The associations between objective numeracy and colorectal cancer screening knowledge, attitudes and defensive processing in a deprived community sample

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Abstract

We examined associations between numeracy and sociocognitive factors associated with colorectal cancer (CRC) screening uptake (n=964). Nearly half (45.7%) the respondents incorrectly answered a numeracy question (low numeracy). Low numeracy respondents were less knowledgeable about CRC ($p<.001$), less positive towards screening (emotional, $p<.001$ and practical, $p=.001$) and less likely to intend to participate in screening ($p=.001$). They also reported greater defensive processing of cancer information ($p=.001$). **Sociocognitive factors fully mediated the relationship between numeracy and screening intention**. Addressing numeracy issues may reduce inequalities in CRC screening participation, but communication strategies could be limited by the tendency process cancer information defensively.

Introduction

Colorectal cancer (CRC) has the second highest cancer-specific mortality in the United States (US) and the United Kingdom (UK; Cancer Research UK, 2011; U.S. Cancer Statistics Working Group, 2013). CRC screening tests aim to detect cancer early or to prevent CRC by identifying and removing pre-cancerous lesions. In the US, the latest figure for up-to-date CRC screening prevalence was estimated to be 63% (Centers for Disease Control and Prevention, 2010). Participation rates in Europe are consistently below 60% (Goulard et al., 2008; von Wagner, et al., 2011a) and sometimes as low as 20% (Katičić et al., 2012).

Inadequate health literacy and numeracy skills have also been shown to be a barrier to CRC screening participation, even after controlling for characteristics such as ethnicity, education and income (Kobayashi et al., 2014; Oldach & Katz, 2014). **Health literacy has been defined as 'the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions' (Institute of Medicine, 2004). When considering numeracy as an isolated skill it is defined as the ability to understand and use numbers, which in a health context can facilitate access to care, engagement with medical treatment and informed decision-making (Reyna, 2009). More recently, there have been calls to extend the scope of health literacy research by incorporating the broader context of the healthcare environment (Rudd, 2013; Estacio & Comings, 2013).**

Conceptual models have suggested pathways linking **health literacy and numeracy** with screening participation (von Wagner et al., 2008). **Building on health psychology theories, the conceptual models suggest that in addition to socio-demographic characteristics, health**

literacy and numeracy skills predict socio-cognitive factors such as knowledge and attitudes, which subsequently explain screening intention and participation (Conner & Norman, 2005). Reviews of empirical research have supported these theoretical predictions (Kiviniemi et al., 2011; von Wagner, et al., 2011b). **An overview of the conceptual model used in this study is shown in Figure 1.**

Evidence suggests there is a relationship between health literacy and socio-cognitive factors such as CRC screening knowledge and attitudes towards screening participation. However, there have been few studies investigating associations with numeracy. Dolan and colleagues found that low health literacy groups were more likely to consider FOB testing to be messy, inconvenient and unnecessary without symptoms (Dolan et al., 2004). Socioeconomic differences in barriers specific to FOB screening such as disgust, storage difficulties, privacy issues, and concerns that the test will be time-consuming have been reported (Jones et al., 2010; Robb, et al., 2008a). However, when differences by health literacy have been investigated, belief scales have been reported as total scores, limiting insight into where differences exist (Peterson et al., 2007).

Knowledge about CRC and CRC screening is not only an important determinant of uptake, but it can also affect informed decision-making (Ramirez & Forbes, 2012; **Smith, et al., 2013a**). Groups with poor basic skills are less likely to have heard of CRC and CRC screening modalities (Dolan et al., 2004). However, there are other components of CRC screening knowledge (e.g. CRC incidence and the risks/benefits of participation) that may highlight disparities (Smith et al., 2012; Viswanath, 2005).

The socio-cognitive antecedents of CRC screening can be affected by the tendency to avoid cancer information (Miles et al., 2008). This is troublesome for screening programs that provide health communication materials designed to inform or challenge erroneous beliefs (Smith et al., 2013b). In McQueen et al's defensive processing framework, informational avoidance is an important component (McQueen et al., 2013), but defensive processing has not been examined relative to numeracy skills.

