



OPEN Increasing the accessibility to colorectal cancer screening in the community via faecal immunochemical test kits dispensed via automated kiosk

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Colorectal cancer (CRC) screening uptake was low in Singapore. An automated kiosk (KIPFIT) dispensing Faecal Immunochemical Test (FIT) kits was developed to facilitate CRC screening. A prospective observational study leveraged on case-encounter approach to recruit community-dwelling adults aged 50–85 years. They were guided to collect two FIT kits from the kiosk on passing by a local multi-purpose mall. The study aimed to determine their CRC screening uptake by returning minimally one completed kit within two months after its collection. Data on their demographics, awareness, and prior screening history, and kiosk usability (as measured by the System Usability Scale SUS) were analysed using bivariate tests, followed by logistic regression for CRC screening completion and linear regression for SUS scores. Among the 350 participants (mean age 66.1 years; 57.4% female; 91.4% Chinese), 68.9% completed CRC screening, which was associated with Chinese ethnicity (AOR = 3.13, 95%CI = 1.42–6.90) and awareness of screening (AOR = 2.18, 95%CI = 1.10–4.33). Benchmarked at 68, the mean SUS score was 57.7, with lower scores in older and lower-educated participants. Guided use of the KIPFIT kiosk had increased CRC screening uptake. Further research is needed to assess its utility without assistance and its effects on CRC screening in real-world setting.

Keywords Colorectal cancer screening, Faecal immunochemical test, Prevention, Usability, Automated kiosk

Colorectal cancer (CRC) is the third most common cancer globally. It accounts for approximately 10% of all cancers and is the second leading cause of cancer-related mortality worldwide¹. In 2020, over 1.9 million people are newly diagnosed with CRC, resulting in over 930,000 deaths worldwide. By 2040, the incidence will rise to 3.2 million new cases annually and 1.6 million deaths each year. CRC is often diagnosed at advanced stages when treatment options are limited and result in poor prognosis and premature deaths. The outcomes of CRC can be significantly improved if it is diagnosed early through screening. Incidence rates of CRC have declined in selected high-income countries, largely due to effective screening programs. A Cochrane review reported that Faecal Occult Blood Test (FOBT) screening could reduce CRC mortality by 16% in average risk persons, while colonoscopies were associated with a 61% decline in CRC mortality.

CRC screening in the community often involves stool-based tests, which are convenient, non-invasive screening methods to detect the presence of CRC or precancerous polyps in the colon and rectum. FOBT and Faecal Immunochemical Test (FIT) are widely used tests to detect hidden blood in the stool, which may indicate CRC or polyps or hemorrhoids. They involve collecting and sampling a small amount of stool and sending it to a laboratory for analysis. If blood is detected in the stool, further diagnostic procedures such as colonoscopy are required to confirm the presence of CRC or polyp. Genetic testing and colonoscopy may be indicated for people with family history of CRC, pending on recommendations by local clinical guidelines on CRC screening.

CRC screening uptake varies depending on the screening modalities and across different populations around the world. A retrospective review of CRC screening in a primary care network in the United States reported

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increase uptake from 71% in 2017 to 78% in 2019². In 2021–22, 68.9% of invited population in England, aged 60–74 years and selectively among higher risk younger individuals aged from 56 years (4 083 100 out of 5 924 232) participated in FOBT screening for CRC. Dorothy Chan et al. reported a FOBT/FIT uptake rate of 43.9% in their Hong Kong community-based study³.

A systematic review revealed that lack of knowledge and awareness; fear of result, procedure, pain; high cost and lack of gastrointestinal symptoms hinder CRC screening in Asia⁴. Raising awareness, perceived risk and severity, family history of cancer and physician recommendation facilitate CRC screening⁴. A qualitative research study in Malaysia showed similar barriers. However, in a separate survey on 546 Malaysian adults, 42.3% agreed to undergo FOBT after a brief health education session but eventually, only 28% completed the screening test. Beyond awareness and knowledge, logistic concerns about sending a stool sample to a clinic were other barriers. Strategies were proposed to overcome these barriers, including simplified illustrated instructions about stool collection, free screening at health clinics and reminders to complete the stool-based screening tests but these measures have yet to be adequately evaluated for their effectiveness in real world settings.

In Singapore, the Health Promotion Board and other official health agencies had organized campaigns and publicity material in public areas to raise the awareness of CRC, which has become the number two most common cancer among local Asian males and females respectively aged 50 years and older⁵. CRC screening modalities using FOBT, FIT and colonoscopy are widely accessible in primary care clinics and hospitals at affordable costs. For example, the Singapore Cancer Society (SCS), a community-based social service agency, offers FIT kits at no cost to eligible Singaporeans and Singapore Permanent Residents aged 50 years and older distributes these FIT kits through various channels. These channels include its network of distribution partners such as community pharmacies and selected Traditional Chinese Medicine centers across the island state. After explaining about the function of FIT, the participants receive instructions to sample and test their stool at the privacy of their residence. Upon completing two separate FIT tests, the participants will mail the kits back using postage-covered envelopes to SCS's appointed laboratories for analysis and receive their results later via mail. Nevertheless, the local CRC screening rate remains low. Only 27.3% of 7125 respondents reported CRC screening in the 2015–2016 Singapore Community Health Survey⁶. A new approach leveraging on medical technology advancement is urgently needed to increase CRC screening.

