Do health behaviours change after colonoscopy? A prospective cohort study on diet, alcohol, physical activity and smoking among patients and their partners.

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Do health behaviours change after colonoscopy? A prospective cohort study on diet, alcohol, physical activity and smoking among patients and their partners.

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ABSTRACT

Objectives

We hypothesised that colonoscopy triggers changes in health behaviours. Our objective was to describe diet, alcohol, physical activity and tobacco use before and after colonoscopy for patients and their partners.

Design

Prospective cohort study of patients and their partners before and 10 months after colonoscopy.

Setting

5 Scottish hospitals.

Participants

Of 5,798 colonoscopy registrations, 2,577 (44%) patients met eligibility criteria of whom 565 (22%) were recruited; 460 partners were also recruited.

Measures

International Physical Activity Questionnaire, Scottish Collaborative Group Food Frequency Questionnaire (includes alcohol), smoking status, age, sex, education, household income, employment status, Scottish Index of Multiple Deprivation (SIMD), Body Mass Index, medical conditions, result of the colonoscopy (abnormal result notification (ARN) or normal result notification (NRN)), Multidimensional Health Locus of Control Scale (MHLC), behaviour-specific self-efficacy scales.

Results

57% of patients were male, mean age 60.8 years (SE 0.5) and 43% were from more affluent areas. Response rate to the second questionnaire at 10 months was 68.9%. Overall, 27% of patients consumed less than 5 measures of fruit & vegetables per day, 20% exceeded alcohol limits, 50% had low levels of physical activity and 21% were obese. At 10 month follow-up, a 5% reduction in excessive alcohol consumption and an 8% increase in low levels of physical activity were observed among patients; no significant behavioural changes occurred in their partners. Baseline high alcohol consumption and low physical activity were the strongest predictors of these behaviours at follow-up. Additionally, low alcohol self-efficacy and increasing age were associated with poorer health-related behaviours at follow-up for alcohol and physical activity, respectively.

Conclusions

Colonoscopy can be regarded as a teachable moment for patients, being associated with changes in some health behaviours. Further work is needed to explore how services can optimize increases in beneficial health behaviours and mitigate increases in harmful ones.

Article summary

Article focus

- Colonoscopy is an increasingly common investigation that might trigger spontaneous behavioural changes in patients.
- Little is known about health behavior change following colonoscopy, particularly in the UK.
- We carried out a prospective cohort study of patients who underwent colonoscopy and their partners.

Key messages

- There is a high prevalence of unhealthy behaviours in colonoscopy patients.
- We observed significant reductions in excessive alcohol consumption but also decreases in physical activity following colonoscopy.
- There may be opportunities to encourage spontaneous improvements in health behaviours among colonoscopy patients and to mitigate harmful behaviours.

Strengths and limitations of this study

- This is the first observational study on health behaviours in colonoscopy patients in the UK.

- We obtained a large sample size and high follow-up rate and were able to use patients' partners as controls.
- Selection biases may have led to our sample comprising healthier patients than in the general colonoscopy population.

INTRODUCTION

Illnesses and interactions with health services may motivate patients to change their behaviours. Such "teachable moments" have been described for changes in smoking behaviour following life transitions, such as pregnancy, and health events, such as screening for lung cancer.[1,2,3,4,5,6,7,8,9,10] A recent review of the literature concludes that while the term "teachable moment" is used imprecisely – to describe either an opportunity for behavioural change or an event associated with actual change - there is evidence that beneficial behavioural changes can be actively created through appropriate clinician-patient interactions.[11] To our knowledge, evidence from the UK that patients who undergo screening for cancer are likely to make improvements in health behaviour is limited to a single pilot study of a health promotion intervention delivered during colorectal cancer screening.[12] The evidence from observational research that there are spontaneous health behaviour changes after a cancer diagnosis is limited to retrospective analyses of population surveys that depend on self-reported cancer diagnosis.[13] Relatives of cancer patients may also change their behaviour in response to a familial diagnosis, but the evidence is limited to one study on breast cancer.[14]

