Smartphone education improves embarrassment, bowel preparation, and satisfaction with care in patients receiving colonoscopy

A randomized controlled trial

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Abstract

Background: Colonoscopy is considered a safe and effective tool for detecting colorectal cancer. Nevertheless, the proportion of patients are hesitating to receive colonoscopy. Smartphone education may decrease the barrier of colonoscopy. The aim of this study is to examine the effectiveness of smartphone education in colonoscopy.

Methods: We conducted a prospective, double-blinded, randomized, controlled study to examine the effectiveness of smartphone education on embarrassment, bowel preparation, and satisfaction in colonoscopy. The patients’ embarrassment was measured by the colonoscopy embarrassment scale. The quality of the bowel preparation was evaluated by gastroenterologists according to the Aronchik Scale. The satisfaction of colonoscopy care was assessed by a satisfaction scale developed by the authors.

Results: A total of 150 patients were analyzed in the smartphone education and control groups (n=75 in each group). The smartphone education group reported fewer embarrassment (β=−2.78, P<.02) than those of the control group, the patients who were older (β=−1.15, P<.001) and who were male (β=2.91, P<.003) showed higher embarrassment. Additionally, smartphone education group were likely to have better colon preparation (odds ratio=2.46, 95% confidence interval: 1.20–5.02) than that of the control group. Smartphone education also improved the satisfaction with care (β=4.60, P<.001), and above normal body mass index decreased the satisfaction with care (β=−0.19, P<.05).

Conclusion: Smartphone education improves embarrassment, bowel preparation, and satisfaction with care in patients receiving colonoscopy.

Abbreviations: B = coefficient estimated by GEE, BMI = body mass index, CI = confidence interval, CRC = colorectal cancer, GEE = generalized estimating equation, OR = odds ratio, SD = standard deviation, SE = standard error.

Keywords: bowel preparation, colonoscopy, embarrassment, satisfaction, smartphone education

Introduction

Colorectal cancer (CRC) is one of the most common cancers worldwide (incidence rate is 6.1% per 100,000 people).[1] In Taiwan, CRC has the second-highest incidence rate (36.43% per 100,000 people) and is the third leading cause of cancer death (24.7% per 100,000 people).[2] Compared with other cancers, patients with CRC have a better survival rate and prognosis in the early stage. For example, the 5-year survival rate of CRC in the early stage was over 90%, but it dramatically decreased in the advanced stage (approximately 10%).[3] This phenomenon indicates the importance of screening and early diagnosis of CRC.

Colonoscopy is an invasive and voluntary medical examination, but it is considered a safe and effective tool for detecting CRC and precancerous lesions that are not easily detected by other non-invasive tests. For example, the 5-year survival rate of CRC in the early stage was over 90%, but it dramatically decreased in the advanced stage (approximately 10%).[4] This phenomenon indicates the importance of screening and early diagnosis of CRC.

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The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Keywords: bowel preparation, colonoscopy, embarrassment, satisfaction, smartphone education

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fecal occult blood test. Moreover, gastroenterologists also conduct polypectomy to remove benign neoplastic lesions during the colonoscopy procedure, thereby decreasing the chance of deterioration in small adenomas. Colonscopy has well-established benefits, but many people continue to avoid colonoscopy.

Although the survival rate of CRC is approximately 90% with early detection, the proportion of patients who partake in CRC screenings remains low. Previous studies have noted that people are embarrassed to receive a colonoscopy. Additionally, the most important barrier is the individuals’ negative perception of CRC screening, such as embarrassment. Moreover, embarrassment are positively associated with an unwillingness to participate in CRC screening, which has negative implications for both early diagnosis and treatment. However, few studies have examined the association between embarrassment and CRC screening from the perspective of multimedia education intervention.