A kiosk is a stand-alone booth used in high traffic areas for marketing purposes such as vending merchandise. Retail kiosks are frequently located in shopping malls or busy city streets with significant traffic and provide owners with a low-cost alternative to market their products or services. Kiosks have also been deployed for healthcare purposes, including integrating devices in their structure for clinical measurements of weight, height, and blood pressure of users. During the COVID-19 pandemic, kiosks were used to dispense masks to the public in Singapore, incorporating additional functionality to prevent abuse from repeated mask collection by the same individual.

A novel kiosk (KIPFIT: *K*iosk to *P*romote *F*aecal *I*mmunochemical *T*esting) has been developed by a team of primary care researchers and kiosk vendor to facilitate CRC screening in Singapore. The KIPFIT kiosk serves to dispense two FIT kits, and envelopes to individuals with average risks of CRC. Any eligible local adult can obtain the FIT kits from the kiosk, complete the 2 stool tests at home and mail them to the laboratory using the pre-addressed envelopes. The do-it-yourself (DIY) modus operandi of the kiosk, its utility and acceptability by the public need to be objectively evaluated before it can be scaled for wider deployment in the community.

Aims

The study aimed to determine the CRC screening uptake rate and outcomes among users who received FIT kits from the KIPFIT kiosk. It also aimed to assess the factors associated with the completion of the FIT and gather the users' feedback on the KIPFIT kiosk pertaining to its usability, acceptability, and recommendations to other users.

Methods

Study site

This prospective observation study was conducted from mid-Dec 23 to Mar 24 in a multi-purpose community mall (Heartbeat@Bedok) located 600 m from the nearest subway station. It includes a sports centre, a public library, a community club, a polyclinic, a senior centre, and more than 30 retailers and eateries. It functions as a community hub to serve the social and lifestyle needs of over 290,000 multi-ethnic Asian residents in Bedok town. The residents comprise approximately 48.5% males and 51.5% females; 38.3% of them are aged 50 to 79 years old; 72.8% are Chinese, 14.2% Malays, 8.8% Indians and 4.1% other ethnic group⁷. The mall has an average monthly footfall from about 280,000 to 300,000 people, which becomes an ideal location for the KIPFIT kiosk to reach out to the target adults for CRC screening^{8,9}.

Eligibility criteria

Participants were recruited if they satisfied the inclusion criteria for CRC screening, including adults aged 50 to 85 years. They should be Singapore Citizens or Permanent Residents (PR) as the results are mailed back to their local addresses. They need to be literate in English to read and understand FIT procedure and study documents. Those who self-reported to have CRC were excluded from the study.

Questionnaire

The digitalised survey instrument collected the following data from the verbally consented participants:

Part 1a comprises general demographic information such as age, gender, ethnicity, residency status, years of education, marital status, and socioeconomic status (SES) information such as housing type, tax payment and medical subsidy.

Part 1b consists of simple questions to (1) assess their level of awareness and (2) gather information on their history of previous CRC screening, if any.

Part 2. scores from the System Usability Scale (SUS), a validated questionnaire developed by John Brooke, to assess perceived usability of a device or system¹⁰. It is selected for its construct validity and high reliability with Cronbach values exceeding 0.85. SUS consists of 10 items, with five response options based on a Likert scale, with “Strongly Disagree” receiving a minimum of 1 point and “Strongly Agree” receiving a maximum of 5 points. It consists of odd-numbered questions, which are positively worded, and even-numbered questions which are negatively worded. The scoring adheres to this approach: for odd-numbered items: subtract one from the user response; for even-numbered items: subtract the user response from 5.

Each question in SUS carries a score from 0 to 4, with 4 being the most positive response. The scores are added up and multiplied by 2.5, which are presented as a percentage ranging from 0 to 100, with higher scores indicating better usability. Based on prior studies, a SUS score of 68 marks the threshold for average level of usability¹¹. The participants completed SUS only after using the kiosk.

Kiosk

The KIPFIT Kiosk, with dimensions of 2000 H x 950 W x 950 D mm, can hold up to 32 FIT kits per row. The touchscreen, where an indication of ‘Step 1’ is shown beside it, displays the QR code for registration in the SCS web portal on a mobile phone and allows the user to ‘purchase’ a FIT kit by clicking on the yellow button. Upon successful registration and ‘purchase’, the user will scan the Redemption QR code on their mobile phone at the QR code scanner below the touchscreen, where ‘Step 2’ is indicated. Upon a successful scan, the FIT kit is dispensed and can be collected at the opening at the bottom of the kiosk, shown as the red rectangular section. During dispensing, the FIT kit passes through a Radio Frequency Identification (RFID) reader, tagging the kit with an RFID code that includes the FIT kit’s serial number followed by 15 zeros (e.g., X1234500000000000000) (see Supplementary Fig. 1 under Appendix). The Eiken OC-SENSOR[†] FIT kits (see Supplementary Fig. 2 under Appendix) were stored in the kiosk with temperature control.

Recruitment procedure

A booth was set up next to the KIPFIT kiosk at the study site for the clinical research coordinators (CRCs) to provide information to adult passer-by and screened them for eligibility to enrol into the study. Those who provided their verbal consent were assisted by the CRCs to use an officially approved digital platform in Singapore (FormSG) to collect their anonymized personal data¹².