Colonoscopy is mainly performed for the diagnosis of colon and rectal cancer and current UK rates of 80 procedures per 10,000 population are likely to increase in the future as screening by flexible sigmoidoscopy is introduced.[15] The number of colonoscopies performed through the Scottish bowel screening programme almost doubled from 5,358 in 2009 to 9,296 in 2011; in England, 368,162 colonoscopies were carried out in 2009-10.[16,17] We hypothesised that colonoscopy represents both concepts of a teachable moment for health behaviour change: it may be a time of concern about a cancer diagnosis and thus be associated with

spontaneous change,[1,18] and it may also present an opportunity for clinicians to promote improvements in behaviours. An abnormal colonoscopy result may be more likely to trigger changes in behaviour, so we compared behaviours between participants with normal and abnormal test results. Our aim was to describe health-related behaviours before and after a colonoscopy among patients and their partners. Our objective was to carry out a prospective observational study on colonoscopy patients and their partners using self-reported questionnaire survey data immediately before and ten months after colonoscopy. As self-efficacy and locus of control are central to several health behaviour theories, including the Health Belief Model,[19] Social Cognitive Theory[20] and Protection Motivation Theory,[21] we assessed their roles using validated questionnaires and also recorded physical activity, tobacco smoking and alcohol consumption.

METHODS

Study design

Prospective cohort study of health behaviours of patients referred for colonoscopy and their partners.

Setting

Colonoscopy clinics in five hospitals within three Health Board areas in Scotland, UK. Recruitment occurred between September 2010 and August 2011.

Participants

Patients were invited by an advert for the study enclosed along with their colonoscopy appointment letter from the hospital. On attendance for colonoscopy, clinic staff obtained

verbal consent for patients (and, if present, their partners) to allow the Research Assistant (RA) to approach them. If a patient did not wish to be approached by the RA, consent was sought to retain non-identifiable data (age, sex and sector level of the postcode) to assess selection bias. The RA asked consenting participants to complete the baseline (T1) questionnaire and written consent form at home and return both in a pre-paid addressed envelope. Patients whose partners were not present were asked to provide the name and contact details of their partner who was subsequently contacted by the RA by telephone about the study.

Eligibility criteria

Patient inclusion criteria were: i) referred for colonoscopy, ii) no past history of cancer, iii) ≥18 years old, iv) has a partner. Partner inclusion criteria: i) ≥18 years old, ii) no history of cancer.

Variables, measures and data sources

Information was self-reported by participants or obtained from medical records.

Heath-related behaviour variables

The International Physical Activity Questionnaire[22,23] was used to categorise participants into low, moderate or high levels of PA using Metabolic Equivalent of Task (MET) scores. The Scottish Collaborative Group Food Frequency Questionnaire (SCG FFQ)[24,25] was used to measure intakes of foods and alcohol. Current smokers were defined as those who had smoked at least 100 cigarettes in their entire life and currently smoked.

An aggregate risk behaviour score was calculated based on generally accepted requirements for risk factor reduction for most of the main chronic diseases and specifically for prevention of colorectal cancer because colonoscopy is a main investigation for colorectal cancer

symptoms.[26,27] Specifically, we defined high risk behaviour using Scottish government recommendations[28,29,30] as follows: <5 measures/day of fruit and vegetables; <3 portions/day of bread; >4 (men) and >3 (women) units/day of alcohol; current smoker; and low physical activity (equivalent to less than thirty minutes of moderate intensity activity on at least 4 days of the week). For the purpose of this study, a 'measure' as defined in the SCG FFQ was assumed to be equal to a 'portion' of fruit or vegetables.

Demographic variables

Participants self-reported their age, sex, level of education, household income, employment status, and postcode (to calculate Scottish Index Multiple Deprivation (SIMD[31])).

Clinical variables

Body Mass Index (BMI) was calculated by dividing weight (kg) by height squared (m^2) using self-reported values. Participants were categorised as obese if BMI≥30.0 kg/m^2. Participants self-reported their medical conditions currently being treated by a doctor. Result of the colonoscopy was obtained from patient medical records. Patients were categorised as receiving a normal result notification (NRN) or abnormal result notification (ARN) such as, colorectal cancer, polyps or diverticulitis.