Apart from embarrassment, bowel preparation is also a key factor for the success of a colonoscopy for CRC screening. However, Paillai et al notes that 17% to 27% of patients have inadequate bowel preparation when they undergo colonoscopy. Similar results from an international population also found that 38% to 72% of incomplete colonoscopies were caused mainly by inadequate bowel preparation. Inadequate bowel preparation is linked to colonoscopy failures, results in poor outcomes and wastes clinical resources. For instance, patients with inadequate bowel preparation have a significantly higher postoperative polyp missed rate than those with optimal bowel preparation.

However, a few studies have performed innovative instructions for patients to enhance the understanding for better bowel preparation. For example, graphics and audio are better instruments for patients to understand colonoscopy preparation and procedures instead of usual instruction. Park et al further demonstrate that patients with video instruction exhibit good bowel preparation for colonoscopy compared with non-video instruction. Although these studies demonstrate the benefits of multimedia education, most studies have focused on comparing the effectiveness of various tools rather than improving patients’ knowledge and understanding of colonoscopy preparation.

Moreover, the satisfaction with care of patients receiving a colonoscopy is also a crucial issue. The process of colonoscopy is painful and uncomfortable for patients. To our knowledge, very little research has focused on this issue among multimedia education. Bytzer & Lindeberg indicates that there is no significant difference between video instruction group and control group; all the patients showed less satisfaction with the procedure. In contrast, the results of Back et al reveal that patients with audio-visuals have significantly higher satisfaction scores than the scores of the control group. With these limited literature, the effect of multimedia education on colonoscopy has shown inconsistent results.

In summary, the use of multimedia education by smartphones in CRC screening as a research field has not yet been extensively explored. The aims of this study are to examine the effectiveness of smartphone education on bowel preparation, embarrassment, and satisfaction with care among patients receiving a colonoscopy, and we also aim to identify the patients’ characteristics affecting bowel preparation, embarrassment, and satisfaction with care.

2. Methods

2.1. Study design and participants

We conducted a prospective, double-blind, randomized controlled trial with convenience sampling in 1 major medical center in central Taiwan from February 2019 to June 2019. Clinical professionals recruited patients who received a colonoscopy in the medical center to provide detailed information of this study, including the purpose, procedures and the rights of the participants. Eligible patients willing to participate in this study were recruited. Figure 1 shows the schematic flow of this study (Fig. 1). Moreover, there were no participants who were aborted due to inadequate preparation in the current study.

Patients who were older than 20 years of age, who had clear consciousness, who were literate, who were able to communicate with the research staff, who received no general anesthetics and who had smartphones were eligible to participate in this study. However, exclusion criteria included

1. history of mental illness,
2. received general anesthetics, and
3. patients did not have smartphones.

Eligible patients were given a detailed written information document that included the purpose and procedures of this study. After the consent form was signed and obtained from eligible patients, the patients received a random assignment.

The minimum required sample size of this study estimated with G*Power Version 3 was 136 with the following conditions: the alpha level = 0.05, power = 0.80, and the effect size = 0.15. Considering a 10% rate of loss to follow-up during this study, a total of 150 eligible patients were recruited in the baseline assessment. After the intervention, ten patients were excluded from this study. There were 140 patients who completed the final assessment (70 in each group) and it fulfilled the minimum required sample size.

2.2. Randomization and allocation

The random assignment was conducted by a randomized number generator with a computer and an allocation ratio of 1:1 (75 in each group). Patients were randomized to either the smartphone education group or the control group according to a randomized number at the outpatient visit. Patients with an even number were assigned to the smartphone education group, and patients with an odd number were assigned to the control group. The randomized allocation was performed by a research assistant who was not involved in this study. The clinical professionals, principal investigators of this study, and data analyses were blinded.

