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ORIGINAL ARTICLE

Interventions to increase uptake in a fecal-immunochemical test population-based colorectal cancer screening program: A quasi-experimental study of first-time invitees

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Abstract

Background: Many countries have established organized colorectal cancer screening programs because they can reduce mortality and incidence from the disease; however, they rely on high participation rates, which are often suboptimal. This study examined the effectiveness of two reminder interventions on uptake rates in Ireland's population-based BowelScreen program.

Methods: Employing a quasi-experimental design, one intervention mailed the fecal-immunochemical test (FIT) directly to clients not responding to an initial invitation; the other mailed a reminder letter modified with behavioral insights. Interventions were tested separately and in combination and compared to the standard reminder letter (1: standard reminder letter [SRL]; 2: modified reminder letter [MRL]; 3: SRL + FIT direct [FITD]; and 4: MRL + FITD). Primary outcome: overall uptake rate (test completion at 5 months); Subgroup outcome: uptake rate among only those receiving reminders. Outcomes were modeled using multivariable logistic regression with group allocation as a fixed effect, adjusted for sex and deprivation.

Results: Uptake was significantly higher in the FITD groups (SRL: 48%; MRL: 50%; SRL + FITD: 54%; MRL + FITD: 54%; $p < .001$). After adjustment, compared to the SRL group, FITD groups had significantly higher odds of uptake (MRL: odds ratio [OR], 1.09; 95% confidence interval [CI], 0.96–1.23; SRL + FITD: OR, 1.30; 95% CI, 1.14–1.48; MRL + FITD: OR, 1.26; 95% CI, 1.11–1.44). This was also the case for subgroup analysis. The MRL did not result in higher uptake compared to SRL.

Conclusion: Mailing the FIT kit directly to nonresponders resulted in improved FIT uptake. Organized FIT-based screening programs not reaching uptake targets should consider implementing this strategy if not already in place.

KEYWORDS

colorectal cancer screening, fecal immunochemical test, intervention, participation, uptake

INTRODUCTION

Colorectal cancer screening is an important public health intervention that has been shown to be effective in reducing both incidence and mortality from the disease.[1,2] Many high income countries have implemented colorectal cancer screening using various screening procedures, including colonoscopy, flexible sigmoidoscopy, and stool-based tests such as guaiac fecal occult blood test (gFOBT) and, in recent years, fecal immunochemical testing (FIT).[2–4]

To optimize health gains at the population-level, high screening uptake is essential.[5,6] However, even with the implementation of noninvasive home-based screening tests, and in particular the simple, sensitive, and specific FIT test,[7] uptake remains suboptimal, even in organized programs with systematic call–recall systems in place.[4,8] A recent study on utilization of colorectal cancer screening across Europe reported few countries achieved rates above 65%, with the majority being below 50%.[9] Uptake rates also vary by socioeconomic status, sex, and ethnicity,[1,10–12] highlighting the need to focus on both improving uptake overall, while reducing differentials.[13] Beyond socioeconomic determinants, beliefs about screening (such as fatalism and defensive reactions) are also important influences on uptake.[14–16]

Numerous interventions have been developed to tackle low uptake in colorectal cancer screening. Some have shown effectiveness, but these have tended to have small effect sizes.[17] The United Kingdom Medical Research Council (MRC) framework for the development of complex interventions for health recommends that interventions are designed and underpinned by evidence and theory.[18] Our previous work,[14–16,19,20] guided by the MRC framework,[18] has established an evidence-base, underpinned by the Theoretical Domains Framework (TDF),[21] to conceptualize a behavioral intervention aimed at increasing colorectal cancer screening uptake.

The Irish BowelScreen program,[22] which is based on biennial FIT, systematically offered to people 59–69 years old (60–69 years old at the time of this study) in the general population, has 20%–25% lower uptake than other similar FIT-based European screening programs.[23–25] One key feature of BowelScreen is the requirement for first-time invitees to contact a call center to consent and request the FIT kit, whereas in some other countries, the FIT kit is sent directly with the screening invitation.[23–25] Reviews of uptake interventions have reported that directly mailing FIT kits to screening clients is effective in achieving higher uptake.[26,27]

In this study, we aimed to test the individual and combined effects on the uptake rate of 1) our behavioral intervention (implemented as a behaviorally modified reminder letter), and 2) provision of a FIT kit, compared to standard reminder letter among first-time screening clients who did not respond to the initial screening invitation after the first invitation letter (primary outcome) and at 3 months after the delivery of the reminder interventions (subgroup outcome). The study is reported in line with the TREND (Reporting Guidelines for Nonrandomized/Quasi-Experimental Study Designs) checklist.[28]

MATERIALS AND METHODS

Setting and design

BowelScreen is an organized national population-based screening program that operates on a call–recall basis. Although Ireland does not have a population register, the program systematically builds a database of invitees from Department of Social Protection sources, while also encouraging clients to self-register for the program. Randomization was not possible within the BowelScreen system that manages screening administration on a day-to-day basis so a quasi-experimental design (nonequivalent control group posttest only) was used. The target population was newly invited screening clients who had not responded to the initial invitation letter by 8 weeks after the initial screening invitation letter and so were eligible, under "usual care," to be sent a standard reminder letter. The two interventions were tested individually and in combination and compared to the current standard reminder letter, resulting in a control group (group 1) and three intervention groups (group 2: behavioral intervention; group 3: FIT kit; group 4; behavioral intervention + FIT kit). Clients who had not completed a FIT by 8 weeks after the initial invitation were allocated—according to date of initial screening invitation—to one of these groups (Figure 1). The study was approved by the Dublin City University Research Ethics Committee and received a waiver of consent (REC approval no. DCUREC/2022/014).