They proceeded to fill Part 1a and 1b of the questionnaire before being guided by the clinical research coordinators to register their personal data using a QR code displayed on a screen in the KIPFIT kiosk. After submission of their information, an acknowledged redemption QR code tagged to that participant’s details will then be generated and transmitted to the participant’s smartphone. Participants will then scan this personalised QR code at the KIPFIT kiosk and select a FIT kit to be dispensed. As each set of FIT kits has a unique serial number, at the point of dispensation when the set drops into the collection trough, a RFID tag coded to each unique set will be read by the sensor embedded in the kiosk. This tags the FIT kit’s serial number to the personalised QR code and the participant’s details. The participants’ personal data captured were used to notify participants to return the kit and to inform the outcome of the test. The results were notified through mail, and through the health portal.

After collecting the set of two separate kits, together with two self-addressed envelopes from the kiosk, the participant completed the questionnaire to provide feedback on their experience using the kiosk.

Finally, the participants were instructed to mail the kits to the designated laboratory by SCS within one week after completing the tests. Step-by-step instructions for proper use of the kits were enclosed in the same package as the kits for reference by the participants. The participants were reimbursed with a supermarket voucher (SGD5 or USD4) for their time and contributions to the study. The flowchart of FIT kit collection is presented in Fig. 1.

Sample size calculation

The study aimed to assess the completion of the CRC screening after the participants collected the FIT kits from the kiosk. No reference result is available due to absence of precedence for this innovative approach to increase accessibility to CRC screening. It was reported that 80.3% of those completed CRC screening completed FIT¹³, and in another study, out of those who received FIT, 53.7% completed FIT¹⁴. Taking an average proportion of the FIT kit completion from both studies, we estimate our study will have a completion of 67%. Using a 5% precision and 95% confidence interval level, the required sample size is 340. To account for potential defaulters, the study population was rounded up to 350.

Statistical plan and analysis

Descriptive statistics were performed and presented in Table 1 below, with the continuous variables presented in mean and standard deviation, and categorical variables presented in percentages and frequencies.

To assess the association between participants who returned their kits and their demographics, the Chi-square test was used to analyze the categorical variables, while independent t-test was applied for the continuous variables. Shapiro-Wilk test was used to test for normality of the continuous variables, including SUS. Mann-Whitney U test was used to assess the difference in SUS score between those who returned their kit and those who did not return. Potential confounding factors with a p-value of less than 0.2 were included in the multiple logistic regression to obtain the adjusted odds ratios. VIFs of each variable were assessed to ensure there is no

