disease which may have impact on quality of life. Health education is one of the strategy to improve knowledge and quality of life.

**OBJECTIVE:** The study aims to assess the effect of health education via mobile application (app) in promoting quality of life among schoolchildren with asthma in urban Malaysia during the COVID-19 era.

**METHODS:** A quasi-experimental, pre- and post-intervention design was used in this study involving a total of 214 students, randomly assigned into two groups (intervention group and control group). The control group received face-to-face health education while the experimental group received health education via a mobile application.

**RESULTS:** The findings showed that the total score of quality of life (QoL) has improved from a mean total score at pre-intervention ( $5.31 \pm 1.27$ ) to post-intervention ( $5.66 \pm 1.28$ ) for the control group, compared with the experimental group with a mean total score of QoL at pre-intervention ( $5.01 \pm 1.36$ ) and post-intervention ( $5.85 \pm 1.29$ ). A comparison between the experimental and control groups using an independent t-test showed statistically significant differences in their mean QoL scores. The effect of health education via mobile application showed a statistically significant improvement in the mean QoL score from pre- to post-intervention [ $F(1,288) = 57.46, p = <0.01$ ].

**CONCLUSION:** The use of mobile technology in health education improved QoL as compared to the traditional methods of face-to-face lecture and/or handbooks among schoolchildren with asthma. Thus, educational modules using mobile applications do improve QoL.

## Background

Asthma is a chronic inflammatory disease of the airways caused by bronchial hyperresponsiveness to a variety of stimuli which leads to the obstruction of airflow that can be reversible by self or by treatment (Fajt & Wenzel, 2017). It is one of the most chronic illnesses prevalent among adolescents in industrialized societies (Alquran et al., 2018).

The global prevalence of asthma varies from one country to another and ranges from 5% to 20% or even more (Shimwela et al., 2014). Among asthmatic patients, 3% to 10% suffer from severe asthma. Moreover, 10% to 25% of asthmatic patients in a speciality clinic have severe asthma (Kim et al., 2018). Asthma is gradually becoming a burden among children in Malaysia and it has been categorized as one of the most influencing factors affecting the quality of life of children and their parents (Fadzil & Norzila, 2002).

Poorly managed effects of asthma can affect children's quality of life. Studies show that low quality of life increases future emergency room visits relating to asthma, which indicates inadequate control of asthma (Ahmad et al., 2017). Asthma can affect the quality of life because the disease or treatment process could change the physical, psychological, and social functions (Patrick & Bergner, 1990) of not only asthmatic children but also their parents (Stelmach et al., 2012).

Education is the main key to improving patient knowledge, skill, and compliance, especially for patients with poor knowledge and compliance (Choi & Cho Chung, 2011). So, improving the knowledge of schoolchildren about asthma leads to reducing distress and severity and thus improving the quality of life; and learning from this, the nursing staff will have guidance in developing better health services to improve the quality of life of children (Yang et al., 2005).

In the recent COVID-19 pandemic, research has found that both children and adults with asthma tended to be more vulnerable to the disease, although there was no major sex disparity (Pei et al., 2020). The existing literature agrees on the wide range of impact of school closure, ranging from not beneficial to transmission declines to more significant consequences. School closure incurs high economic costs and possible damages (Viner et al., 2020). At the same time, being indoors could make children more vulnerable to indoor conditions that may worsen asthma, including secondary sensitivity to cigarette smoke and occupational allergens such as moulds, rodents, and roaches (Oreskovic et al., 2020). Despite the lack of evidence, experts strongly agree that all children and adolescents with asthma stay on their asthma treatment plan throughout the COVID-19 outbreak (Licari et al., 2020).

Smartphones are used by about 50% of adolescents aged 12–17 years old and 75% of adults aged 30–49 years old. Hence, an intervention via mobile health (mHealth) applications is a great alternative during this time, directed at assisting adolescents with chronic asthma as they shift to take on more responsibility for their asthma treatment (Fedele et al., 2018). Unfortunately, the literature on the usage of smartphone technology in patient care is lacking. Most healthcare application users focus on monitoring their

condition rather than improving their knowledge or management of the disease (Haze & Lynaugh, 2013). However, there are several studies available evaluating the effectiveness of smartphone usage in children's health education and how health education can improve their QoL, especially during the COVID-19 era (Choi & Cho Chung, 2011).