Conditions

All clients within the study received the same initial invitation letter to participate in screening.

- Control

Clients allocated to the control group (group 1) received the BowelScreen standard reminder letter (SRL) (SRL: Supporting Information 1) mailed, as per the program protocol, 8 weeks after the initial BowelScreen invitation. Clients wishing to take part in screening on receipt of the SRL were advised to contact the call center to request a FIT kit.

- Interventions

The intervention groups were a modified reminder letter (MRL), where clients were required to contact a call center to request the FIT kit if they wished to take part in screening (MRL: group 2; Supporting Information 1); a FIT kit enclosed with the SRL (and no requirement to contact the call center; SRL + FIT direct [FITD]: group 3); and the modified reminder letter and, enclosed with it, a FIT kit (and no requirement to contact the call center; MRL + FITD: group 4).

MRL development

The MRL reminder letter included key messages that aimed to tackle barriers to screening participation identified in our previous

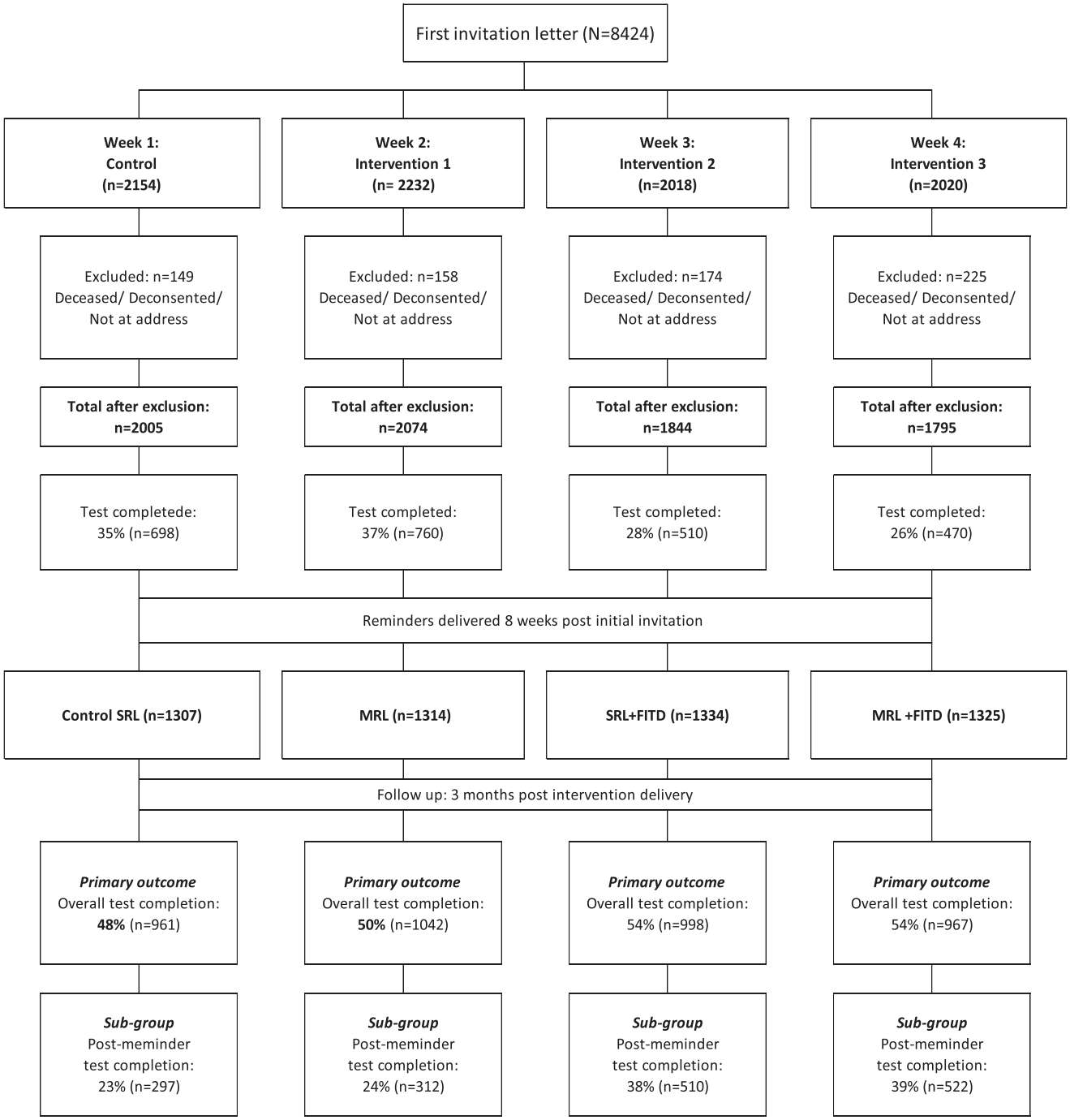

FIGURE 1 Consolidated Standards of Reporting Trials flow diagram of study recruitment and uptake.

research[14–16,20] and within the literature.[10,29] This evidence was drawn together, mapped to the TDF[21] and the behavior change taxonomy[30] to specify the active ingredients of the intervention. The content of the MRL was co-designed within workshops with public and patient involvement (PPI) and National Screening Service representatives.