2.3. Interventions

After the randomized allocation, all patients received traditional education including a teaching pamphlet and verbal instructions before examination. The pamphlet contained information on the purpose of examination, indication of bowel preparations and laxative use, explanation of how to wear the examination pants, examination process, and post care. Traditional education took about 20 minutes per patient. The smartphone education group received interactive information about CRC, the possible situation of embarrassment, bowel preparation, and colonoscopy procedures. Smartphone education took about 12 minutes. The
smartphone education program was designed by the professional research team, including surgeons, physicians, healthcare professionals, health educators, and multimedia communication professionals of the Center of Augmented Intelligence in Healthcare of China Medical University Hospital. The smartphone education program was pilot tested with 30 cases and the content was modified accordingly. The content of smartphone education program was also reviewed and approved by the Medical Administrative Office. The smartphone education group was instructed to scan a QR code to access into the educational program. Patients were encouraged to review the content as many times as they needed.

2.4. Procedures

All patients completed the baseline survey questionnaire, including the demographic, clinical characteristics, and embarrassment scale, on the outpatient clinic while scheduling an appointment for colonoscopy. The final assessment was conducted on the day of the colonoscopy (time 2), which was approximately 1 to 2 weeks after the baseline. At time 2, all patients completed the final assessment, including the embarrassment scale and satisfaction scale. The status of bowel preparation was assessed by the gastroenterologist with the Aronchik scale. All procedures performed in this study involving human participants were approved by the Institutional Review Board of China Medical University Hospital (No: CMUH108-REC1-008; Date of approval: January 19, 2019).

2.5. Demographic and clinical characteristics

Patients’ demographic characteristics were obtained from the survey questionnaire, including age, gender, education level, and body mass index (BMI). BMI was classified as normal weight (18.5%–23.9%) and above normal weight (≥24%). In addition, we also collected patients’ clinical characteristics, including bowel movement, stool softener use, laxative use, chronic disease, abdominal surgery history, and colorectal cancer family history.

2.6. Assessment of embarrassment

The patients’ embarrassment was measured by the colonoscopy embarrassment scale, which was developed by Kimberly and Mitchell (2012); this instrument can be used to measure the level
of colonoscopy-related embarrassment\(^{(23)}\) with well reliability (Cronbach \(\alpha=0.96\)) and validity.\(^{(24)}\) This scale could provide further information about the sources of embarrassment. For example, the response of “I would be embarrassed to have a colonoscopy when the endoscopist of opposite gender” could help identify the specific factors that contribute to colonoscopy-related embarrassment. It is a 15-item instrument that uses a 4-point Likert-like rating scale. The total scores represent the level of embarrassment, and higher scores indicate a higher level of embarrassment. The Cronbach \(\alpha\) of this study was 0.95.

2.7. Bowel preparation

Patient bowel preparation was evaluated by the Aronchik Scale, which is a commonly used validated bowel preparation quality scale in research, and it also performed well and satisfied reliability and validity.\(^{(11,25)}\) This scale assessed the effectiveness of bowel preparation by gastroenterologists at 5 levels, including excellent, good, fair, poor, and inadequate. According to the guidelines of colonoscopy quality,\(^{(12)}\) patients with excellent or good bowel preparation were classified as good bowel preparation, and those with fair, poor or inadequate bowel preparation were classified as poor bowel preparation.

2.8. Satisfaction with care in colonoscopy

Patients’ satisfaction with care was assessed by the satisfaction scale developed by the authors. This scale consists of ten items based on previous literature related to colonoscopy (eg, “Are you satisfied with your care during the colonoscopy procedure?”). The 10-item scale measures variables that reflect the subject’s perception of satisfaction with care during a colonoscopy including both the period of examination and the interaction between patients and medical professionals such as “The medical professionals could notice the patients’ restlessness and provide support during the colonoscopy.” It uses a 5-point Likert-like rating, including strongly dissatisfied (1), dissatisfied (2), neither satisfied nor dissatisfied (3), satisfied (4), and strongly satisfied (5). The responses are summed, and higher scores represent better satisfaction with care in colonoscopy. The content validity of this scale was evaluated by 1 gastroenterologist, 1 senior technical staff, and 1 expert of health education in nursing, and it demonstrated satisfactory content validity. Both the Kaiser–Meyer–Olkin measure of sampling adequacy (\(=.92\)) and Bartlett test of sphericity (\(\chi^2=2413.47, P<.001\)) indicated that our data could perform factor analysis. The results of the factor analysis showed that all items were meaningful indicators of satisfaction with care in colonoscopy, and factor loadings ranged from 0.76 to 0.96. This scale explained 85.36% of the variation in satisfaction with care in colonoscopy. The Cronbach \(\alpha\) of this scale was 0.98.