The present study is part of a research project titled Developing Children Asthma Program (CAP) that promotes health outcomes among schoolchildren in Malaysia. This study aims to assess the effect of health education via mobile application in promoting quality of life among asthmatic schoolchildren in urban Malaysia during the COVID-19 era.

## Methods

### Design

This is a quantitative study in the form of a quasi-experimental, pre-test and post-test, non-equivalent control group design. The quasi-experimental study is a research design used to evaluate interventions that do not involve randomization (Harris et al., 2006; Houser, 2016). The researcher chose this design because of the inability to manipulate or control the environment and the use of non-randomized subjects. Randomization is difficult in educational studies; and since this study took place in a group environment which included schoolchildren in classrooms, the samples could not be individually monitored by the researcher (Stone et al., 2013). This study design would also assess the differences between the pre-test results of the experimental and control groups, variations between pre-test and post-test results, and variations between the post-test results of the experimental and control groups that are compatible with the particular objectives of the current study.

As shown in Figure 1, the participants from the selected schools were randomly divided into two groups. The schoolchildren in the experimental group were from different schools than those in the control group. In this study, the control group used only traditional methods of education (face-to-face) while the experimental group received education via a mobile application. In addition, there employed 'controlled before and after', a control population with similar characteristics to the study population who were expected to undergo similar changes that occurred to the study population (Grimshaw et al., 2000). The outcome measures were assessed after 3 months, post-intervention, for both groups. We randomly chose 6 schools located in the city of Petaling Jaya in the state of Selangor, Malaysia. We then randomly assigned the schools into 2 groups, 3 schools for the experimental group and 3 schools for the control group, from which we recruited schoolchildren who met the inclusion criteria. According to Brydges (2019), the sample size required for group differences research to achieve 80% statistical power using a power analysis with  $\alpha=.05$  (two-tailed) is 107 per group; hence, a total of 214 schoolchildren were involved in this study. The inclusion criteria were students who have had an asthma diagnosis, students showing asthma symptoms in the last 12 months, students who have a smartphone, and students who speak either English or Malay. The exclusion criteria were students who have other significant comorbidities and students who refused to participate in the study.

### Research Phases

This research was conducted in four phases. The first phase was constructing the health education program about bronchial asthma, 'Asthma Care Program®' and developing the mobile application, 'MemahamiAsma®' that began with an extensive literature review. The second phase was conducting a quasi-experimental study which first used a survey to identify eligible participants according to the inclusion criteria, followed by a pre-intervention assessment. In the third phase, the control group attended face-to-face health education regarding asthma and the experimental group attended online learning for 1 hour, followed by mobile application-based learning over the next 3 months. The last phase was the follow-up three months after the health education interventions for the control and experimental groups using a self-administered questionnaire, similar to that at pre-health education intervention, to assess the schoolchildren' QoL.

### Study Instruments

#### Demographical Data

This instrument was developed by the researcher based on previous studies (Mehravar et al., 2016; Narayana et al., 2010; Quah et al., 1997; Shimwela et al., 2014; Solis Soto et al., 2014). This data consists of the schoolchildren's general information, their demographical

status, gender, age, race, and family history of asthma. This questionnaire aims to evaluate the correlation between demographic factors and QoL level among asthmatic schoolchildren.

## Quality of Life Questionnaire

The questionnaire used to measure the quality of life of the schoolchildren was adopted from the Pediatric Asthma Quality of Life Questionnaire (PAQOLQ) which was designed and validated by Juniper et al. (1996). This instrument contains 23 questions in three domains (symptoms, activity limitations, and emotional function). The schoolchildren were asked to recall their experiences during the previous week and to respond to each question on a 7-point scale.

## Health Education Intervention Tools

### Educational pamphlet 'Asthma Care Program®'

Asthma Care Program® is a children's asthma pamphlet developed by the researcher in both English and Malay based on the literature review and the evaluation by a panel of experts. This tool was designed to be colourful, entertaining, educational, and developmentally appropriate as well as diverse regarding gender, race, and culture. The content of the pamphlet includes the anatomy and physiology of the lungs and the management and prevention of asthma. This pamphlet was distributed to the control group (Figure 2).