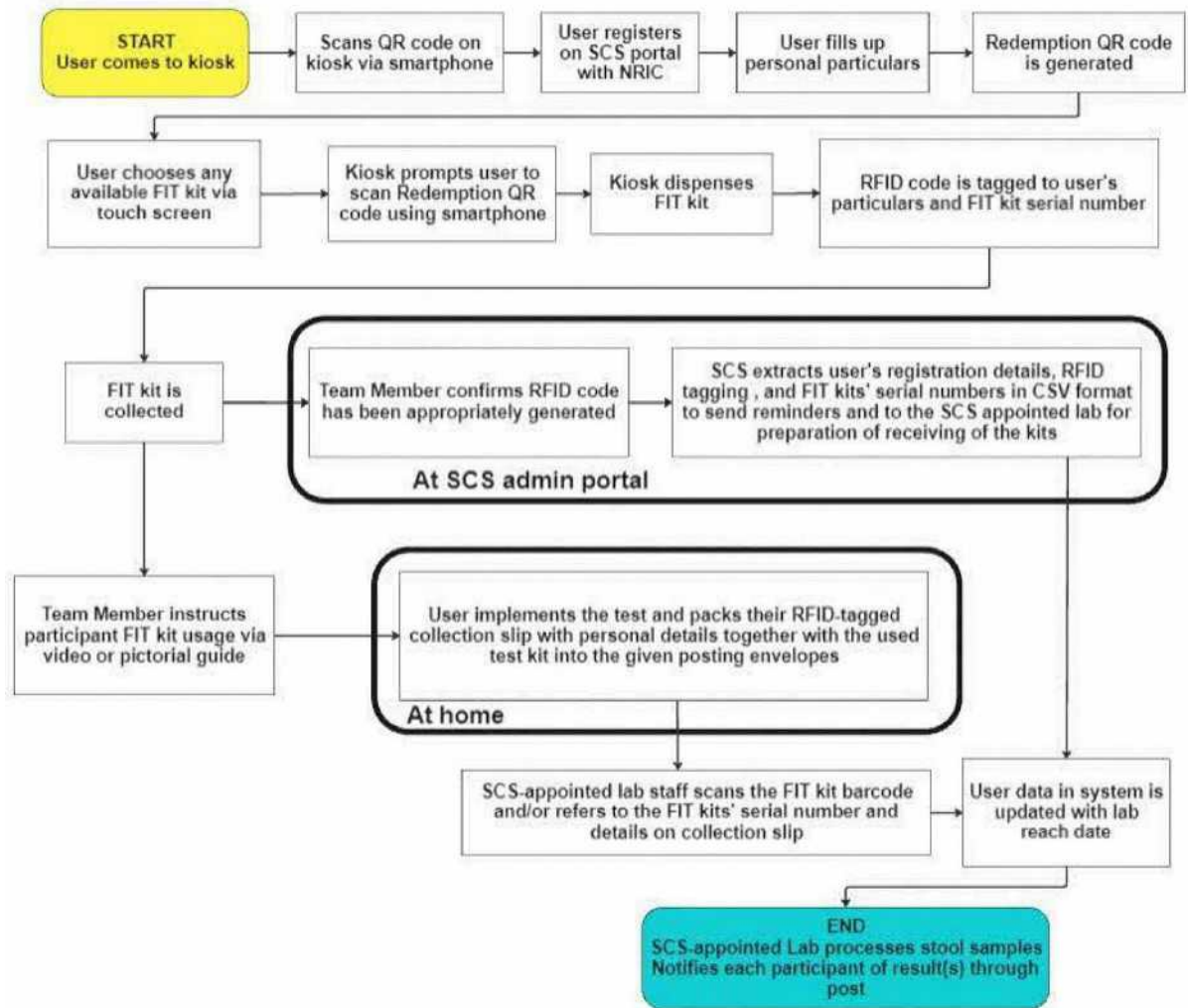


Fig. 1. FIT kit collection flowchart.

multi-collinearity in the model. The association of the SUS scores with the demographics was performed using independent t-test and Pearson's correlation. The potential factors were included in the multiple linear regression for Model 1 (adjusted for gender, age and education) and subgroup analyses based on education were conducted to determine the significant factors for high SUS, A p-value of less than 0.05 is statistically significant. To control for family-wise error rate for multiple comparisons, the Holm-Bonferroni adjusted alpha is $0.05/14 = 0.00357$ in Table 1 and $0.05/4 = 0.0125$ in Table 3. All analyses were performed using IBM SPSS version 29.0.

Results

Among the 1240 adults passing by the kiosk approached by the clinical research coordinators for this study, 600 declined and were not screened for eligibility criteria. Among the remaining 640, 176 were excluded due to eligibility criteria, 109 had other commitments and did not participate, 5 declined due to failure to scan QR code in their phone. 350 eligible adults consented to use the kiosk and were recruited. Their average age was 66.1 years. More of the participants were female (57.4%), Chinese (91.4%) and staying in public housing (67.4%). Slightly less than half of them (49.7%) had less than 10 years of education.

Table 1: Out of the 350 participants, almost one-third of them (31.1%) did not return any of the FIT kits. Among the 241 (68.9%) who returned kit, 16 of them returned only 1 kit (Chart 4) while the remaining 225 returned both kits. Significantly more participants of minority ethnic groups did not return the kits after collecting them from the kiosk. 73.6% of those who self-reported being aware of screening tests for colorectal cancer returned the kits and completed the CRC screening, significantly more than the 51.4% who lacked such awareness. Participants who had prior CRC screening by either stool-based test or colonoscopy were more likely to return their kits (74.8% vs. 56.9%) compared to those without. No significant difference was noted between the two groups based on their SUS scores.

	Total	Did not return kit	Returned kit	p-value
Total	350 (100.0)	109 (31.1)	241 (68.9)	
Age, median (IQR)	69 (63–74)	66 (60.5–71.5)	67 (61–72)	0.392
Gender				0.544
Male	149 (42.6)	49 (32.9)	100 (67.1)	
Female	201 (57.4)	60 (29.9)	141 (70.1)	
Ethnic group				0.002
Chinese	320 (91.4)	92 (28.8)	228 (71.3)	
Other minority groups	30 (8.6)	17 (56.7)	13 (43.3)	
Highest education				0.965
Up to 10 years of education	174 (49.7)	54 (31)	120 (69)	
More than 10 years	176 (50.3)	55 (31.3)	121 (68.8)	
Housing				0.330
Public housing	236 (67.4)	73 (30.9)	163 (69.1)	
Private housing	113 (32.3)	35 (31)	78 (69)	
Decline to answer	1 (0.3)	1 (100)	0 (0)	
Marital status				0.358
Single	37 (10.6)	9 (24.3)	28 (75.7)	
Married	279 (79.7)	86 (30.8)	193 (69.2)	
Divorced/separated/widowed	33 (9.4)	14 (42.4)	19 (57.6)	
Decline to answer	1 (0.3)	0 (0)	1 (100)	
Pay income tax last year (proxy for employment)				0.312
Yes	116 (33.1)	32 (27.6)	84 (72.4)	
No	234 (66.9)	77 (32.9)	157 (67.1)	
Receive medical subsidy (in public healthcare institution)				0.999
Yes	289 (82.6)	90 (31.1)	199 (68.9)	
No	61 (17.4)	19 (31.1)	42 (68.9)	
Receive official financial assistance				0.868
Yes	12 (3.4)	4 (33.3)	8 (66.7)	
No	338 (96.6)	105 (31.1)	233 (68.9)	
Do you know what colorectal cancer is?				0.135
Yes	306 (87.4)	91 (29.7)	215 (70.3)	
No	44 (12.6)	18 (40.9)	26 (59.1)	
Do you know that screening tests are available for CRC?				< 0.001
Yes	276 (78.9)	73 (26.4)	203 (73.6)	
No	74 (21.1)	36 (48.6)	38 (51.4)	
Have you been screened for CRC before (FOBT/FIT or a colonoscopy)?				0.001
Yes	234 (66.9)	59 (25.2)	175 (74.8)	
No	116 (33.1)	50 (43.1)	66 (56.9)	
SUS score, mean (SD)	57.7 (10.3)	58.3 (10.1)	57.5 (10.4)	0.515
SUS score, median (IQR)	57.5 (50–65)	57.5 (50–65)	57.5 (50–65)	0.476

Table 1. Baseline characteristics of KIPFIT study participants.