2.9. Statistical analysis

The distribution of demographic and clinical characteristics was demonstrated by the percentage, mean, and standard deviation among patients. The differences between 2 groups were analyzed using Student t test for continuous variables and \(\chi^2\) test (or Fisher exact test, as appropriate) for categorical variables. Mann–Whitney U test was conducted to examine the difference between 2 groups for median scores. The correlation between dichotomous variables and continuous variables was examined with point bi-serial correlation. All demographic and clinical variables were included in the multivariable analysis. The embarrassment score at 2-time points was to aggregate changes in embarrassment scores for outcome in the generalized estimating equation (GEE) models. The GEE models with robust standard error were used to examine the association between demographic and clinical characteristics and the dynamic changes in patients’ embarrassment. The satisfaction of care was a continuous variable, hence, the factors affecting the satisfaction of care in colonoscopy were explored with multiple regressions with stepwise selection. Multiple logistic regressions with backward selection were generated to identify the potential risk factors of bowel preparation because the bowel preparation was a dichotomous variable. All P-values are 2-tailed with a significance level <.05. Statistical analysis was conducted using SPSS Statistics Version 22.0 (IBM, Armonk, NY) software.

3. Results

3.1. Background demographic characteristics

In this study, 70 patients were in the smartphone education group, and 70 patients were in the control group. The mean age of all subjects was 47.38 years (standard deviation = 12.95), and the majority of participants were male (n = 89, 63.6%), had an above normal BMI (n = 77, 55%), were employed (n = 93, 66.4%), and had an education level under high school (n = 76, 54.3%). Ninety-eight participants had a bowel movement at least once a day (70%), and 122 (87.1%) had used stool softeners. One hundred 7 participants had used laxatives (90.7%), and most of the subjects did not have a chronic disease (n = 101, 72.1%), a history of abdominal surgery (n = 102, 72.9%), and a family history of colorectal cancer (n = 112, 80%). We found no differences in characteristics between the smartphone group and the control group (Table 1).

Patients who received a smartphone education program had higher satisfaction scores for care (Mean: 48.7 vs 43.42, P < .001; Median: 50.00 vs 45.50, P < .001) and percentage of good colon preparation (72.90 vs 51.40, P < .001) in colonoscopy than those control group. There was no significant difference between the 2 groups in embarrassment before colonoscopy (40.47 vs 38.69, P > .05). Compared with control group, the smartphone education group reported fewer embarrassments after colonoscopy (31.76 vs 33.77, P < .05). However, there was no significant difference in the median score of embarrassments between 2 groups at both pretest (40.00 vs 37.00, P = .135) and posttest (31.00 vs 32.50, P = .159) (Table 1).

3.2. Predictors of embarrassment in the GEE model

Table 3 shows that the main effects of patients’ embarrassment scores were improved after colonoscopy (B = −14.07, P < .001). There was no statistical difference in embarrassment scores at baseline between 2 groups (B = −4.05, P = .964). Nevertheless, subjects who were older (B = −0.25, P < .001) and who were male (B = −5.62, P < .001) showed lower embarrassment scores. However, the results of the interaction analysis indicated that subjects who received the smartphone education program (B = −2.78, P = .02) reported fewer embarrassment scores than those of the control group. Yet, subjects who were older (B = 0.15, P = .001) and who were male (B = 2.91, P = .003) showed higher embarrassment scores.
3.3. Predictors of bowel preparation in the multivariable logistic regression

The results of correlation analysis indicated that only the smartphone education ($\chi^2 = 6.83, P = .009$) was associated with bowel preparation (Table 2). However, there were similar results in the multivariable logistic regression with backward selection when all variables were included in the model. Smartphone education was the only significant factor affecting colon preparation. People who received the smartphone education were likely to have better colon preparation (odds ratio = 2.46, 95% confidence interval: 1.20–5.02) than that of the control group. This model would explain 9.7% of the variation for colon preparation ($R^2 = 0.097, P < .05$) (Table 4).