Psychological variables

Participants' perceived control over their health-related behaviours was measured using the Multidimensional Health Locus of Control Scale[32,33]. The instrument measures three dimensions of control: internal, powerful others and chance. Participants' self-efficacy was measured using four separate self-efficacy scales (smoking, diet, alcohol, PA) recommended by Schwarzer and colleagues.[34] There is no cut-off score to define persons as being high or low self-efficacious so we split the sample at the median, as recommended by Schwarzer.

Data collection

The baseline (T1) questionnaire was administered to patients who attended a colonoscopy clinic between September 2010 and August 2011. A pre-paid envelope was provided for participants to return the questionnaire after completing it at home. The follow-up questionnaire (T2) was posted 10 months after the clinic date for colonoscopy, between July 2011 and June 2012.

Bias

We attempted to minimise information biases by using, where possible, validated questionnaires and to minimise selection biases by inviting all colonoscopy patients to participate.

Sample size and statistical analysis

Statistical analysis was carried out using Stata/SE 11.2 software. Means ± standard errors or medians [interquartile range (IQR)] were presented as appropriate following visual assessment of histograms of continuous variables. Differences in characteristics and behaviours between groups were assessed using Pearson's chi-squared test for categorical measures and either T-tests or Mann-Whitney tests for continuous variables as appropriate. Differences in continuous variables between T1 and T2 were assessed using a paired T-test or the Wilcoxon signed-rank test. Differences in categorical variables between T1 and T2 were assessed in SPSS version 20 using the McNemar-Bowker test for variables with 3 or more categories, and the McNemar test for binary variables. To predict health-related behaviour at T2 logistic regression models were undertaken.

This paper reports a comparison of changes in health behaviours of patients with NRN and ARN following colonoscopy. However, the study had initially aimed to detect an increase in physical activity of 25 or greater MET hours in patients diagnosed with cancer at colonoscopy compared to non-cancer patients, and samples of 46 cancer and 46 non-cancer patients would have been required. The effect size was derived from Satia,[35] and sample size calculations assumed conventional values of α=0.05 and β=0.20 (giving a power, or 1- β, of 80%). Thus, our study numbers exceeded those required by the initial sample size calculation.

RESULTS

Of 5,798 colonoscopy registrations, 2,577 patients (44%) met eligibility criteria for the study of whom 565 (22%) eligible patients and 460 partners were recruited (**Error! Reference source not found.**). Recruited patients compared to non-recruited patients were significantly older (60.3 ± 0.5 versus 57.2 ± 0.4), more affluent (Carstairs decile 1 and 2, 43% versus 29%) and a higher proportion male (57% males versus 50% male). Overall, 68.9% (n=706) of participants returned a second, follow-up questionnaire at T2.

{Please insert Figure 1 here}

At baseline (T1), a higher proportion of patients with abnormal result notification (ARN) were male, older, retired, and with a household income under £20,000 compared to patients with normal result notification (NRN) - **Error! Reference source not found.**. Overall 27% consumed less than five measures a day of fruit/vegetable, 20% exceeded recommended alcohol limits, 50% had low levels of physical activity and 21% were obese. Higher proportions of ARN patients were not meeting these recommendations but the

difference was only significant for physical activity. Only 11% of patients reported current smoking. When combined, overall 52% of participants had 2 or more risk behaviours, which comprised 55% of ARN and 42% of ARN.

{Please insert Table 1 here}

There were no significant differences between patients with abnormal and normal results with respect to self-efficacy for smoking cessation, physical activity, diet and alcohol (Table 2). Partners of patients with normal results were more likely to have low self-efficacy for smoking cessation.

{Please insert Table 2 here}

Overall, there was a 5% reduction in respondents who exceeded alcohol consumption guidance and an 8% increase in the proportion with low physical activity - **Error! Reference source not found.**. The proportionate increase in low physical activity was similar in patients with abnormal and normal colonoscopy results but statistically significant only among those with abnormal findings (which might be explained by the larger sample size in the abnormal category). When risk behaviours were aggregated, there was no overall change in behaviours in any patient group. We found no significant change in health behaviours of partners, irrespective of the colonoscopy result of the patient (data not shown).