The key messages within the MRL were:

"*Bowel cancer is one of the most common cancers in Ireland, but the good news is, it is easier to treat if found early.*"

This statement attempted to overcome negative beliefs about the consequences of cancer, specifically fatalistic cancer beliefs and beliefs that cancer cannot be cured.

"*This is the best home test available and is a good way of looking after your health, even if you feel healthy.*"

This statement attempted to overcome defensive reactions to screening, namely suppression by self-exemption and denial of the immediacy to be screened.

Recruitment and participants

Participants were first-time clients (90% were 60–62 years old; 10% were 63 years old and over due to COVID-related delays) invited to take part in the nationwide BowelScreen program. First invitation letters were mailed to clients during May 2022. Clients who had not responded to the initial invitation after 8 weeks were eligible to receive a reminder.

Control and intervention groups were allocated by week. In week 1 of May 2022, clients were assigned to the SRL group (control; group 1); week 2 to the MRL group (group 2); week 3 to the SRL + FITD group (group 3); and in week 4 to the MRL + FITD group (group 4). This meant that those who did not participate in the initial screening invitation would receive the allocated intervention or control reminder.

Sample size

At the time of study design, overall screening uptake was 40% (subsequently rising to 47%[31]). BowelScreen estimated that 10% of those who participate do so following a reminder. A sample size of 3554 nonresponders to the initial screening invitation would have 90% power to detect a 3.5% absolute change in uptake ($\alpha = 0.05$, two-sided) following a reminder (taking overall uptake to 43.5%). This improvement is consistent with those achieved when testing uptake interventions in other screening programs.[32,33]

Outcome and statistical analysis

The primary outcome was overall uptake proportion: this was defined as the proportion of individuals sent an initial invitation (denominator) who had satisfactorily completed the FIT by 3 months after the reminder (numerator: i.e., they had completed the FIT either following the initial invitation or following the reminder). Subgroup analysis was post-reminder uptake: this was defined as the proportion of individuals, from among those sent a reminder (denominator), who had satisfactorily completed the FIT 3 months after the delivery of the reminder. We excluded from analyses clients who were not at the address listed, were deceased, or had de-consented from screening. We also conducted additional supplementary analysis with no exclusions (i.e., de-consented, not at address or deceased, being categorized as nonparticipants) as per BowelScreen's routine calculation of program uptake rates.

Characteristics of participants (by allocation group, sex, and deprivation) were compared using χ^2 tests; age was not considered because all individuals were 60–63 years old inclusive and first-time invitees. Characteristics, descriptives, and outcomes are described separately for 1) all clients invited to be screened (primary analysis), and 2) only clients who were sent the reminders (subgroup analysis).

Area level deprivation was assigned (to individual cases) based on the Pobal Haase Pratschke (HP) deprivation index[34] (eight categories based on characteristics of the population resident in the area), ranging from extremely disadvantaged to extremely affluent. Deprivation was collapsed into two categories for analysis (disadvantaged and affluent).

Multivariable logistic regression was used to model the outcome (FIT completion) with group allocation (SRL as the reference group) as a fixed effect and adjusting for sex and deprivation as these have previously been shown to be associated with uptake[16,19] and were included in the final multivariable model (the p value from the associated likelihood ratio test (LRT) was <0.05). Odds ratios (OR) and 95% confidence intervals (CI) are presented. We tested for interactions between the covariates and group by fitting cross-product terms (i.e. sex*group allocation; deprivation*group allocation) to a model containing all main effects. Statistical analysis was performed with STATA 16. Significance at $p < 0.05$ (two-sided tests) is assumed.

RESULTS

Study participants

A total of 8424 clients were included in the study (Figure 1). After exclusions (i.e., opted out of screening, deceased, and not at address) the data set included 7718 clients; their characteristics are described in Table 1. The distribution of sex and deprivation across groups was similar, although a higher percentage of individuals in the MRL + FITD group was resident in disadvantaged areas ($p = .05$).

By 8 weeks following the initial invitation letter, and before delivery of the reminders, overall uptake (FIT satisfactorily completed) across all four groups combined was 32%. A higher proportion of the control group (SRL) and the MRL group had completed the FIT test (35%–37%) at this point, compared to the SRL + FITD group (28%) and the MRL + FITD group (26%; $p < .001$) (Table 1). By 5 months following the initial invitation letter, and after delivery of the reminders, overall uptake across all four groups combined was 51%.

Primary outcome—overall uptake: FIT completion among all invited clients

There was a statistically significant association between overall uptake (FIT completion following the initial invitation and reminder) and group ($p < .001$) (Table 2). Overall uptake was higher in the two FITD groups (SRL + FITD: 54% and MRL + FITD: 54%) compared to the SRL group (48%; $p < .001$) (Table 2). It was intermediate in the MRL group (50%).

In the multivariable model adjusted for sex and deprivation, the odds of FIT completion were significantly higher among the SRL + FITD group (OR, 1.30; 95% CI, 1.14–1.48; $p < .001$) and the MRL + FITD group (OR, 1.26; 95% CI, 1.11–1.44; $p < .001$) compared to the SRL group, whereas a similar odds of completion was observed in the MRL group (OR, 1.09; 95% CI, 0.96–1.23) (Table 2).