3.4. Predictors of satisfaction of colonoscopy care in the multivariable regression

The results of correlation analysis indicated that only the smartphone education ($r = 0.48, P < .001$) and BMI ($r = -0.22, P = .009$) were associated with the satisfaction of colonoscopy care (Table 2). However, there were similar results in the multivariable regression with stepwise selection when all variables were included in the model. People who were above...
Table 2

|                         | Embarrassment | Satisfaction | Bowel preparation |
|-------------------------|---------------|--------------|-------------------|
|                         | r             | P-value      | r                | P-value       | χ²/t | P-value |
| Group                   |               |              |                  |               |      |         |
| Gender                  | 0.10          | .24          | 0.48             | <.001         |       | 6.83    | .009   |
| Education               | −0.40†        | <.001        | −0.10            | .26           | 1.28   | .26     |
| BMI                     | 0.18‡         | .04          | −0.22            | .009          | 1.82   | .18     |
| Job                     | 0.37‡         | <.001        | 0.01             | .92           | 0.66   | .42     |
| Bowel movement          | 0.15          | .09          | −0.15            | .07           | 4.49   | .21     |
| Stool softeners use     | −0.13         | .13          | −0.07            | .42           | 2.42   | .30     |
| Laxative use            | 0.07          | 0.43         | −0.04            | 0.64          | 0.46   | .80     |
| Chronic disease         | −0.35‡        | <.01         | 0.004            | 0.96          | 4.14   | .05     |
| Abdominal surgery history| −0.03         | .77          | −0.01            | 0.91          | 0.06   | .85     |
| Colorectal cancer family history | −0.04 | .64 | 0.06 | 0.48 | 1.09 | .38 |
| Age                     | −0.57†        | <.001        | 0.06             | 0.48          | −0.12  | .16     |

1 P<.05.  
2 P<.01.  
3 P<.001.  
4 The scores of embarrassment were pre-test.

normal weight reported lower satisfaction of colonoscopy care than those who were normal weight (β=-0.19, P<.05). People who received the smartphone education program showed better satisfaction with colonoscopy care (β=4.60, P<.001). The final model explained 25% of the variation in satisfaction of colonoscopy care (Adj-R²=0.23, P<.05) (Table 5).

4. Discussion

In this study, smartphone education significantly improved the level of embarrassment, bowel preparation, and satisfaction with colonoscopy care. In addition, the older age and male increased the change rates of embarrassment, and higher BMI decreased the satisfaction with care in a colonoscopy.

The current study showed that the smartphone education group had a significant average reduction of 2.78 points in embarrassment (P<.05). This result might be explained by the effectiveness of smartphone education. Patients could feel humiliated, shy or embarrassed when naked or being examined,[16,20] and the exposure of intimate parts would be inevitable in colonoscopy. Visual information, such as videos and graphics, would improve the understanding of colonoscopy among patients.[16,20] Patients understand that body exposure is a medical behavior conducted by professionals instead of a negative feeling. In other words, smartphone education provides patients with attractive visual knowledge and medical reassurance to eliminate negative feelings. Moreover, patients can review smartphone education anytime by using a smartphone to boost

Table 3

Predictors of patients’ embarrassment as estimated by generalized estimating equations (GEE).