This study aimed to investigate the associations **and mediating pathways** between numeracy and FOBt-related knowledge, attitudes, and defensive processing among a sample of adults approaching the eligible age for CRC screening in England. **Our hypotheses were: i) people with higher objective numeracy would be more knowledgeable, have more positive attitudes, lower defensive processing tendencies, and greater intention to participate in CRC screening; ii) the relationship between numeracy and screening intention would be mediated by sociocognitive factors; iii) defensive processing would mediate the association between numeracy and knowledge and attitudes; and iv) knowledge and attitudes would mediate the association between defensive processing and CRC screening intention.** These data were collected as part of a secondary analysis of a randomized controlled trial reported elsewhere (Smith et al., in press).

Method

Study design

Data were from a study undertaken between July, 2012 and March, 2013, in which adults approaching the screening eligible age were randomised to receive two versions of CRC screening information. One group was sent the CRC information booklet used in the NHS

screening programme ('Bowel Cancer Screening: The Facts'), and the other was sent a supplementary low literacy booklet (Smith et al., 2013c; in press). For this study, groups were combined to create a single pool of respondents, but analyses controlled for group allocation.

In addition to the information materials, potential participants were sent a questionnaire containing the study measures and a return envelope. Non-responders were sent a reminder letter and additional questionnaire after three weeks (median=22 days [range 22-41 days). The protocol was given ethical approval in February, 2012.

Sample

With assistance from the Primary Care Research Network (PCRN), four General Practices in the North of England were identified using the Index of Multiple Deprivation (IMD), **a routinely calculated metric from the Department of Communities and Local Government. It** provides a score for small area concentrations of deprivation based on income, employment, health, education & training, access to services, living environment/housing, physical environment and crime. **Scores range from 0 (least deprived) to 88 (most deprived) and were obtained for each practice by entering their postcode into GeoConvert (www.geoconvert.mimas.ac.uk). After identifying practices willing to assist with research, they were rank ordered by deprivation, and the most deprived practices were approached first. A single affluent practice was also selected to ensure an adequate response rate. In order of the most deprived first, IMD scores for the practices used in this study were: Liverpool A (77.3), Manchester (43.6), Liverpool B (37.6), and Stockport (10.8). The IMD** has previously been used in studies demonstrating associations between SES and CRC screening uptake (Moss et al., 2012; Steele et al., 2010). Men and women aged 45-59.5 registered with the

Practices were sent study information. People were not invited if they had severe cognitive impairment, a recent diagnosis of cancer or other significant illness, were under CRC surveillance, or were registered as not speaking English.

Measures

Numeracy

Numeracy was assessed using a single-item measure: '*Which of the following numbers represents the biggest risk of getting a disease*': '1 in 100', '1 in 1000', '1 in 10'. Respondents were scored as either correct (higher numeracy) or incorrect (lower numeracy). This item was used in the nationally representative HINTS survey, where over one fifth of respondents responded incorrectly (Nelson et al., 2013).

CRC Screening Knowledge

CRC screening knowledge was assessed with a nine item scale reflecting essential knowledge to make a screening decision (Mullen et al., 2006). The response options were 'true', 'false' or 'don't know'. This method has previously been used in the assessment of gist knowledge (Smith et al., 2012). One point was awarded per correct answer, and a total score was calculated. Internal consistency was adequate (α=.73).

Attitudes

Five questions adapted from other studies assessed emotional attitudes towards the FOBt on 4-point Likert scales (strongly disagree to strongly agree)(online appendix) The score range was 5-20, with higher scores indicating more negative attitudes. Internal consistency was adequate (α=.69). Four questions related to attitudes to practical aspects of the FOBt (online

appendix). Score range was 4-16, with higher scores indicating more negative attitudes. Internal consistency was adequate (α=.80).

Defensive processing

Eight items were adapted from McQueen and colleagues' defensive processing scale (McQueen et al., 2013). Respondents answered items on 4-point Likert scales (strongly disagree to strongly agree) (see online appendix). The score range was 8-32, with higher scores indicating greater defensive processing. Internal consistency was adequate (α=.85).

Screening intention

The screening intention item was based on the question asked in the UK Flexible Sigmoidoscopy Trial (Atkin et al., 2010). Responses options were 'yes, definitely', 'yes, probably', 'probably not', 'definitely not'.

Respondent characteristics

Questionnaire items assessing age, gender, marital status, ethnicity, education and self-rated health were included.