TABLE 1 Screening client characteristics by allocation (after exclusions[a]).

	SRL No. (%)	MRL No. (%)	SRL + FITD[b] No. (%)	MRL + FITD[c] No. (%)	*p*
All	2005 (26.0)	2074 (26.9)	1844 (23.9)	1795 (23.3)	
Sex					.219
Male	1013 (50.5)	1023 (49.3)	971 (52.7)	908 (50.6)	
Female	992 (49.5)	1051 (50.7)	873 (47.3)	887 (49.4)	
Deprivation[d]					.050
Disadvantaged[e]	1050 (54.4)	1113 (55.9)	980 (54.8)	1005 (58.6)	
Affluent[f]	881 (45.6)	880 (44.2)	807 (45.2)	709 (41.4)	
Responds to first invitation letter					<.001
Test completed	698 (34.8)	760 (36.6)	510 (27.7)	470 (26.2)	
Sent reminder and interventions	1307 (65.2)	1314 (63.4)	1334 (72.3)	1325 (73.8)	

Abbreviations: FIT, fecal-immunochemical test; FITD, SRL + FIT direct; MRL, modified reminder letter; SRL, standard reminder letter (control).

[a]Excluded: $n = 706$ (625 of which were incorrect addresses).

[b]Standard reminder letter plus the FIT mailed directly.

[c]Modified reminder letter plus the FIT mailed directly.

[d]Deprivation category not allocated for 293 individuals.

[e]Disadvantaged includes very disadvantaged, disadvantaged, and marginally below average.

[f]Affluent includes marginally above average, affluent, and very affluent.

Although overall uptake did not differ across groups among males, higher percentages of females completed the test in the two FITD groups (58%–59%) compared to the SRL group (51%), whereas the MRL group was intermediate (54%; $p < .001$) (Table 2).

Within the disadvantaged deprivation category, compared to the SRL group (47%), overall uptake was similar in the MRL group (47%) and higher in the two FITD groups (SRL + FITD, 52%; MRL + FITD, 51%; $p = .049$) (Table 2). Among the affluent category, overall uptake was 8%–9% higher in the FITD groups, and almost 4% higher in the MRL group, than in the SRL group (50%; $p = .001$).

However, in the multivariable model, no significant interactions were found between socio-demographic variables and group allocation for all invited clients (data not shown).

Subgroup analysis—Post-reminder test completion: FIT completion among those who received the reminders

Among those eligible to receive reminders, compared to the SRL control group (23%), uptake was at least 15% higher in the SRL + FITD (38%) and the MRL + FITD (39%) groups but was similar among the MRL group (24%; $p < .001$) (Table 2).

In the multivariable model the odds of FIT completion were significantly higher among the SRL + FITD (OR, 2.10; 95% CI, 1.77–2.50; $p < .001$) and the MRL + FITD groups (OR, 2.18; 95% CI, 1.82–2.60; $p < .001$) compared to the SRL group (Table 2); a nonsignificant 5% higher odds of FIT completion was observed in the MRL group (OR, 1.05; 95% CI, 0.88–1.27).

Male uptake varied by group ($p < .001$) (Table 2). Compared to the SRL group (20%) it was higher in the SRL + FITD (35%) and MRL + FITD groups (35%) but did not differ in the MRL group (21%). A similar pattern was seen among females: SRL: 25%; SRL + FITD: 42%; MRL + FITD: 44%; MRL: 27%; $p < .001$ (Table 2).

Uptake also varied significantly by group in both the disadvantaged and affluent groups ($p < .001$ for both) (Table 2). For the disadvantaged group, uptake did not differ in the MRL compared to the SRL groups (22%), but was at least 13% higher in the FITD groups (SRL + FITD: 35%; MRL + FITD: 38%). Although uptake was slightly higher in the affluent group, the same pattern across groups (SRL: 24%; MRL: 26%; SRL + FITD: 44%; MRL + FITD: 41%) was observed.

No significant interactions were found between socio-demographic variables and group allocation for those eligible to receive reminders (data not shown).

Additional supplementary analysis that categorized all excluded clients (screening de-consented, deceased, and not at address) as nonparticipants (note significantly higher rates of excluded clients in the MRL + FITD group), had minimal effect on the adjusted ORs reported above (Supporting Information 2).

DISCUSSION

This study tested two interventions, individually and combined, to increase uptake in Ireland's BowelScreen program. Mailing the FIT kit directly to clients who had not responded to the initial invitation letter resulted in significantly higher uptake of FIT-based screening

TABLE 2 Uptake by allocation (after exclusions[a]) for primary and secondary outcomes and univariable and multivariable ORs and 95% CIs with *p* values.