### Mobile application 'MemahamiAsma®'

The asthma mobile application called MemahamiAsma® was developed by an android developer in cooperation with the research team in both English and Malay to support children with asthma in their daily care needs. The mobile application is an electronic alternative for the pamphlet and contains all data on asthma.

### Application design process

The design process of MemahamiAsma® is based on the goal-directed design (GDD) (Duan et al., 2020) and Health Literacy Online's six main strategies (Hou, 2012). To simplify the process of the design, modifications were made to both aforementioned methods by dividing the design process into four stages covering the two phases of development and deployment. Figure 3 depicts the design process of MemahamiAsma®.

### User manual

'Understanding Asthma' or MemahamiAsma® is a simple-to-use and straight-to-the-point android application for high school students in Malaysia. The application is developed in both English and Malay as shown in Figure 4.

On the first page, the user will see the login page. They have to enter their login ID and password. The user then has to choose their preferred language, either English or Malay. After choosing their language, the user will be greeted by a tabbed page, populated with INFO tabs (information on asthma) and FAQ tabs (frequently asked questions about asthma). The last page is the contacts page; if advanced knowledge and information regarding asthma or asthma research or any other related events or activities are needed, this page provides the user with the contacts to societies related to asthma, which are the Malaysian Thoracic Society (MTS) and the Malaysian Society of Allergy and Immunology (MSAI).

## Data Collection

Data collection was carried out for both groups separately to avoid contamination of data. The samples were randomly divided into two groups, the experimental group and the control group. The control group attended a face-to-face lecture about asthma and received Asthma Care Program®, the educational pamphlet. The experimental group first attended online learning for 1 hour, followed by mobile app-based learning over the next 3 months. The frequency and duration of use of the mobile application were flexible and according to the user's preference.

## Data Analysis

Data were analyzed using the Social Package Statistical Software (SPSS) version 22. Descriptive and inferential statistics were used to summarize the demographics of the schoolchildren and their level of QoL. Quantitative data included the calculation of mean and standard deviation. The associations between categories were determined using the Chi-squared test and the difference in mean at pre-test and post-test was analysed using the Split-plot ANOVA. The statistical significance is fixed at  $p < 0.05$ .

## Results

### Profile of the Sample

A total of 214 schoolchildren participated in this study, with 107 students in the control group and another 107 students in the experimental group. The data show that female students made up more than half of all students in both control and experimental groups with (n=55, 51.4%) and (n=63, 58.9%) respectively. Also, there were more students aged 15-16 years old than 13-14 years old in the control group (n=59, 55.1%) and the experimental group (n=62, 57.9%). Regarding ethnicity, around two-third of the students are Malay, (n=73, 68.2%) in the control group and (n=72, 67.3%) in the experimental group; Indian, (n=25, 23.4%) in the control group and (n=18, 16.8%) in the experimental group; and Chinese, (n=9, 8.2%) in the control group and (n=17, 15.9%) in the experimental group.

In addition, the results showed that the age of more than half of the students in the control group (n=60, 56%) and the experimental group (n=55, 51%) when they had first been diagnosed with asthma is between 0 – 6 years old, while around half of them from both the control and experimental groups, (n=45, 42%) and (n=48, 45%) respectively, were diagnosed with asthma in a hospital (Table 1).

### ***Relationship Between Demographic Characteristics and QoL of the Control and Experimental Groups at Pre-Intervention***

The data in Table 2 show that the quality of life level of 'No Impairment' was highest in the control group whereas 'Moderate Impairment' was highest in the experimental group. In the control group, 'No Impairment' was highest for the following factors: 15 – 16 years old (n=34, 58.6%), Malay (n=43, 58.9%), and male students (n=35, 67.2%). Meanwhile, in the experimental group, 'Moderate Impairment' was highest for the following factors: 14 – 15 years old (n=29, 48.8%), Malay (n=45, 62.5%), and female students (n=39, 61.9%).