|                         | B              | SE  | 95% CI       | Wald χ² | P-value |
|-------------------------|----------------|-----|--------------|---------|---------|
| Intercept               | 53.33          | 3.86| 45.74        | 60.93   | 189.39  |
| Time (ref: baseline)    | −14.07         | 2.47| −18.91       | −9.19   | 32.45   |
| Intervention (ref: control) | −0.05       | 1.19| −2.39        | 2.26    | 0.12    |
| Age                     | −25            | 0.07| −0.39        | −0.12   | 13.26   |
| Gender (ref: female)    | −5.62          | 1.52| −8.59        | −2.65   | 13.71   |
| Education (ref: Under Senior high school) | −4.0          | 1.17| −2.69        | 1.88    | 0.12    |
| BMI (ref: normal)       | 1.96           | 1.20| −0.39        | 4.32    | 2.67    |
| Job status (ref: no)    | 2.79           | 1.51| −0.16        | 5.74    | 3.43    |
| Bowel movement (ref: At least 1) | 0.81    | 1.45| −2.03        | 3.65    | 0.31    |
| Stool softeners use (ref: no) | −1.28    | 1.59| −4.40        | 1.83    | 0.65    |
| Laxative use (ref: no)  | −1.64          | 2.01| −5.57        | 2.29    | 0.67    |
| Chronic disease (ref: no) | −2.98      | 1.57| −6.06        | 0.10    | 3.59    |
| Abdominal surgery history (ref: no) | .003     | 1.29| −2.52        | 2.53    | <.001   |
| Colorectal cancer family history (ref: no) | .06  | 1.29| −2.47        | 2.59    | 0.002   |
| Interaction†            |                |     |              |         |         |
| Time 2 × Intervention (ref: control) | −2.78     | .93 | −4.62        | −0.95   | 8.88    |
| Time 2 × Age            | .15            | .04 | 0.06         | 0.23    | 10.81   |
| Time 2 × Gender (ref: female) | 2.91      | 1.22| 0.51         | 5.31    | 5.67    |

B = coefficient estimated by GEE; CI = confidence interval; SE = standard error.

† P<.05.  
‡ P<.01.  
§ P<.001.

The interaction term was only present the significant difference.
their confidence for colonoscopy. Hence, patients perceive less embarrassment.

In addition, we found that older patients reported more embarrassment. This might be because older people thought that colonoscopy was uncomfortable and unpleasant in the traditional culture of Taiwan. For example, they may refuse to receive a colonoscopy because they consider the procedure as “exposure” and to be “dirty.” Furthermore, it is possible that it was difficult for older people to read the printed instructions of colonoscopy. In other words, older patients did not understand the context of the patients’ instruction adequately, including the process of colonoscopy regarding “exposure” and bowel preparation, leading to embarrassment. Mayer et al indicated that animation can create an engaging experience that is constructive and potentially demystifies textual descriptions. Therefore, older patients understand the exposure area by visual information easily, and bowel preparation is understood as a medical preparation technique instead of dirty behavior to reduce embarrassment. Additionally, we found that male patients reported more embarrassment than that of females, which was consistent with a previous study. Generally, females would have more embarrassment than that of males in colonoscopy. A possible explanation is that the clinical professionals in Taiwan were mostly female during examination. People would feel more embarrassment when their intimate parts are exposed to a different gender. The results, however, suggest that smartphone education will improve knowledge and establish the correct perception of colonoscopy to reduce embarrassment. Alternatively, clinical professionals could also recommend endoscopic sedation to patients avoiding contact with clinical professionals with different genders. In summary, our studies showed that smartphone education is similarly valuable to patients preparing for colonoscopy, and it might play a critical role in preoperative preparation to decrease psychological burden, especially embarrassment.