	SRL		MRL		SRL + FITD		MRL + FITD		
	Total *n*	Uptake, No. (%)	Total *n*	Uptake, No. (%)	Total *n*	Uptake, No. (%)	Total *n*	Uptake, No. (%)	*p*
Primary outcome: overall test completion									
All	2005	961 (47.9)	2074	1042 (50.2)	1844	998 (54.1)	1795	967 (53.9)	<.001
Sex									
Male	992	442 (44.6)	1051	486 (46.2)	873	431 (49.4)	887	431 (48.6)	.140
Female	1013	519 (51.2)	1023	556 (54.4)	971	567 (58.4)	908	536 (59.0)	.001
Deprivation[b]									
Disadvantaged[c]	1050	489 (46.6)	1113	525 (47.2)	980	505 (51.5)	1005	511 (50.9)	.049
Affluent[d]	881	439 (49.8)	880	471 (53.5)	807	473 (58.6)	709	409 (57.7)	.001
Univariable: OR (95% CI; LRT)	Ref	—	1.10	0.97–1.24	1.28	1.13–1.45	1.27	1.12–1.44	<.001
Multivariable[e]: OR (95% CI; LRT)	Ref	—	1.09	0.96–1.23	1.30	1.14–1.48	1.26	1.11–1.44	<.001
Subgroup outcome: post-reminder test completion									
All	1307	297 (22.7)	1314	312 (23.7)	1334	510 (38.2)	1325	522 (39.4)	<.001
Sex									
Male	669	135 (20.2)	693	145 (20.9)	657	228 (34.7)	677	234 (34.6)	<.001
Female	638	162 (25.4)	621	167 (26.9)	677	282 (41.7)	648	288 (44.4)	<.001
Deprivation[a]									
Disadvantaged[c]	700	153 (21.9)	740	164 (22.2)	702	243 (34.6)	767	289 (37.7)	<.001
Affluent[d]	559	136 (24.3)	528	137 (26.0)	584	254 (43.5)	497	205 (41.3)	<.001
Univariable: OR (95% CI; LRT)	Ref	—	1.06	0.88–1.27	2.10	1.78–2.50	2.21	1.87–2.62	<.001
Multivariable: OR (95% CI; LRT)	Ref	—	1.05	0.88–1.27	2.10	1.77–2.50	2.18	1.82–2.60	<.001

Abbreviations: CI, confidence interval; FIT, fecal-immunochemical test; FITD, SRL + FIT direct; OR, odds ratio; LRT, likelihood ratio test; MRL, modified reminder letter; SRL, standard reminder letter (control).

[a]Excluded: *n* = 706 (625 of which were incorrect addresses).

[b]Deprivation category not allocated for 293 cases.

[c]Disadvantaged includes very disadvantaged, disadvantaged, and marginally below average.

[d]Affluent includes marginally above average, affluent, and very affluent.

[e]Adjusted for sex and deprivation.

compared to the current standard BowelScreen invitation and reminder approach (as observed in the control group), when both all clients and those eligible for a reminder were considered.

FIT direct mailing

Interventions that included the FIT mailed directly to clients resulted in 6% higher overall uptake (and 26%–30% higher odds of test completion), bringing uptake to 54%. Systematic reviews have indicated that mailing the FIT kit directly to screening clients is an effective way of increasing uptake; however, many of the studies were based in the United States and often within low-income settings.[35–37] Our study extends the evidence base to European populations and specifically among first time invitees and, importantly, shows this strategy is effective at a population level.

It is important to note here a key study limitation. Allocation began immediately after Bowel Cancer Awareness month. Uptake in response to the initial BowelScreen invitation letter (before reminders issued) was significantly higher in the first 2 weeks of the study (when allocating to the SRL and MRL groups) than the final 2 weeks, possibly reflecting the impact of that public health campaign. The overall (primary outcome) results are therefore biased toward the standard reminder approach and the MRL approach. It is likely, therefore, that the effect of directly mailing FIT was underestimated.

It is also notable that although mailing the FIT directly to clients in the reminder significantly increased uptake (54%), it still did not reach European Union recommended uptake (65%). Although this

level of first-time uptake is lower than other programs such as Denmark (64% first-time uptake[38]), it is similar to first-time uptake reported in the English bowel screening program (52%).[39]

It is worth considering implementation of mailing FIT directly to all screening clients given the results here, and in the hope of further improvements, although considering evidence of the implications in terms of costs to the program and the exchequer,[40] warranting economic evaluation of this approach. Although there were no additional labor requirements to implement the interventions in this study, scaling up to a population level would require additional resources that can only be evaluated within a full cost-effectiveness analysis.

Sex

When considered from the perspective of sex, the interventions that mailed the FIT directly to clients performed better among females, with overall uptake increasing to 58%–59%. Although this in part reflects higher uptake following the initial invitation letter among females than males it is worth noting that, among males, overall uptake did not vary across groups. The reason why uptake is higher in females is still unclear, but it may be associated with a longer history of cancer screening in women (with programs for breast and cervical cancer, which have rather high uptake[41,42]) and greater acceptability of noninvasive home-based testing for colorectal cancer.[10,43]

In terms of why the intervention did not impact overall uptake in males, several studies, including our work in Ireland, have reported male-specific barriers to colorectal cancer screening participation; these include factors such as cancer fatalism, fear of cancer, ambiguous procrastination, less knowledge about cancer and cancer screening, less consistent relationships with general practitioners, living alone, and a lack of social support.[14–16,44,45] Further behavioral research among males (particularly from deprived areas) would be useful in advancing understanding of the gender gap in participation.

Deprivation

Colorectal cancer incidence is significantly higher in males from more deprived areas, whereas both males and females from more deprived areas have significantly higher mortality.[46] The importance of ensuring that interventions do not exacerbate inequalities has been highlighted[13]; this has been suggested to be a particular risk with "downstream" preventive interventions.[47] Although direct provision of FIT resulted in higher uptake in people resident in affluent areas, it was particularly encouraging that this beneficial effect was also seen among those resident in more disadvantaged areas.