However, there was no statistically significant difference ( $p < 0.05$ ) in the quality of life level throughout, so univariate logistic model analysis was not conducted in this situation. Thus, the demographic variables do not influence the dependent variable, QoL.

#### ***Total QoL Level and QoL Domains***

As can be seen from Table 3, data show a slight increase in the mean total quality of life score in the control group from pre-intervention ( $5.31 \pm 1.27$ ) to post-intervention ( $5.66 \pm 1.28$ ). Meanwhile, the experimental group experienced a significant increase in the mean total quality of life score from pre-intervention ( $5.01 \pm 1.36$ ) to post-intervention ( $5.85 \pm 1.29$ ). Regarding the QoL domains: in the control group, symptoms functioning had the highest score at pre-intervention ( $4.99 \pm 1.39$ ) and post-intervention ( $5.92 \pm 1.09$ ), whereas activity limitation had the lowest score at pre-intervention ( $5.19 \pm 1.33$ ) and emotional functioning at post-intervention ( $5.48 \pm 1.39$ ). Furthermore, in the experimental group, symptoms functioning had the highest score at pre- and post-intervention, ( $5.13 \pm 1.53$ ) and ( $6.09 \pm 1.26$ ) respectively, whereas emotional functioning had the lowest score at pre- and post-intervention, ( $4.9 \pm 1.27$ ) and ( $5.57 \pm 1.41$ ) respectively.

A comparison between the experimental and control groups using an independent t-test showed statistically significant differences in the mean quality of life scores between them.

### Effectiveness of Health Education via Mobile Application

This research question was answered using inferential statistics. Generalized Linear Model (GLM), Split-Plot ANOVA (SPANOVA) was used to examine the significant difference in the mean score of QoL (improvement) among the schoolchildren with asthma between the experimental and control groups.

Table 4 presents the summary of SPANOVA results that includes within-subjects effects (pre- and post-intervention score of QoL level) and between-subject effects (the experimental and control groups). The null hypothesis is rejected, and the effect of the mobile application is significantly effective in improving the QoL level of the students. The profile plot in Figure 5 indicates that the QoL level of the experimental group increased from pre-test to post-test.

## Discussion

The present study reveals that poor asthma control will affect the daily life of asthmatic schoolchildren and their adaptation to the illness in several aspects of life such as the physical, emotional, psychological, and social during the COVID-19 era. These complications of asthma may lead them to have a high risk of school absenteeism (Anwar et al., 2008). In the USA, the National Interview Survey mentioned that children with asthma have 3 times more school absentees and have more risk of learning disability compared with normal children (Cicutto et al., 2014).

During the recent COVID-19 pandemic, parents of children with asthma have voiced their worries regarding asthma management during this pandemic. They may have even improved their attention to medicine for their children (Oreskovic et al., 2020). In the UK, one research found a 76% decline in emergency visits for asthma of all severities during the COVID-19 pandemic. It is doubtful that this drop in hospital admissions can be compensated solely by parents who treat mild attacks at home, but the reasons remain unclear for what is obviously a relevant improvement. Lockdowns to avoid the spread of conventional respiratory viruses and diminished exposure to outdoor allergens may be factors. (Kenyon et al., 2020).

In this study, the emotional sub-scale contributed the most to the schoolchildren's QoL impairment in both groups, and this is consistent with previous studies which revealed that adolescents with persistent asthma had common emotional symptoms related to asthma due to increased asthma morbidity, healthcare use, and school absenteeism. On the other hand, it would mean that adolescents with high morbidity from asthma have a high risk of poorer QoL. Therefore, emotional QoL should be included in the assessment of adolescents with asthma (Cerdan et al., 2012). Another study conducted in Saudi Arabia assessed the influence of attitude on asthma severity and quality of life among asthmatic children. Their levels of quality of life also showed a higher score in the emotional domain compared to the physical (Alsamghan et al., 2016).