{Please insert Table 3}

We used multiple logistic regression analyses to explore predictors of the two behaviours that changed significantly over time: low physical activity and high alcohol intake - **Error! Reference source not found.**. Low physical activity at baseline was the strongest predictor of low physical activity at T2 among patients and increasing age was also associated with lower physical activity. Sex, socio-economic circumstances, co-morbidities, colonoscopy findings and self-efficacy did not predict changes in physical activity over time.

{Please insert Table 4}

Excessive alcohol consumption at T2 was most strongly determined by excessive consumption at baseline - **Error! Reference source not found.**. Lower self-efficacy at T1 was associated with higher alcohol consumption at T2. Age, sex, socio-economic circumstances, co-morbidities and colonoscopy findings were not associated with higher alcohol intake at follow-up.

{Please insert Table 5}

DISCUSSION

Colonoscopy is associated with spontaneous changes (that is, without a behavioural intervention) in some health-related behaviours. We found that there was a 5% reduction in excessive alcohol consumption but an 8% increase in low levels of physical activity 10 months after colonoscopy. There were no significant changes in health behaviours among patients' partners, suggesting that behavioural changes in colonoscopy patients were not necessarily part of wider temporal trends. No behavioural advice was given to patients as part of their investigations, and thus colonoscopy might be regarded as a teachable moment in which spontaneous changes are triggered. However, colonoscopy also represents an

interaction with health services that might be optimized to encourage improvements in health-related behaviours. This conclusion is similar to a recent systematic review of eleven articles about the impact of cancer screening (nine of which investigated the impact of lung screening on smoking cessation) which concluded that cancer screening 'might' be a teachable moment for health behaviour change[36]. We found that baseline health behaviours for low physical activity and excessive alcohol consumption were the strongest predictors of the same behaviours 10 months after colonoscopy but, additionally, increasing age predicted lower physical activity and lower self-efficacy around alcohol predicted excessive alcohol consumption at follow-up. Among our patient sample, 11% smoked, which is much lower than the Scottish general adult population prevalence of 23%.[37]

This study found that a low level of PA at the time of colonoscopy and older age were predictive of a low level of PA 10 months post-colonoscopy. Further, high alcohol intake at the time of colonoscopy and low alcohol self-efficacy were predictive of high alcohol intake post-colonoscopy. Of note, fatalism (MHLC Chance score) was not predictive of any differential health behavior change. ARN was not predictive of health behaviour change following this health event, which is in contrast to studies of smokers under-going screening for lung disease.[38,39] A cross-sectional study of over 10,000 smokers at 2-3 years post-screening for COPD found that those with a first-time positive result were significantly more likely to stop smoking than those with a negative result[38]. A cross-sectional study of 134 active smokers who underwent spiral CT screening found that 62% of those with a positive result either stopped or decreased smoking, whereas only 46% with a negative result did so.[39] Thus, the effect of test results following screening for disease on health-related behaviour appears to vary according to type of screen (e.g., colonoscopy versus spiral CT), reason for screening (e.g., colon disease versus lung disease) and health-related behaviour (e.g., alcohol versus smoking).

Our study has strengths and limitations. This is the first prospective observational study to report health-related behaviours of patients and their partners before and 10 months after colonoscopy. We used validated questionnaire survey tools, obtained a relatively large sample for a prospective cohort study and achieved high follow-up rates of 69%. There are however, several study limitations. First, the sample may not be representative of all patients population undergoing colonoscopy. The response rate of eligible patients was 22%, and there was some selection bias towards a more affluent, older and male population. Socio-economic affluence may explain why our sample had lower smoking prevalence than the general population. Patients who participate in the newly introduced national colorectal cancer screening programme also may be more likely to be motivated to change in their behaviour. Although valid and reliable survey instruments were used, self-reported data are susceptible to expectation biases and other misclassification effects.[40] However, our principal interest was in behavioural change rather than absolute prevalences of behaviours, and thus over- or under-reporting of certain behaviours would not necessarily invalidate our findings on whether they changed after colonoscopy. The observed decreases in excessive alcohol consumption and in physical activity following colonoscopy may not be caused by the procedure but by other confounding factors that we have not identified. We are not aware of any health promotion activity associated with colonoscopy as it was delivered within the participating hospitals and our questionnaires were designed not to imply any favourable behaviours. The fact that there were no observed changes in partners and no differences between ARN and NRN patients suggests that the observed behavioural changes in patients was related to the colonoscopy.