Behavioral intervention

Results indicate that the behavioral intervention (i.e., the MRL) did not have a significant effect on uptake. Although tests for interactions were nonsignificant, there was a suggestion in the data that disadvantaged females responded well to the combined FIT direct and modified reminder letter (primary outcome, overall uptake: disadvantaged MRL + FITD; OR, 1.30; 95% CI, 1.01–1.67; subgroup outcome: OR, 2.42; 95% CI, 1.75–3.34) (see Supporting Information 3). Although this should be taken with caution, the modified reminder letter combined with the mailed FIT may have specific utility among females within more deprived areas. Development of behavioral interventions is complex, and although we followed guidance,[18] we were still unsuccessful. This may be as a result of the selection of the active ingredients of the intervention (either not enough or different ingredients) or that the intervention required more effective subgroup targeting. Behavioral messaging may be more useful in uptake interventions targeting specific subgroups within populations but more in-depth research is required; thus, the main challenge is in identifying "what works" and "for whom." In this regard, several studies have indicated potential utility of social norm-based interventions,[48,49] whereas behavior change interventions targeting access to resources, material incentives, and descriptive norms show promise.[50]

Limitations

We were unable to randomize the sample to the four study groups within the BowelScreen system, and this is an important limitation because the possibility remains that the findings could have resulted from an uncontrolled confounder. Although the quasi-experimental design, with allocation by week, resulted in broadly equal distribution of characteristics, there was a somewhat higher ($p = .05$) percentage of client's resident in disadvantaged areas in the MRL + FITD group. We did, however, adjust for deprivation in our models and uptake remained significantly higher in the FIT direct groups, despite the deprivation gradient. However, there may have been some residual confounding present.

In conclusion, mailing a FIT kit directly to clients within the reminder letter is an effective strategy to increase BowelScreen uptake. Organized FIT-based screening programs not reaching uptake targets should consider implementing this strategy if not already in place. Further research is needed to better understand how determinants of colorectal cancer screening participation can be translated into effective, low cost, behavioral interventions.

AUTHOR CONTRIBUTIONS

Nicholas Clarke: Conceptualization, funding acquisition, writing–review and editing, writing–original draft, investigation, methodology, formal analysis, project administration, and data curation. **Therese Mooney**: Data curation, writing–review and editing, and project administration. **Pamela Gallagher**: Writing–review and editing, supervision, and funding acquisition. **Christian von Wagner**: Writing–review and editing. **Paul Hanly**: Writing–review and editing. **Deirdre McNamara**: Writing–review and editing. **Hilary Coffey**: Writing–review and editing and project administration. **Patricia**

Fitzpatrick: Writing–review and editing. **Linda Sharp**: Conceptualization, methodology, writing–original draft, writing–review and editing, and funding acquisition.

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CONFLICT OF INTEREST STATEMENT

Linda Sharp reports grant and/or contract funding from 3D Matrix and Medtronic. Christian von Wagner reports copyright payments for publications. The other authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author on reasonable request.