Furthermore, in the USA, there reported slightly poorer emotional processing in Hispanic children in comparison to the non-Hispanic White and African American children. The emotional sub-scale explored how often children feel upset, anxious, worried, or distressed because of their asthma and how often they are frightened by an asthma attack (Horner et al., 2012). Poor asthma control among children is a manifested public health problem. It causes respiratory health problems, limits physical activity, and leads to missed school days and also parental work absenteeism (Gerald et al., 2012). Different studies found that physical functioning and vitality are the typical measurements most impaired by asthma, and the explanation for this contradicts our study conducted among schoolchildren with mild asthma, as these other studies were performed among those with moderate to extreme illness, where the study population had weak physical functioning (Sararaks et al., 2001).

On the other hand, the present study reveals the effect of a mobile application in promoting quality of life among asthmatic schoolchildren, the result of this study is similar to the previous systemic review which aimed to assess the effect of a mobile application to support adult patients with asthma; the result demonstrated that both patients with asthma and healthcare providers had improved quality of life (Hui et al., 2017). Another study in the USA that assessed a mobile technology-based educational program on schoolchildren to improve asthma self-management and outcomes found that parents of the schoolchildren demonstrated significant improvements in their asthma caregiver-related quality of life (Warren et al., 2016).

It is therefore concluded that the use of mobile technology in health education has a good impact in improving the QoL of schoolchildren with asthma as compared to other traditional methods like face-to-face lecture or handbooks. This finding agrees with those of other research which revealed that the mobile health (mHealth) initiatives have an impact on improving chronic disease conditions (Everhart et al., 2017). In another systemic review conducted by Majeed-Ariss et al. (2015), it was explained that mobile applications have good benefits to adolescents since mobile technologies and featuring software applications are now widely used by this age group either for social networking or for gaming purposes. Hence, mobile applications could be used for healthcare educational purposes or as healthcare support.

As recommended, there is a need to assess efficacy and cost-effectiveness for using information technology to improve asthma treatment and knowledge, which must be reinforced by randomized trials (Mosnaim et al., 2012). The outcomes of such studies are

urgently needed. The simplicity with which these strategies integrate into our everyday lives and the meaning of continuous chronic care indicates that these imaginative and innovative approaches may be a beneficial addition to successful clinical practice.

## Conclusion

In this quasi-experimental research, there concluded the finding – the use of mobile technology in health education improves QoL levels of schoolchildren with asthma, compared with other traditional methods like face-to-face lecture or handbooks, especially during the COVID-19 era.

## Limitations And Recommendations

The first limitation identified in this study is its quasi-experimental design. Due to the absence of randomization, there is likely the presence of selection bias. There realized that self-reported questionnaires could lead to introducing bias to the results of the study, as it might not describe the true condition of the participants; they might rate higher or lower than the true condition. Other limitations include the probability of some participants failing to install the application, of which the reason is undetermined (might have occurred during registration). Also, we do not know if any of the schoolchildren in the control group had somehow accessed or downloaded the application. Similarly, we did not account for the use of other asthma mobile health software by the participants.

In this study, data on the patients' perception of illness, self-motivation, and approaches to self-management were not collected. Therefore, it is recommended for future research to investigate further regarding symptoms experienced by patients by gathering information on their illness perceptions, self-motivation, self-efficacy, and self-management strategies. Data retrieved can be integrated into psycho-educational programs to promote behaviour change, hence improving the patients' self-management skills.

## Practical Value

With sufficient basic knowledge regarding asthma, especially on adhering to proper medication, the QoL of asthmatic schoolchildren would eventually improve. Thus, it is important for school nurses to identify and implement different strategies regarding asthma medication/treatment.

Health education via mobile applications is considered a great innovation in asthmatic students' education, or as a supplement to conventional learning methods. It is necessary to place health education via mobile applications as a prominent learning strategy for asthmatic students, with careful planning considering all aspects such as the age of the students, lecturers, learning facilitators, and technological use to achieve learning outcomes, which are to decrease symptoms and prevent complications. Therefore, health education via mobile applications is suggested as an effective learning strategy in promoting knowledge and QoL of asthmatic students within their existing education in schools throughout Malaysia.

## Declarations

### ETHICAL APPROVAL

Permission was granted by the Ministry of Education, the Ministry of Health, and the respective schools and principals. This study was registered under the Medical Research Committee, University Malaya Medical Centre, MRECID. NO: 2016112-4501. Also, this study is registered with the Australian New Zealand Clinical Trials Registry (ANZCTR) under Trial ID: ACTRN12614300582550.