Sample size

The study was powered to detect differences in screening intention between the study groups in the original trial. However, sensitivity power analyses assuming two groups, seven covariates, α=.05 and 90% power indicated that a sample of 964 respondents would be sufficient to detect a small effect ($\eta\rho^2$=0.011).

Analysis

Non-responder analyses using Chi-square and t-tests compared questionnaire data on gender, age, deprivation and number of people in the household against GP records. Differences in numeracy across participant characteristics were assessed using chi-square analyses. Analysis of Covariance (ANCOVA) was used to test the difference in mean knowledge, attitudes, intention and defensive processing between the numeracy groups. These analyses were adjusted for age, gender, marital status, ethnicity, education, self-rated health, and study arm. Partial eta-square ($\eta\rho^2$) effect sizes were calculated for ANCOVA analyses. Group differences on the individual items were described, but not tested statistically. **Pearson's correlation was used to test associations between the outcome measures, and step-wise linear regression using the enter method tested mediating pathways.**

Numeracy data were frequently missing (10.5%) and considered to be 'missing not at random' (MNAR). Numeracy data were considered to be missing not at random, as most of these respondents had data for knowledge and intention (94% and 100% respectively). Respondents with missing numeracy data were coded as having 'low numeracy', but analyses were repeated excluding respondents without numeracy scores. These analyses yielded no substantial changes. Knowledge data were considered to be MNAR if at least five items had been completed. Individuals who responded to fewer than five items (n=6) were excluded from these analyses. For the remaining respondents (n=31), the knowledge scale was transformed to a percentage to account for the number of items that the participant responded to. Missing data were minimal (0.7%-2.7%) for the remaining outcomes and were considered to be 'missing at random'. They were therefore deleted pairwise.

Results

Sample

A total of 4452 individuals were sent an invitation to participate in the study, and 3631 (81.6%) were sent a reminder. Twenty three invitations were not delivered. Questionnaires were returned by 1269 individuals, of which 964 were at least partially completed, providing a cooperation rate of 21.9%. Questionnaire data on age and gender were compared with practice records and people were excluded if there were discrepancies (n=26). Non-responders were more likely to be male ($p<.001$), younger ($p<.001$), deprived ($p<.001$) and be in a home with two or more invitees ($p=.044$).

Approximately half were male (49%), and there was a good age span (Table 1). The majority were married (66.9%) and white (83.8%), and most had received either some formal education (49.9%) or had attended university (36.5%). Over half indicated that their health was good (53.9%) or excellent (11.2%). Nearly half (45.7%) were classified as having low numeracy. There were no differences in numeracy by gender ($p=.528$), age ($p=.263$), marital status ($p=.306$), or self-rated health ($p=.112$). Respondents with lower levels of education more frequently had low numeracy ($p<.001$). White respondents (56.1%) and those classified as 'Other' (56.4%) generally had higher levels of numeracy than Black (45.2%) and South Asian (37.9%) respondents ($p=.033$).

CRC and CRC screening knowledge

Respondents had high levels of knowledge (M=7.70 out of a possible 9; SD=1.74). In analyses controlling for age, gender, marital status, ethnicity, education, self-rated health, and study arm, the average number of correct responses was 7.31 (SD=1.93) and 8.06 (SD=1.44) in the low and high numeracy groups, respectively ($F(1, 926)=32.82$, $p<.001$, $\eta\rho^2=.034$).

Supplementary Table 1 shows responses to individual knowledge items. Differences were greater for the items *'Bowel cancer is a common cancer in people over 60'* (15.7% difference), and *'The FOB test can miss bowel cancer'* (16.4% difference).

Emotional attitudes towards FOBt

A minority of respondents agreed that the test would be disgusting (17.3%), embarrassing (7.9%), or would be tempting fate (6.9%) (Table 2). A similar proportion agreed that the test would make them worry more about CRC (17.6%). Over half (51.3%) were afraid of an abnormal result. On average, participants scored 9.52 (SD=2.40) out of 20 on the emotional attitudes scale, indicating slightly more disagreement than agreement with the items. Negative attitudes were higher for the low numeracy group (M=10.01, SD=2.36) than the high numeracy group (M=9.10, SD=2.32; $F(1, 900)=28.27$, $p<.001$, $\eta\rho^2=.030$). As shown in Table 2, differences in agreement between the numeracy groups were noted for all emotional attitudes, but a particularly strong effect occurred for the item, '*I would be afraid of getting an abnormal result from my FOB test*' (11.7% difference).