In Table 2, Chinese participants and those who know that screening tests are available for colorectal cancer were more likely to return the kits (AOR (95% CI) = 3.13 (1.42–6.9), $p = 0.005$) and AOR (95% CI) = 2.18 (1.1–4.33), $p = 0.026$).

Table 3 showed that the younger participants, and those with higher education attained higher SUS scores. These results are statistically significant.

Table 4: In Model 1, older participants tend to have lower SUS score ($-0.265(-0.406-0.124)$, $p < 0.001$), while higher education has higher SUS score (3.934 (1.763–6.104), $p < 0.001$). Gender does not contribute significantly to the SUS score. However, when we analysed by education subgroups, older and female participants have significantly lower SUS scores in those with lower education (Model 2). Whereas, in the higher education subgroup, only older participants have significantly lower SUS score (Model 3).

Almost 7 in 10 participants (68.6%) would use this kiosk for future collection of FIT kits. About 6 in 10 participants (62.3%) perceived that “the kiosk was easy to use” and 57.4% perceived that “most people would learn to use this kiosk very quickly” (Fig. 2). Nonetheless, 14.9% of them found the kiosk unnecessarily complex and 34.3% indicated that they might need the support of technical person to help in the use of the kiosk. The overall mean SUS score is 57.7, which is lower than the average score of 68.

	Adjusted OR (95% CI)	p-value
Ethnic group		
Chinese	3.13 (1.42–6.9)	0.005
Other minority groups	1	-
Do you know what colorectal cancer is?		
Yes	0.82 (0.38–1.77)	0.611
No	1	-
Do you know that screening tests are available for colorectal cancer?		
Yes	2.18 (1.1–4.33)	0.026
No	1	-
Have you been screened for CRC before (FOBT/FIT or a colonoscopy)?		
Yes	1.5 (0.85–2.65)	0.157
No	1	-

Table 2. Association between returning kit and their demographics and knowledge using logistic regression.

	SUS, Mean (SD) or rho	p-value
Total		
Age	-0.218	<0.001
Gender		0.026
Male	59.1 (10.6)	
Female	56.7 (10)	
Ethnic group		0.499
Chinese	57.8 (10.4)	
Other minority groups	56.5 (9.8)	
Highest education		<0.001
Up to 10 years of education	55.1 (9.4)	
More than 10 years of education	60.3 (10.6)	

Table 3. Factors associated with SUS score.

	Model 1 (All patients, n = 350)		Model 2 (Up to 10 years of education, n = 174)		Model 3 (More than 10 years of education, n = 176)	
	Beta (95% CI)	p-value	Beta (95% CI)	p-value	Beta (95% CI)	p-value
Age	-0.265 (-0.406–0.124)	<0.001	-0.197 (-0.386–0.007)	0.042	-0.327 (-0.533–0.12)	0.002
Gender						
Male	1.763 (-0.355–3.881)	0.103	2.952 (0.037–5.867)	0.047	0.769 (-2.279–3.817)	0.621
Female	Reference		Reference		Reference	
Education						
Up to 10 years	Reference		-		-	
More than 10 years	3.934 (1.763–6.104)	<0.001	-		-	

Table 4. Factors determining SUS score using multiple linear regression.

Among the 116 (33.1%) participants who were not screened before (Table 1), 66 of them (56.9%) returned the kits and 50 (43.1%) did not. Unawareness of the FIT, absence of symptoms and perceived no necessity for screening were their top reasons for not participating in prior CRC screening (Fig. 3).

Among participants who had collected FIT kits from the kiosk, 241 of them (68.9%) mailed at least one kit to the laboratory within 2 months post-collection (Fig. 4). A total of 21 participants (8.7%) had one positive test result.

Discussion

This study presented the outcomes of CRC screening, leveraging on an innovative establishment of an automated kiosk to increase accessibility of stool-based tests to the target people. The uptake rate of 58.3% and the screening completion rate of 68.9% are more than the reported 27.3% who had CRC screening in another local community