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### CONFLICTS OF INTEREST/COMPETING INTERESTS:

The authors declare that they have no conflicts of interest.

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## Tables

Table 1: Baseline socio-demographic characteristics (N=290)

Variables	Control Group	Experimental Group	$\chi^2$	P
n (%)	n (%)			
Gender			.086	.769
Male	52 (48.6)	44 (41.1)		
Female	55 (51.4)	63 (58.9)		
Age			1.476	.478
13-14	48 (44.9)	45 (42.1)		
15-16	59 (55.1)	62 (57.9)		
Ethnic			6.682	.083
Malay	73 (68.2)	72 (67.3)		
Indian	25 (23.4)	18 (16.8)		
Chinese	9 (8.2)	17 (15.9)		
Age at asthma diagnosis			5.454	0.708
0 - 6 years old	60 (56)	55 (51)		
6 - 13 years old	47 (44)	52 (49)		
Where was your asthma first diagnosed?			264.981	<0.001
Hospital	45 (42)	48 (45)		
Clinic	36 (33)	48 (45)		
Non-specific	27 (25)	11 (10)		
Total	107 (100)	107 (100)		

Table 2: Relationship between demographics characteristics and QoL levels at pre-intervention (n=107)

Factors	Control Group				Chi-square $\chi^2$ <i>P</i>	Experimental Group				Chi-square $\chi^2$ <i>P</i>
	N=107	QoL level n (%)				N=107	QoL level n (%)			
		No impairment	Moderate impairment	Severe impairment			No impairment	Moderate impairment	Severe impairment	
<b>Gender</b>										.179
Male	52	35 (67.3)	16 (30.8)	1 (1.9)	.177	44	18 (40.9)	26 (59.1)	0 (0.0)	
Female	55	30 (54.5)	23 (41.9)	2 (3.6)		63	20 (31.7)	39 (61.9)	4 (6.3)	
<b>Age</b>										.597
13-14	48	31(64.6)	15 (31.3)	2 (4.2)	.376	45	18 (40.0)	26 (57.8)	1 (2.2)	
15-16	59	34 (58.6)	24 (39.7)	1 (1.7)		62	20 (32.3)	39 (62.9)	3 (4.8)	
<b>Ethnic</b>										.717
Malay	73	43 (58.9)	27 (37)	3 (4.1)	.685	72	23 (31.9)	46 (63.9)	3 (4.2)	
Indian	25	17 (68)	8 (32)	0 (0.0)		18	8 (44.4)	10 (55.6)	0 (0.0)	
Chinese	9	5 (55.6)	4 (44.4)	0 (0.0)		17	7 (41.2)	9 (52.9)	1 (5.9)	

\*Significance level at p<0.05

Table 3: Descriptive statistics of QoL domains of experimental and control groups (n=214)

Domains	Control Group (N=107)				Experimental Group (N=107)				Between groups (Exp. vs. Con.) <i>P</i>
	The mean total of QoL M±SD		Diff. (Post-Pre)	Within-group Paired t-test, <i>P</i>	The mean total of QoL M±SD		Diff. (Post-Pre)	Within-group Paired t-test, <i>P</i>	
	Pre-health education	Post-health education			M±SD	Pre-health education			
<b>Overall mean</b>	5.31 (1.27)	5.66 (1.28)	0.35 (1.25)	<0.001	5.01 (1.36)	5.85 (1.29)	0.84 (1.41)	<0.001	<0.001
<b>Activity limitation</b>	5.19 (1.33)	5.57 (1.43)	0.39 (1.25)	0.03	5.03 (1.56)	5.81 (1.48)	0.78 (1.67)	<0.001	<0.001
<b>Emotional function</b>	4.99 (1.39)	5.48 (1.39)	0.49 (1.60)	<0.001	4.9 (1.27)	5.57 (1.41)	0.67 (1.51)	<0.001	<0.001
<b>Symptoms</b>	5.44 (1.37)	5.92 (1.09)	0.49 (1.36)	<0.001	5.13 (1.53)	6.09 (1.26)	0.97 (1.51)	<0.001	<0.001