Practical attitudes towards FOBt

Approximately 1 in 6 respondents agreed that they would not want to keep stool samples in the house (14.4%) (Table 2). Fewer respondents anticipated insufficient privacy (5.4%) or lack of time to do the FOB test (5.1%), or said that they would only complete the test if they had CRC related symptoms (5.6%). The average scores on the scale were 6.54 (SD=2.13) out of 16, indicating disagreement with most items. Respondents with low numeracy (M=6.80, SD=2.22) reported significantly more negative practical attitudes than those with high numeracy (M=6.26,

SD=2.00; F(1,914)=10.30, p=.001. $\eta\rho^2$=.011). As shown in Table 2, low numeracy respondents were more likely to agree with all practical attitude items (range=4.1%-5.6%).

Defensive processing

The prevalence of defensive processing ranged from 4.4% to 21.5% (Table 2). The average level of defensive processing was 14.43 (SD=3.58) out of 30, indicating more or less equal agreement. Low numeracy respondents (M=14.90, SD=3.79) had higher levels of defensive processing than those with high numeracy (M=13.99, SD=3.32; F(1,895)=11.38, p=.001. $\eta\rho^2$=.013). Low numeracy respondents were more likely to agree with each of the defensive processing items (difference range=3.7%-7.0%).

CRC screening intention

The majority of the sample either 'definitely' (71.7%) or 'probably' (24.3%) intended to participate in screening, with very few respondents saying they would 'probably not' (2.4%) or 'definitely not' (1.6%) take part. Scoring intention from 1 to 4 (with higher indicating more intention), the average was 3.66 (SD=0.61). Low numeracy respondents had lower levels of screening intention than high numeracy respondents (Mean=3.59, SD=0.67 vs. M=3.73, SD=0.53 respectively; (F(1,923)=10.75, p=.001. $\eta\rho^2$=.012).

All outcome measures were strongly associated (ps<.001). To investigate if defensive processing, knowledge, emotional attitudes and practical attitudes mediated the relationship between numeracy and screening intention, step-wise linear regression entering numeracy (step 1) and then numeracy with all sociocognitive variables (step 2) was performed. All mediation analyses controlled for age, gender, marital status, ethnicity, education, self-rated health, and study arm. The relationship between numeracy and

screening intention was fully attenuated by the sociocognitive factors (numeracy: step 1; β=-.07, p=.038, step 2; β=-.006, p=.856, 91% attenuation). Additional analyses investigated if defensive processing mediated the relationship between numeracy and knowledge, emotional attitudes, and practical attitudes. Step 1 entered numeracy, and step 2 entered numeracy with defensive processing. Defensive processing marginally attenuated numeracy's relationship with knowledge (numeracy: step 1; β=-.17, p<.001, step 2; β=-.14, p<.001, 14% attenuation) and emotional attitudes (numeracy: step 1; β=.17, p<.001, step 2; β=.11, p<.001, 36% attenuation), but full mediation was seen for the practical attitudes outcome (numeracy: step 1; β=.10, p<.003, step 2; β=.03, p=.223, 67% attenuation). Using a similar process entering defensive processing, participant characteristics, and numeracy (step 1) and then knowledge and attitudes (step 2) full mediation of the relationship between defensive processing and screening intention was seen (defensive processing: step 1; β=-.25, p<.001, step 2; β=-.05, p=.236, 80% attenuation).

Discussion

In this UK sample recruited from General Practices, people with low numeracy had lower levels of knowledge about CRC screening, and reported more negative attitudes towards FOB testing. Less numerate respondents were also less inclined to take part in CRC screening, and had a greater tendency to engage in defensive processing of cancer-related information. These findings were significant after adjustment for socio-demographic characteristics such as education and ethnicity. Numeracy skills may be an independent explanatory variable that should be considered when investigating the antecedents of CRC screening uptake.