Health care settings are recognised as important loci for promoting health behaviour change[41,42,43] and health events have been conceptualised as a teachable moment,

particularly in relation to smoking cessation.[1,2,3,4,5,6,7,8,9,10] Conceptualising health events as teachable moments may be appealing to policymakers and clinicians because they represent an opportunity to introduce low-intensity interventions to change modifiable risk health-related behaviours to prevent disease and a recent review has identified 9 lifestyle interventions at the point of cancer screening to take advantage of this health event as a teachable moment , including 2 studies of a multiple lifestyle intervention offered to people who had undergone colonoscopy and had adenomas removed.[44,45]

For future research, developing and testing the effect of low intensity interventions (e.g., self-efficacy enhancement) to further reduce alcohol consumption may be appropriate because patients appear to spontaneously reduce alcohol consumption following colonoscopy, whereas more intense interventions may be required for health-related behaviours that do not change (e.g., diet) or change for the worse (e.g., physical activity). Qualitative to understand why patients spontaneously change some health behaviours but not others following a major health event will add to understanding about the utility of teachable moments for public health.

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Registrations

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UKCRN 9911

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Contributors: GH designed and managed the study, obtained ethics approval and drafted the paper. DM designed and managed the study, obtained ethics approval and revised the paper. RO, NC, AC, KS, BD and AB designed the study and revised the paper. LM designed the study, wrote the statistical analysis plan, cleaned and analysed the data and revised the paper. SF advised on the statistical analysis plan and analysed the data. All authors have full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

Competing interests: All authors had no support from any organisation for the submitted work, no financial relationships with any organisations that might have an interest in the submitted work in the previous three years and no other relationships or activities that could appear to have influenced the submitted work.

Ethics: The study received West of Scotland Medical Research Ethics Committee approval (REC REF 10/S0709/24). All participants provided written informed consent. The study was funded by the Chief Scientist Office Scotland and the study sponsor was the University of Stirling. The researchers acted independently from the funder and sponsor.

Study hypothesis: The study hypothesis that major health events are teachable moments triggering spontaneous health-related behaviour change arose before inspection of the data. The main hypothesis was that colorectal cancer diagnosis is a teachable moment. This

article reports a further study hypothesis, which was that colonoscopy is a teachable moment.

Data sharing statement: The relevant anonymised patient level data are available on reasonable request from the corresponding author. Participant consent was not obtained but the presented data are anonymised and risk of identification is low.