In terms of bowel preparation, even though the adequate bowel preparation rate in both the smartphone education group and control group were lower than the criteria of the Taiwanese guidelines (80%), our study found that the smartphone education group had higher rates of good bowel preparation than those of the control group (72.9% vs 51.4%; \( P < .01 \)). Moreover, patients who received smartphone education were more likely to have better bowel preparation than that of patients who received traditional education (odds ratio = 2.46, 95% confidence interval: 1.20–5.02). These results were in accordance with previous studies. The difference in adequate bowel preparation rates between the 2 groups might be due to the effects of smartphone education. Multimedia would help people obtain an accurate representation of complex concepts efficiently by substituting long textual descriptions with images and motions. Smartphone education facilitates comprehension by using a combination of pertinent information of patients’ concerns with simple images and sound. The previous study also showed that colonoscopy instructions could be effectively delivered through a video by the multimedia education method via smartphone. The strength of our study is that we used a QR code to provide colonoscopy instructions instead of watching an education video in hospitals, entering website addresses or installing Apps. Moreover, given the relative prevalence rate of smartphones (77.3%) in Taiwan, the use of multimedia may be easier and convenient. As a consequence, patients would review the colonoscopy instructions without limitations of place and time; hence, they had substantial comprehension to perform reliable bowel preparations which could significantly reduce the costs of colonoscopy in clinical practice. Because there was no subsidization for conscious sedation by the national health insurance system, most patients receive the unconscious sedation during colonoscopy in Taiwan. Therefore, smartphone education could be implied to maximize the benefits of better bowel preparation to reduce the burden of clinical resources and cost in colonoscopy.

Additionally, we also found that the smartphone education group reported higher satisfaction with colonoscopy care than that of the control group. This result was in line with the previous study. This might be because smartphone education provides simple information to patients instead of complicated printed instructions. Written instructions might not help people understand the patients’ instructions for colonoscopy. The more clearly they understand the information about the examination, the less anxiety-related concern during bowel preparation and difficulties with the procedure they have. Hence, patients reported higher satisfaction scores in the colonoscopy care.

Besides, we found that patients with an above-normal BMI had

### Table 4

**Multiple logistic regressions for bowel preparation.**

|                | B    | SE   | Exp (B) | 95% CI          |
|----------------|------|------|---------|-----------------|
| Constant       | −0.29| 0.27 | 0.75    |                 |
| Intervention (ref: control) | 0.90 | 0.36 | 2.46\(\ast\) | 1.20–5.02 |

\(\ast P < .05.\)

### Table 5

**Multiple regressions for satisfaction of colonoscopy.**

|                | B       | 95% CI          | \(\beta\) | t    | Adj-\(R^2\) |
|----------------|---------|-----------------|----------|------|-------------|
| **Model 1**    |         |                 |          |      |             |
| Constant       | 43.43   | 42.27–44.59     |          | 73.99\(\ast\) | 0.22 |
| Intervention (ref: control) | 5.27 | 3.63–6.91 | 0.48 | 6.35\(\ast\) | |
| **Model 2**    |         |                 |          |      |             |
| Constant       | 44.65   | 43.17–46.13     |          | 59.54\(\ast\) | 0.25 |
| Intervention (ref: control) | 5.12 | 3.51–6.74 | 0.46 | 6.28\(\ast\) | |
| BMI (ref: normal) | −2.08 | −3.70 to −0.46 | −0.19 | −2.54\(\ast\) | |

\(\ast P < .05.\)

\(\ast P < .001.\)
lower satisfaction with colonoscopy care. This might be because patients with an abnormal BMI were easy to cause inadequate bowel preparation.\(^{[66]}\) Although patients suffered an uncomfortable procedure of colonoscopy, they did not have a successful colonoscopy; hence, they reported less satisfaction with colonoscopy care.

There were several limitations in our study. First, we were unable to include the times of watching the video. Although we encouraged participants to review the education video as needed and we could not confirm how many times that the patients actually viewed the video. The dose-response of the times of reviewing the smartphone education video needs further evaluation in future studies. Second, we did not exclude patients with previous experience of colonoscopy, which might have caused a selection bias in our study. However, the effects of selection bias could be minimized by random assignment. Third, the results of this study might be difficult to generalize because this study was performed in only 1 large medical center. It is necessary to include participants from multiple centers for generalizability in future studies.

In conclusion, our findings showed the effectiveness of innovative ways to help people understand colonoscopy easily and formulate a more effective colonoscopy screening program in long-lasting CRC screening programs. The video of the smartphone education program opened for access after the study (https://youtu.be/o3u2n7fbG5Y).

**Author contributions**

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