Note:

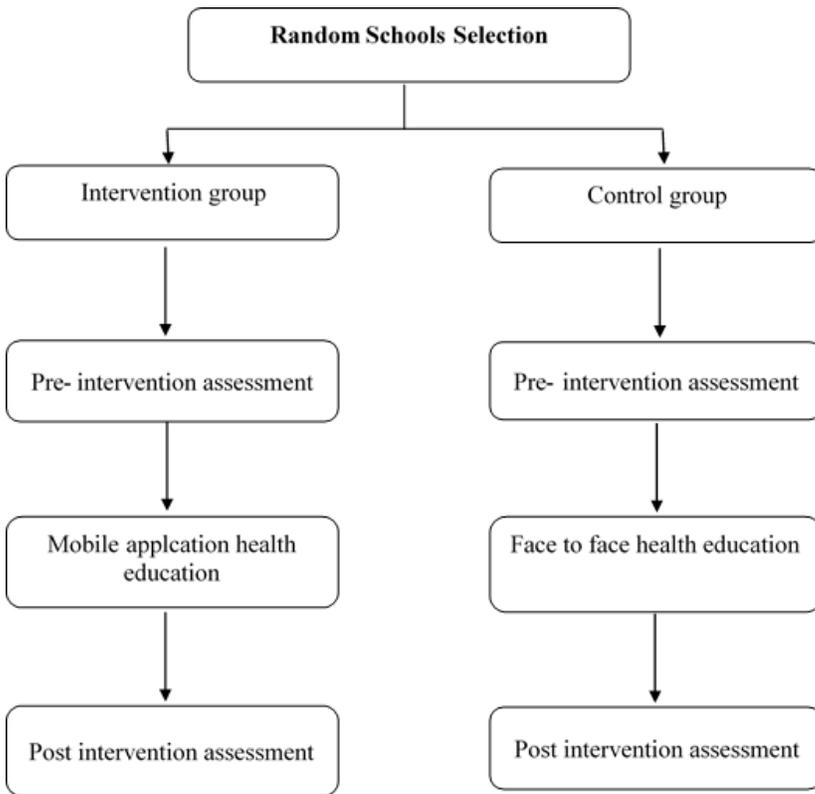
Within-group - pre and post comparison within experimental and control groups

Between-group - comparison between experimental and control groups

Table 4: SPANOVA results for effectiveness of health education via mobile app

	Sum of Squares	df	Mean Square	F	p
Within-subjects					
Test	51.27	1	51.27	57.46	<0.01
Test* Group	8.69	1	8.69	9.74	<0.01
Error (Test)	257.01	288	257.01		
Between-subjects					
Group	.446	1	.446	.178	.673
Error	720.797	288	2.503		

## Figures



**Figure 1**

Research Design.

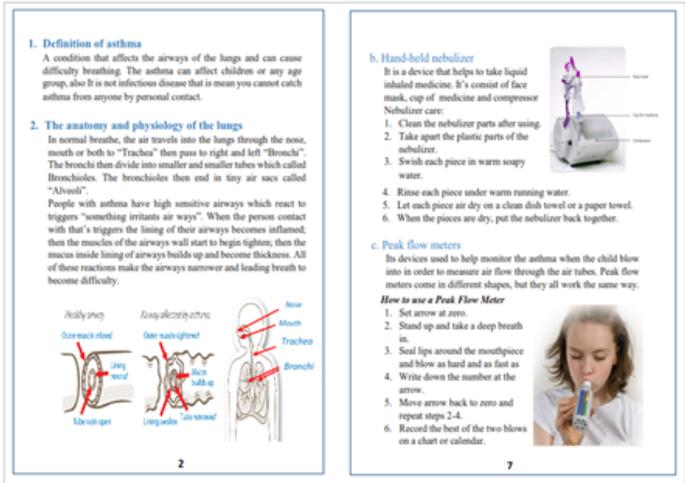
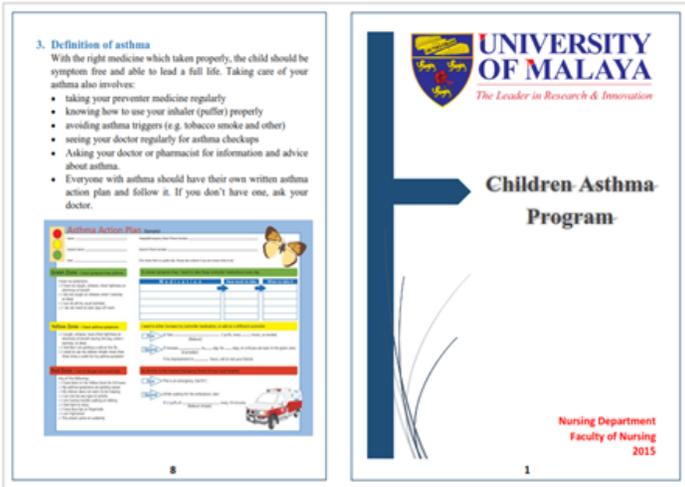