REFERENCES

1. Senore C, Lansdorp-Vogelaar I, de Jonge L, Rabeneck L. Rationale for organized colorectal cancer screening programs. *Best Pract Res Clin Gastroenterol*. 2023;66:101850. doi:10.1016/j.bpg.2023.101850
2. Cardoso R, Guo F, Heisser T, et al. Colorectal cancer incidence, mortality, and stage distribution in European countries in the colorectal cancer screening era: an international population-based study. *Lancet Oncol*. 2021;22(7):1002-1013. doi:10.1016/s1470-2045(21)00199-6
3. Ebell MH, Thai TN, Royalty KJ. Cancer screening recommendations: an international comparison of high income countries. *Public Health Rev*. 2018;39(1):7. doi:10.1186/s40985-018-0080-0
4. Senore C, Basu P, Anttila A, et al. Performance of colorectal cancer screening in the European Union Member States: data from the second European screening report. *Gut*. 2019;68(7):1232-1244. doi:10.1136/gutjnl-2018-317293
5. Essink-Bot M-L, Dekker E. Equal access to colorectal cancer screening. *Lancet*. 2016;387(10020):724-726. doi:10.1016/s0140-6736(15)01221-0
6. European Colorectal Cancer Screening Guidelines Working Group, von Karsa L, Patnick J, et al. European guidelines for quality assurance in colorectal cancer screening and diagnosis: overview and introduction to the full supplement publication. *Endoscopy*. 2013;45:51-59.
7. Allison JE, Fraser CG, Halloran SP, Young GP. Population screening for colorectal cancer means getting FIT: the past, present, and future of colorectal cancer screening using the fecal immunochemical test for hemoglobin (FIT). *Gut Liver*. 2014;8(2):117-130. doi:10.5009/gnl.2014.8.2.117
8. Navarro M, Nicolas A, Ferrandez A, Lanas A. Colorectal cancer population screening programs worldwide in 2016: an update. *World J Gastroenterol*. 2017;23(20):3632-3642. doi:10.3748/wjg.v23.i20.3632
9. Ola I, Cardoso R, Hoffmeister M, Brenner H. Utilization of colorectal cancer screening tests across European countries: a cross-sectional analysis of the European health interview survey 2018–2020. *Lancet Reg Health Eur*. 2024;41:100920. doi:10.1016/j.lanepe.2024.100920
10. Mosquera I, Mendizabal N, Martín U, et al. Inequalities in participation in colorectal cancer screening programmes: a systematic review. *Eur J Public Health*. 2020;30(3):416-425. doi:10.1093/eurpub/ckz236
11. De Klerk C, Gupta S, Dekker E, Essink-Bot M; Expert Working Group 'Coalition to reduce inequities in colorectal cancer screening' of the World Endoscopy Organization. Socioeconomic and ethnic inequities within organised colorectal cancer screening programmes worldwide. *Gut*. 2018;67(4):679-687. doi:10.1136/gutjnl-2016-313311
12. Sekhon Inderjit Singh H, Lal N, Majeed A, Pawa N. A systematic review of ethnic disparities in the uptake of colorectal cancer screening. *Perspect Public Health*. 2023;143(2):105-120. doi:10.1177/17579139221093153
13. Wardle J, Robb K, Vernon S, Waller J. Screening for prevention and early diagnosis of cancer. *Am Psychol*. 2015;70(2):119-133. doi:10.1037/a0037357
14. Clarke N, Gallagher P, Kearney PM, McNamara D, Sharp L. Impact of gender on decisions to participate in faecal immunochemical test-based colorectal cancer screening: a qualitative study. *Psycho Oncol*. 2016;25(12):1456-1462. doi:10.1002/pon.4085
15. Clarke N, Hayes L, McQueen A, et al. The role of defensive information processing in population-based colorectal cancer screening uptake. *Cancer*. 2023;129(8):1253-1260. doi:10.1002/cncr.34603
16. Clarke N, Kearney PM, Gallagher P, McNamara D, O'Morain CA, Sharp L. Negative emotions and cancer fatalism are independently associated with uptake of faecal immunochemical test-based colorectal cancer screening: results from a population-based study. *Prev Med*. 2021;145:106430. doi:10.1016/j.ypmed.2021.106430
17. Tsipa A, O'Connor DB, Branley-Bell D, et al. Promoting colorectal cancer screening: a systematic review and meta-analysis of randomised controlled trials of interventions to increase uptake. *Health Psychol Rev*. 2020;15(3):1-24. doi:10.1080/17437199.2020.1760726
18. O'Cathain A, Croot L, Duncan E, et al. Guidance on how to develop complex interventions to improve health and healthcare. *BMJ Open*. 2019;9(8):e029954. doi:10.1136/bmjopen-2019-029954
19. Clarke N, McNamara D, Kearney PM, O'Morain CA, Shearer N, Sharp L. The role of area-level deprivation and gender in participation in population-based faecal immunochemical test (FIT) colorectal cancer screening. *Prev Med*. 2016;93:198-203. doi:10.1016/j.ypmed.2016.10.012
20. Clarke N, Sharp L, Osborne A, Kearney PM. Comparison of uptake of colorectal cancer screening based on Fecal Immunochemical Testing (FIT) in males and females: A systematic review and meta-analysis. *Cancer Epidemiol Biomarkers Prev*. 2015;24(1):39-47. doi:10.1158/1055-9965.epi-14-0774
21. Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implement Sci*. 2012;7(1):37. doi:10.1186/1748-5908-7-37
22. National Screening Service. BowelScreen Programme Report 2020-2021; 2023. Accessed August 5, 2024. https://assets.hse.ie/media/documents/BowelScreen_Programme_Report_2020-2021.pdf
23. National Institute for Public Health and the Environment. *Monitoring colorectal cancer screening 2022*. RIVM. Accessed January 11, 2024. https://www.rivm.nl/en/documenten/monitoring-colorectal-cancer-screening-2022