Figure 1: Recruitment of participants

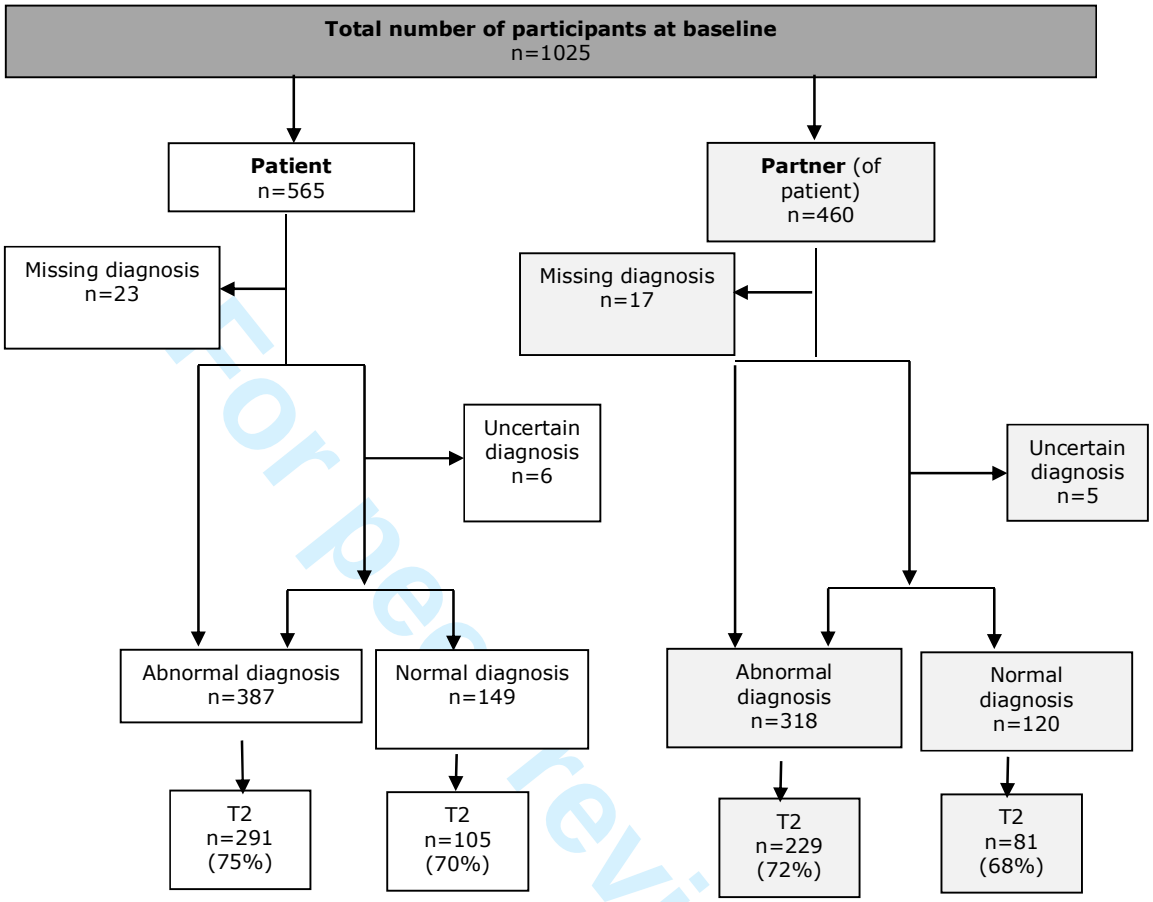

Table 1. Patient and partner baseline characteristics.

	Patients (n=536)				Partners of patients (n=438)		
	All (n=536)	ARN (n=387)	NRN (n=149)	p[1]	ARN (n=318)	NRN (n=120)	p[2]
Sex: Male	308 (57)	236 (61)	72 (48)	***0.008***	121 (38)	56 (47)	*0.101*
Female	228 (43)	151 (39)	77 (52)		197 (62)	64 (53)	
Age (years): mean ± SE	60.8 ± 0.5	62.1 ± 0.6	57.6 ± 1.1	***<0.001***	62.0 ± 0.6	56.8 ± 1.2	***<0.001***
SIMD quintile:							
1 (most deprived)	41 (8)	31 (8)	10 (7)	*0.979*	26 (9)	9 (8)	*0.425*
2	76 (14)	56 (15)	20 (14)		40 (13)	9 (8)	
3	91 (17)	65 (17)	26 (18)		48 (16)	25 (22)	
4	131 (25)	93 (25)	38 (26)		78 (26)	28 (24)	
5 (least deprived)	186 (35)	134 (35)	52 (36)		113 (37)	44 (38)	
Highest level of education:							
School completed	282 (53)	208 (54)	74 (50)	*0.578*	171 (54)	51 (43)	*0.092*
College/University	197 (37)	137 (35)	60 (40)		120 (38)	55 (46)	
Postgrad degree completed	57 (11)	42 (11)	15 (10)		26 (8)	14 (12)	
Employment status:							
Self-employed/paid emp.	231 (43)	153 (40)	78 (52)	***0.010***	128 (41)	71 (59)	***0.001***
Not employed	14 (3)	11 (3)	3 (2)		3 (1)	5 (4)	
Retired from paid work	252 (47)	196 (51)	56 (38)		154 (49)	38 (32)	
Looking after family-home	22 (4)	12 (3)	10 (7)		24 (8)	4 (3)	
Long term sick or disabled	15 (3)	13 (3)	2 (1)		7 (2)	2 (2)	
Household income:							
Under £20,000	138 (30)	108 (32)	30 (25)	***0.040***	85 (31)	29 (28)	***0.002***
£20,000-29,999	99 (21)	79 (23)	20 (17)		71 (26)	12 (12)	
£30,000-39,00	60 (13)	46 (13)	14 (12)		43 (16)	13 (13)	
£40,000-49,000	61 (13)	42 (12)	19 (16)		25 (9)	13 (13)	
£50,000 and above	104 (23)	66 (19)	38 (31)		53 (19)	37 (36)	
Physical activity (MET-minutes/week)		4152 [1997, 7668]	4381 [2157, 7338]	*0.801*	4250 [1980, 8406]	4134 [1964, 8178]	*0.917*
Risk behaviour							
1. <5 measures/day of fruit & vegetables	93 (27)	70 (28)	23 (25)	0.493	62 (29)	20 (27)	0.764
2. <3 measures/day of bread & consume white bread only	75 (15)	54 (15)	21 (15)	0.989	49 (16)	12 (10)	0.126
3. >4 (men) & >3 (women) units/day of alcohol	88 (20)	67 (22)	21 (17)	0.267	36 (14)	26 (28)	0.002
4. Current smoker	54 (11)	36 (10)	18 (13)	0.320	36 (12)	19 (17)	0.169
5. Low physical activity level	203 (50)	159 (54)	44 (40)	0.009	135 (53)	40 (41)	0.050
6. Obese (BMI≥30.0 kg/m2)	92 (21)	70 (23)	22 (18)	0.355	44 (19)	25 (26)	0.205