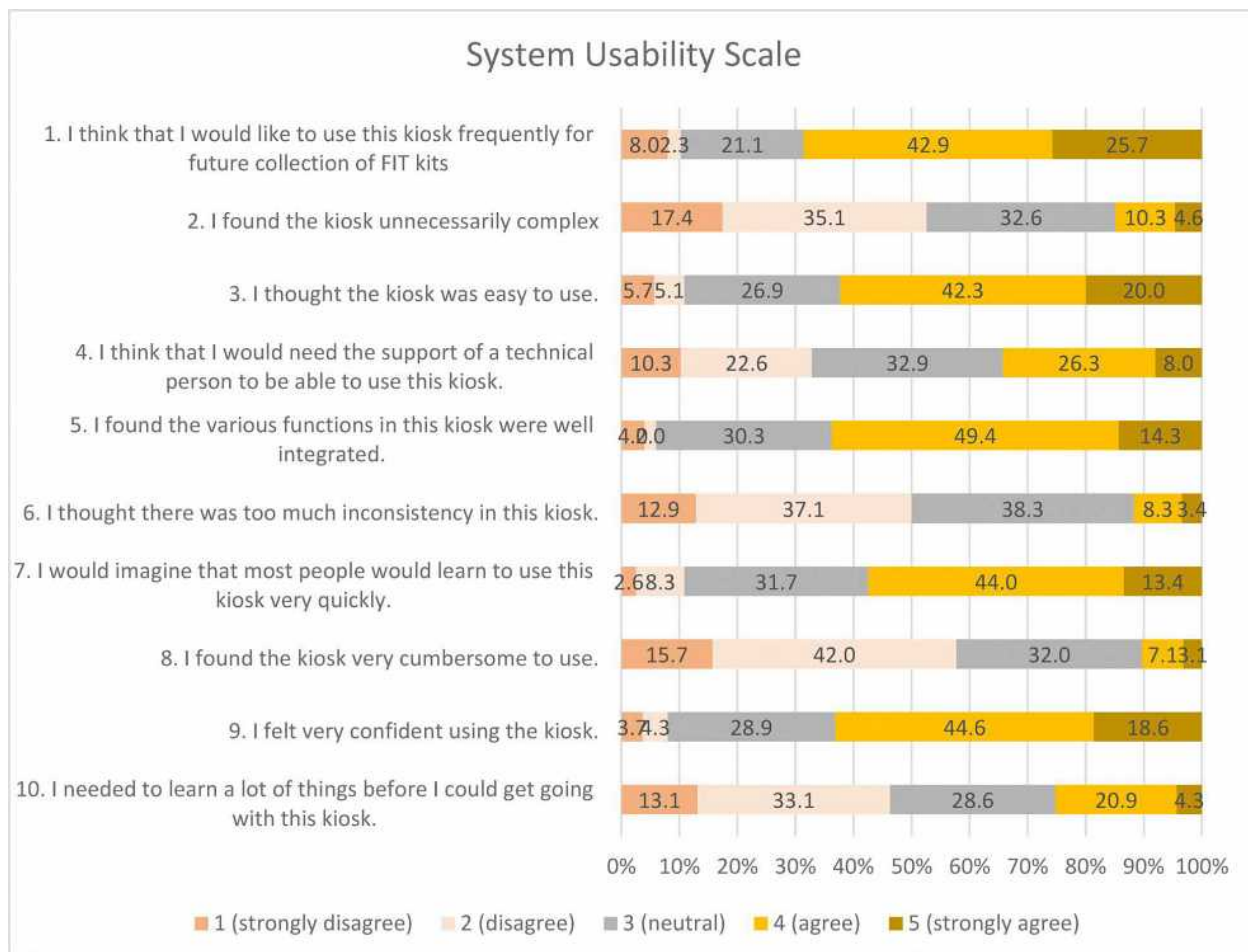


Fig. 2. Evaluating user's experience of kiosk using system usability scale.

survey⁶. Emily Power et al. highlighted in their review that successful intervention strategies included increasing access to stool-based test and educational approaches to enhance awareness and attitudes towards CRC screening¹⁵. They also alluded that multifactor interventions that target more than one level of the screening process are likely to have larger effect.

The kiosk is sited in a highly visible location with high footfall in a community hub for ease of accessibility. It is designed to allow the target persons to collect the FIT kits around the clock at their convenience. Mailing the completed FIT kits back to the provider free of charge or drop off at collection points helps to close the loop for the CRC screening. Once the kiosks are scaled up in the community, they can also be deployed at the base of public housing or even at their primary healthcare clinic locations (e.g. within a polyclinic). Primary healthcare professionals can easily direct target persons to the nearest kiosks once a network is established for increased productivity of staff (when patient self-serves) and consolidation of stocks in the locality (less individual administrative work needed).

Participants who were aware of CRC screening test were twice (AOR = 2.18) more likely to return the kits. Literacy of CRC screening appears to be an enabler to proceed with the tests. In contrast, no significant difference was noted on the completion of the CRC screening among those who had CRC screening before, either via stool-based test or colonoscopy, and those without prior experience. Most of them would likely result in negative findings from a previous screening and could result in complacency and a false sense of security. Some of them might have unpleasant experiences which deterred them from completing the test for this study. Those without prior experience would need longer time to transit from ambivalence to adoption of any screening test.

Participants of Chinese ethnicity were thrice more likely (AOR = 3.13) to return the kits compared to minority ethnic groups. Tyson Chan et al. had revealed that Malay subjects were significantly less likely to screen for colorectal cancer (aPR = 0.55, CI = 0.44–0.68, $p < 0.001$) compared to Chinese subjects in their community survey⁶. Emily Power et al. shared that the biggest challenge for future research in CRC screening will be to reduce inequalities related to socio-economic position and ethnicity in its uptake¹⁵. Cost to subjects is unlikely to be a major issue in Singapore as FIT kits are available free to the local target population regardless of their ethnicity and socioeconomic status.

The KIPFIT kiosk offers an opportunity to raise public awareness of CRC and its screening modalities. The enclosed information and instructions with the FIT kits explain the need and procedure for CRC screening.

Why did you not go for screening?