24. Office of Health Improvement and Disparities. Public health profiles - OHID: NHS England, Bowel Cancer Screening Programme Uptake. Accessed January 11, 2024. https://fingertips.phe.org.uk/search/screening#page/4/gid/1/pat/159/par/K02000001/ati/15/are/E92000001/iid/92601/age/280/sex/4/cat/-1/ctp/-1/yrr/1/cid/4/tbm/1
25. Public Health Scotland. Scottish Bowel Screening Programme statistics; 2023. Accessed January 11, 2024. https://publichealthscotland.scot/publications/scottish-bowel-screening-programme-statistics/scottish-bowel-screening-programme-statistics-for-the-period-of-invitations-from-may-2020-to-april-2022/
26. Gruner LF, Amitay EL, Heisser T, et al. The effects of different invitation schemes on the use of fecal occult blood tests for colorectal cancer screening: systematic review of randomized controlled trials. *Cancers*. 2021;13(7):1520. doi:10.3390/cancers13071520
27. Rubin L, Okitondo C, Haines L, Ebell M. Interventions to increase colorectal cancer screening adherence in low-income settings within the United States: a systematic review and meta-analysis. *Prev Med*. 2023;172:107522. doi:10.1016/j.ypmed.2023.107522
28. Haynes AB, Haukoos JS, Dimick JB. TREND reporting guidelines for nonrandomized/quasi-experimental study designs. *JAMA Surg*. 2021;156(9):879-880. doi:10.1001/jamasurg.2021.0552
29. Le BA, Meade O, Fredrix M, et al. Exploring non-participation in colorectal cancer screening: a systematic review of qualitative studies. *Soc Sci Med*. 2023;329:116022.
30. Michie S, Richardson M, Johnston M, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Ann Behav Med*. 2013;46(1):81-95. doi:10.1007/s12160-013-9486-6
31. National Screening Service. BowelScreen Programme Report 2020-2021; 2023. Accessed August 5, 2024. https://assets.hse.ie/media/documents/BowelScreen_Programme_Report_2020-2021.pdf
32. Wardle J, von Wagner C, Kralj-Hans I, et al. Effects of evidence-based strategies to reduce the socioeconomic gradient of uptake in the English NHS Bowel Cancer Screening Programme (ASCEND): four cluster-randomised controlled trials. *Lancet*. 2016;387(10020):751-759. doi:10.1016/s0140-6736(15)01154-x
33. Santare D, Kojalo I, Huttunen T, et al. Improving uptake of screening for colorectal cancer: a study on invitation strategies and different test kit use. *Eur J Gastroenterol Hepatol*. 2015;27(5):536-543. doi:10.1097/meg.0000000000000314
34. Haase T, Pratschke J. The 2016 Pobal HP Deprivation Index for Small Areas (SA). 2017. Accessed June 14, 2024. http://trutzhaase.eu/deprivation-index/the-2016-pobal-hp-deprivation-index-for-small-areas/
35. Dougherty MK, Brenner AT, Crockett SD, et al. Evaluation of interventions intended to increase colorectal cancer screening rates in the United States: a systematic review and meta-analysis. *JAMA Intern Med*. 2018;178(12):1645-1658. doi:10.1001/jamainternmed.2018.4637
36. Davis MM, Freeman M, Shannon J, et al. A systematic review of clinic and community intervention to increase fecal testing for colorectal cancer in rural and low-income populations in the United States - how, what and when? *BMC Cancer*. 2018;18(1):40. doi:10.1186/s12885-017-3813-4
37. Issaka RB, Avila P, Whitaker E, Bent S, Somsouk M. Population health interventions to improve colorectal cancer screening by fecal immunochemical tests: a systematic review. *Prev Med*. 2019;118:113-121. doi:10.1016/j.ypmed.2018.10.021
38. Pallesen AVJ, Herrstedt J, Westendorp RGJ, Mortensen LH, Kristiansen M. Differential effects of colorectal cancer screening across sociodemographic groups in Denmark: a register-based study. *Acta Oncol*. 2021;60(3):323-332. doi:10.1080/0284186x.2020.1869829
39. Hirst Y, Stoffel S, Baio G, McGregor L, von Wagner C. Uptake of the English Bowel (Colorectal) Cancer Screening Programme: an update 5 years after the full roll-out. *Eur J Cancer*. 2018;103:267-273. doi:10.1016/j.ejca.2018.07.135
40. Peterse EFP, Osoro CB, Bardou M, Lansdorp-Vogelaar I. Comparative success and cost-effectiveness of mailed-out faecal immunochemical tests versus collection at the general practitioner. *Aliment Pharmacol Ther*. 2021;53(10):1118-1125. doi:10.1111/apt.16317
41. McCowan C, McSkimming P, Papworth R, et al. Comparing uptake across breast, cervical and bowel screening at an individual level: a retrospective cohort study. *Br J Cancer*. 2019;121(8):710-714. doi:10.1038/s41416-019-0564-9
42. Njor SH, Søborg B, Tranberg M, Rebolj M. Concurrent participation in breast, cervical, and colorectal cancer screening programmes in Denmark: a nationwide registry-based study. *Prev Med*. 2023;167:107405. doi:10.1016/j.ypmed.2022.107405
43. Wools A, Dapper EA, Leeuw JRJD. Colorectal cancer screening participation: a systematic review. *Eur J Public Health*. 2016;26(1):158-168. doi:10.1093/eurpub/ckv148
44. Jolidon V, De Prez V, Bracke P, Cullati S, Burton-Jeangros C. Lack of social support, gender and colorectal cancer screening participation across Europe: how do screening programmes mitigate the effect of social support for men and women? *Sociol Health Illn*. 2024;46(6):1212-1237.
45. Ritvo P, Myers RE, Paszat L, Serenity M, Perez DF, Rabeneck L. Gender differences in attitudes impeding colorectal cancer screening. *BMC Public Health*. 2013;13(1):500. doi:10.1186/1471-2458-13-500
46. Bambury N, Brennan A, McDevitt J, Walsh P. Cancer inequality in Ireland by deprivation 2004-2018: a National Cancer Registry report. *Cork: Ireland*. 2023. Accessed June 14, 2024. https://www.ncri.ie/sites/ncri/files/pubs/NCRI_CancerInequalityReport_01022023.pdf
47. Lorenc T, Petticrew M, Welch V, Tugwell P. What types of interventions generate inequalities? Evidence from systematic reviews. *J Epidemiol Community Health*. 2013;67(2):190-193. doi:10.1136/jech-2012-201257
48. von Wagner C, Hirst Y, Waller J, et al. The impact of descriptive norms on motivation to participate in cancer screening – evidence from online experiments. *Patient Educ Couns*. 2019;102(9):1621-1628. doi:10.1016/j.pec.2019.04.001
49. Gorini G, Betti E, Stoffel S, et al. Testing behavioral economics messages to increase non-responders' participation in organized colorectal cancer-screening programs: a randomized controlled trial. *Prev Med*. 2023;174:107615. doi:10.1016/j.ypmed.2023.107615
50. Albarracín D, Fayaz-Farkhad B, Granados Samayoa JA. Determinants of behaviour and their efficacy as targets of behavioural change interventions. *Nat Rev Psychol*. 2024;3(6):377-392. doi:10.1038/s44159-024-00305-0

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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