The relationship between numeracy and screening intention was fully attenuated when including the sociocognitive factors in the model. Furthermore, defensive processing attenuated the relationship between numeracy and practical attitudes, while knowledge and attitudes mediated the relationship between defensive processing and screening intention. These results supported our conceptual model by suggesting that low numeracy individuals may be less inclined to participate in CRC screening because of more negative attitudes, less knowledge and a greater tendency to process cancer information defensively. Experimental evidence is needed, but addressing these barriers may increase interest in CRC screening among low numeracy groups without having detrimental effects on the motivation of high numeracy groups.

In response **to the higher levels of practical barriers reported by low numeracy respondents,** CRC screening programs could implement single-sample immunochemical test kits. Such changes may help to reduce barriers such as disgust (von Wagner et al., 2012), and a meta-analysis suggests screening uptake would increase (Vart et al., 2012). **The extent to which these interventions narrow attitudinal differences between numeracy groups should be investigated.**

Most respondents agreed that they would be screened despite having no symptoms, but people with low numeracy were less likely to indicate this. They were also more likely to endorse the defensive process that they did not need to be screened because they had regular bowel movements. These findings are problematic as early stage CRC is often asymptomatic and defecation frequency has no relationship with CRC (Power et al., 2013). Raising public awareness that CRC screening should be performed prior to the identification of symptoms may correct erroneous beliefs regarding the development of CRC.

There were consistent differences between the numeracy groups in knowledge. Over 40% of the low numeracy group did not realise that the FOB test can miss CRC and over 30% were not aware that CRC is a common cancer. These differences highlight the importance of educating the public about CRC, particularly with regard to the incidence and symptoms of the disease (Peacock et al., 2013). **Targeted outreach campaigns situated in deprived areas where literacy and numeracy skills may be lacking could reduce communication inequalities (Smith et al., 2014).**

The higher levels of defensive processing among the low numeracy group may partially explain their poorer knowledge and negative attitudes. Healthcare professionals interacting with the public should be aware of differences in defensive processing if communication inequalities are to be avoided. Interventions have successfully reduced informational avoidance, but they have been confined to laboratory settings **and differences by health literacy and numeracy were not investigated** (Howell & Shepperd, 2013).

Strategies are needed to reduce knowledge disparities and address sociocognitive barriers, while also being mindful of the tendency to engage in defensive processing. The UK program relies on written information to communicate the screening offer, making it easy for the public to ignore (Smith et al., 2013b). **Improving the readability of information may not have the expected effect on communication inequalities. For example, a UK study tested an information leaflet promoting cancer symptom awareness. Despite using principles of health literacy in the leaflet design, greater knowledge improvements were seen among those with adequate health literacy (Boxell et al., 2011).** Efforts from the US have increased screening completion rates when professional health workers or laypersons actively 'navigate' patients through the process, **with particularly strong effects for low health literacy patients**

(Davis et al., 2014). Similar **navigation** approaches could be taken in the UK Flexible Sigmoidoscopy program which necessitates contact with a healthcare professional. **The effects of patient navigation on groups with low health literacy and numeracy skills should be monitored.**

The most serious limitation was the low cooperation rate (21.9%), particularly among men, those from a less affluent neighbourhood, and people in the younger age group. The response rate was low compared with previous general practice surveys, which might be explained by our recruitment from socioeconomically deprived areas (Robb, et al., 2008b). The assessment of basic skills was limited to numeracy, which was necessary due to paucity of health literacy assessments that reliably and objectively measure the construct in the absence of a researcher. However, we note that the most commonly used health literacy tools often contain numeracy components (Parker et al., 1995; Weiss et al., 2005) and studies have suggested a high degree of overlap between the constructs (Osborn et al., 2010). Subjective assessments are available, but they correlate poorly with objective measures of health literacy (Smith et al., 2010). Our findings are observed in a sample that had high intentions to participate in CRC screening, which may have biased responses to the attitudinal statements.

In conclusion, this study identified substantial and important differences in knowledge, attitudes and defensive processing associated with CRC and CRC screening across numeracy groups. Identifying group differences in socio-cognitive constructs known to be associated with CRC screening uptake highlights targets for future intervention strategies aiming to reduce disparities. Our observation that there are differences in defensive processing between numeracy groups suggests improving attitudes and knowledge may be challenging. Researchers attempting to communicate with the public should pay attention to the defensive processing construct, and

be aware that more intensive efforts may be needed to overcome avoidance of cancer-related information.

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