Figure 2

Children's asthma pamphlet developed by the research team

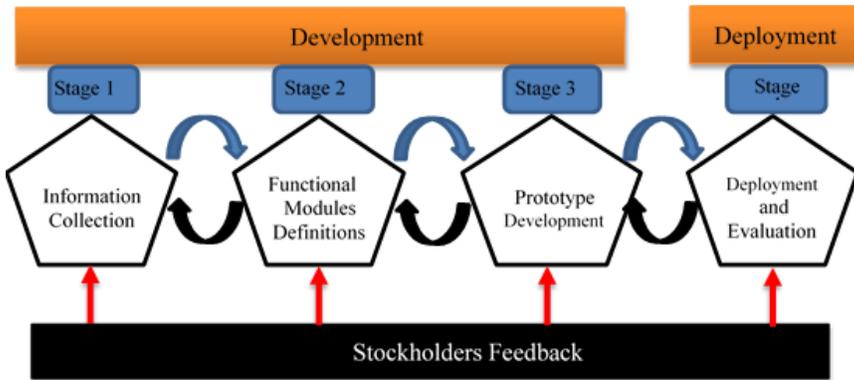


Figure 3

Design process of asthma mobile app, MemahamiAsma@



Figure 4

Screenshots of asthma mobile app, MemahamiAsma@

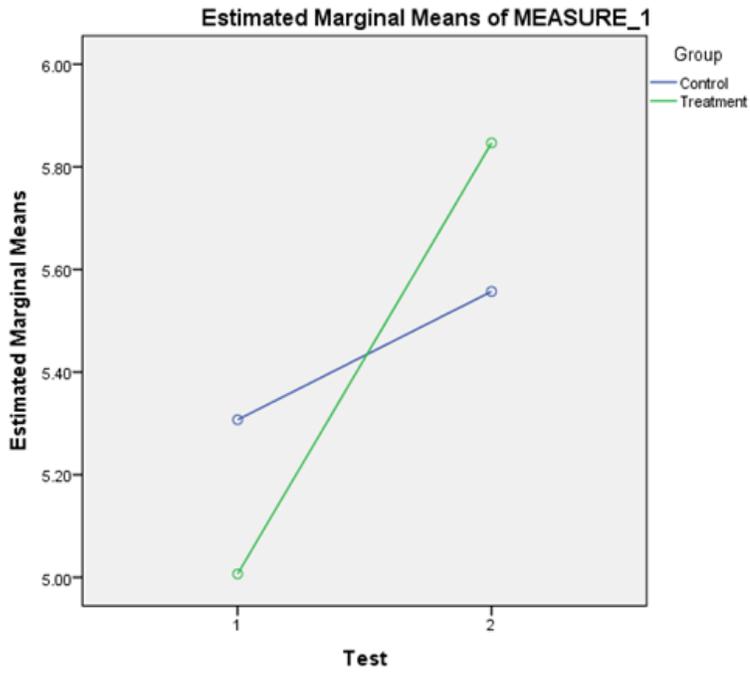


Figure 5

SPANOVA graph plot of control and experimental groups at pre-intervention and post-intervention