Risk behaviour score group							
1 or less	154 (48)	102 (45)	52 (58)	0.026	88 (45)	31 (44)	0.930
2 or more	164 (52)	127 (55)	37 (42)		108 (55)	39 (56)	

[1]P-value for difference between patients; [2]P-value for difference between partners

Table 1: **Self-efficacy and multidimensional health locus of control scores at baseline (ARN and NRN patients and their partners): median [IQR]**

	Patients			Partners of patients		
	ARN (n=387)	NRN (n=149)	p[1]	ARN (n=318)	NRN (n=120)	p[2]
Smoking cessation self-efficacy[3]						
Score (range 5 - 20)	12 [9, 16]	13 [9, 18]	*0.355*	11 [9, 14]	10 [7, 12]	*0.055*
Low (5 - 12): n (%)	20 (51)	8 (42)	*0.512*	20 (54)	14 (82)	***0.045***
High (13 - 20): n (%)	19 (49)	11 (58)		17 (46)	3 (18)	
Physical activity self-efficacy						
Score (range 5 - 20)	14 [11, 15]	14 [12, 18]	*0.073*	14 [11, 17]	14 [10, 16]	*0.948*
Low (5 - 14): n (%)	205 (55)	76 (52)	*0.530*	163 (53)	65 (56)	*0.588*
High (15 - 20): n (%)	167 (45)	70 (48)		144 (47)	51 (44)	
Diet self-efficacy						
Score (range 5 - 20)	15 [14, 18]	15 [14, 20]	*0.121*	15 [14, 19]	15 [12, 20]	*0.875*
Low (5 - 15): n (%)	230 (62)	84 (59)	*0.566*	191 (62)	73 (64)	*0.731*
High (16 - 20): n (%)	144 (39)	59 (41)		116 (38)	41 (36)	
Alcohol resistance self-efficacy						
Score (range 3 - 12)	9 [7, 12]	10 [7, 12]	*0.657*	11 [8, 12]	10 [7, 12]	*0.530*
Low (3 - 10): n (%)	187 (55)	71 (55)	*0.956*	133 (48)	55 (51)	*0.511*
High (11 - 12): n (%)	151 (45)	58 (45)		146 (52)	52 (49)	
MHLC Internal						
Score (range 6 - 36)	25 [22, 28]	26 [21, 29]	*0.381*	26 [22, 28]	26 [22, 29]	*0.696*
Low (6 - 25): n (%)	203 (53)	72 (49)	*0.415*	152 (48)	59 (50)	*0.783*
High (26 - 36): n (%)	183 (47)	76 (51)		164 (52)	60 (50)	
MHLC Chance						
Score (range 6 - 36)	17 [13, 21]	17 [13, 21]	*0.335*	18 [14, 22]	17 [13, 22]	*0.788*
Low (6 - 17): n (%)	197 (51)	83 (56)	*0.332*	154 (49)	61 (51)	*0.638*
High (18 - 36): n (%)	189 (49)	66 (44)		162 (51)	58 (49)	
MHLC Powerful others						
Score (range 6 - 36)	18 [14, 23]	17 [12, 21]	***0.032***	18 [13, 22]	15 [11, 20]	***0.018***
Low (6 - 17): n (%)	186 (48)	77 (52)	*0.442*	154 (49)	75 (63)	***0.008***
High (18 - 36): n (%)	199 (52)	71 (48)		162 (51)	44 (37)	