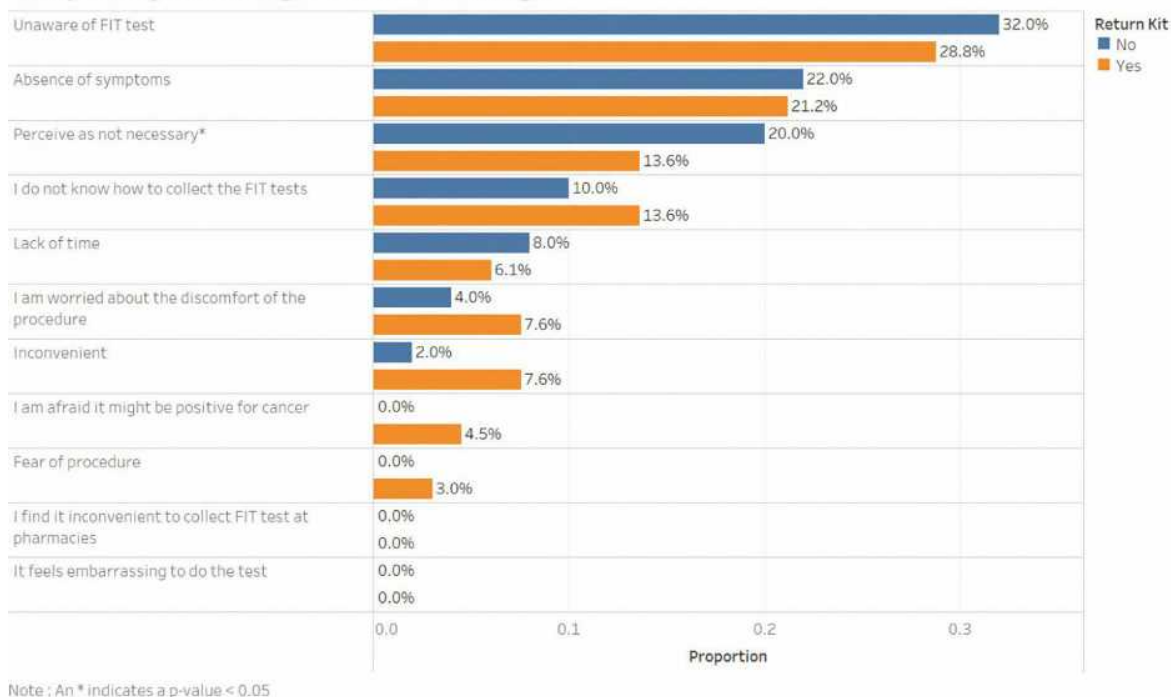


Fig. 3. KIPFIT results.

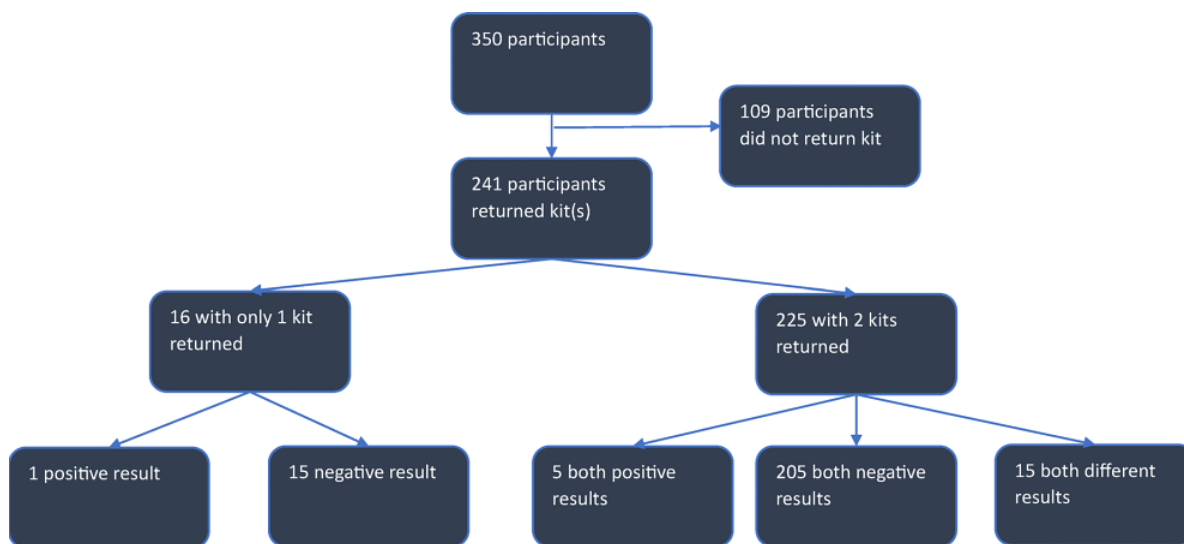


Fig. 4. Barriers for not going for any colorectal cancer screening before.

Printed instructions and QR links to video instructions in major local languages (English, Chinese) are provided to the participants, which are dispensed together with the FIT kits at the kiosk to address language barrier. However, almost half of the study population (49.7%) had less than 10 years of education, and their comprehension of the use of the kits was not known, despite opportunity for clarification was available from the onsite clinical research coordinators. Further study is needed to explore the ethnicity and literacy related barriers which hinder the minority groups from completing the CRC screening.

Nonetheless, after collecting the FIT kits, approximately 7 in 10 participants (68.9%) returned the kits back to the provider, despite providing them with the information on CRC screening and instructions on kit usage at the convenience of their residence. Hence, other hurdles could remain, including apathy due to absence of

symptoms, subjective fear of cancer diagnosis, pain during procedure and perceived inconvenience even among those who had completed the CRC screening in this study (Fig. 3).

There were limitations of the kiosk. Its SUS score (57.7) was lower than the average score of 68, reflecting usability challenges for certain users. About one in seven of them (14.9%) of them deemed the kiosk “unnecessarily complex”. One in three (34.3%) indicated that they might need the support of support personnel to help in the use of the kiosk. The results suggest that the kiosk needs further refinement to improve its usability, such as reducing the steps for user registration (Fig. 1). Nevertheless, most of the participants (62.3%) perceived that “the kiosk was easy to use”; 57.4% of them opined that “most people would learn to use this kiosk very quickly” and 68.6% would use this kiosk to collect the FIT kits in the future. The KIPFIT kiosk is the first prototype and technical enhancement is expected before it is scaled up for deployment in the community.

Age, gender, and education status are significant factors associated with the kiosk utility based on the SUS scores. The kiosk aims to complement the existing CRC screening programme via distribution of the FIT kits from healthcare providers and community pharmacy. It is not intended to replace the modality of CRC screening in primary care. Hence the target population for CRC screening who are older, female and had lower education level should continue to leverage on existing healthcare system to collect the FIT kits if they find challenges and difficulties in using the kiosk on their own. The kiosk provides another access option of obtaining the FIT kits, so that the overall CRC screening rate can be augmented.

The visual cue to the kiosk, adjacent to the recruitment booth and operated by the clinical research coordinator who approached passer-by, had invariably influenced the uptake rate of the public to use the kiosk. The uptake rate is also expected to be affected adversely when the kiosk is eventually deployed as a Do-It-Yourself or Self-Help tool for colorectal cancer screening due to manpower constraints. Advertisements to publicize the kiosk using various media and direct recommendations by healthcare professionals at primary care clinics will be implemented to support the kiosk utility once it is rolled out in the community.

Among those who submitted at least one FIT kit, 8.7% of them were tested positive. With a single application, FITs are 65–87% sensitive to detect CRC across all stages based on a recent meta-analysis¹⁶. Hence, for every 11 persons who have a FIT, one will show a positive result and about 7 to 8 of them may have cancer. The result is similar to the positivity rate of 8.4% reported in a 2014 Netherlands study, in which 4523 people aged 50–74 years underwent FIT screening.

A total 16 of the 241 participants only returned one instead of two FIT kits, and one of them was positive (6.3%). Those who returned two kits, 5 had both positive tests and 15 had one positive and one negative test (Fig. 4). According to Moosavi S et al., the positive predictive value of two positive FITs is superior to one positive FIT for CRC and high-risk polyps¹⁷. The added value of the second FIT was 12% of total CRCs and 23% of total high-risk polyps¹⁷. This information should be shared with the participants to raise their awareness of the higher detection rate for double FITs and to minimize wastage of valuable healthcare resources.

The KIPFIT is a novel intervention to raise the CRC screening rate by easing the dispensing of the FIT kits in an accessible location in a community. The investigators recognize that digitalized education material including video demonstrating the procedure of FIT kit collection and reliable technical support are crucial features which will be introduced in the kiosk before its deployment as a standalone kiosk. While enhancements are needed to improve the procedure of collecting the kits, the results are helpful for healthcare policy makers and community leaders to recognize the potential value of the kiosk in the preventive health ecosystem. KIPFIT kiosks can potentially be adapted to expand CRC screening outreach to communities beyond Singapore, especially those living in densely populated urban environment. Concurrently publicity should be stepped up to raise the awareness of the public, especially those in the target population, on preventive health, cancer screening and the purpose of the kiosk.

This study has its limitations. The study population comprised of largely adults of Chinese ethnicity, English literate and received higher education, who might potentially be subjected to self-selection bias, and hence limiting its generalizability to the local multi-ethnic Asian population. The study is confined to one kiosk in a designated location, with clinical research coordinators on-site to assist the users in their collection of the FIT kits and to handle technical glitches. The results, such as the uptake rate of the CRC screening, cannot be extrapolated if the kiosk is deployed in a self-service setting and in other localities. The investigators are unable to report the clinical outcomes of participants with positive FITs after they received them by mail. As the participants were public who passed by the kiosk, their identities were anonymized as part of the ethics board-approved study protocol.

Conclusion

The study showed that the KIPFIT kiosk could potentially be used to dispense FIT kits and may increase the CRC screening rate among target population in the community if it is widely deployed. About two-thirds of the study participants mailed back at least one FIT kit to the provider after collecting two kits from the kiosk. Those who were aware of CRC screening and of Chinese ethnicity, compared with minority ethnic groups were more likely to complete the CRC screening. Most participants found the kiosk relatively easy to use and would use it for FIT kit collection in the future. However, the functionalities of the kiosk need upgrading and further enhancement to improve its usability, especially for the older and less educated participants.

The goal is to leverage on the kiosk to optimize the limited healthcare human resources in implementing evidence-based screening programs. Nonetheless, the results in this study show that gaps remain in CRC screening. Prior public education on CRC screening and initial induction of the kiosk by healthcare professionals are vital to maximize its utility.

Data availability

The data that support the findings of this study are available in SingHealth Polyclinics, but restrictions apply to the availability of these data, so they are not publicly available. The data are, however, available from the authors upon reasonable request and with the principal investigator's permission.

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Author contributions

TNC designed the study protocol; SRC, TFY, SRK, CLLL implemented the study and collected the data; EYLK analysed the data; TNC, EYLK reviewed and interpreted the results, TNC, EYLK, SRC, TFY drafted the manuscript; all authors reviewed the draft and approved the final manuscript.

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Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

Informed verbal consent was obtained from participants in the study was taken during the recruitment. The study was approved by the SingHealth Centralized Institution Review Board (CIRB #2021/2603) in accordance with the ICH-Good Clinical Practice guidelines.

Additional information

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1038/s41598-025-21057-8>.

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