[1]P-value for difference between patients

[2]P-value for difference between partners

[3]Current smokers only

Table 1: Change in patient risk behaviours between T1 and T2: n (%)

	All patients (n=418)*			ARN (n=387)			NRN (n=149)		
	T1	T2	p[1]	T1	T2	p[1]	T1	T2	p[2]
Risk behaviour									
<5 measures/day of fruit & vegetables	38 (23)	40 (24)	*0.845*	28 (24)	30 (26)	*0.815*	9 (20)	7 (15)	*0.687*
<3 measures/day of bread & consume white bread only	46 (12)	43 (11)	*0.766*	34 (13)	30 (11)	*0.585*	11 (11)	10 (10)	*1.000*
>4 (men) & >3 (women) units/day of alcohol	58 (21)	45 (16)	***0.047***	41 (22)	31 (17)	*0.064*	14 (17)	13 (16)	*1.000*
Current smoker	27 (8)	24 (7)	*0.250*	15 (6)	13 (5)	*0.500*	10 (10)	9 (9)	*1.000*
Low physical activity level	131 (50)	150 (58)	***0.004***	98 (54)	112 (61)	***0.013***	25 (40)	29 (46)	*0.388*
Obese (BMI≥30.0 kg/m^2)	56 (19)	64 (22)	*0.152*	43 (21)	49 (24)	*0.238*	10 (14)	11 (15)	*1.000*
Risk behaviour score group (number of risk behaviours)									
1 or less	84 (54)	80 (51)	*0.572*	52 (49)	47 (44)	*0.359*	29 (67)	30 (70)	*1.000*
2 or more	73 (47)	77 (49)		55 (51)	60 (56)		14 (33)	13 (30)	

[1]P-value for difference between T1 and T2 in patients with an abnormal diagnosis

[2]P-value for difference between T1 and T2 in patients with a normal diagnosis

* Includes patients with missing diagnosis.

Table 1: Predictors of low physical activity at T2 in patients (n=268)

	Odds Ratio	95% CI	P
Low PA at T1 (versus high)	26.2	(9.57, 71.7)	***<0.001***
Age (years)	1.07	(1.02, 1.12)	***0.005***
Female sex (versus male)	0.73	(0.29, 1.81)	*0.495*
SIMD Quintile			
1	1.00		
2	0.98	(0.14, 6.67)	*0.981*
3	1.65	(0.23, 11.8)	*0.618*
4	4.93	(0.77, 31.6)	*0.093*
5	1.70	(0.29, 10.1)	*0.558*
Any medical conditions (versus none)	1.13	(0.44, 2.93)	*0.801*
ARN (versus NRN)	1.17	(0.44, 3.13)	*0.749*
Raw MHLC Internal score	0.96	(0.88, 1.05)	*0.421*
Raw MHLC Chance score	0.99	(0.91, 1.07)	*0.775*
Raw MHLC Powerful others score	1.06	(0.98, 1.15)	*0.126*
Raw Physical activity self-efficacy score	0.99	(0.96, 1.02)	*0.517*
Raw Time spent sitting per day (including motor vehicle)	1.00	(0.99,1.00)	*0.922*
Constant	0.004	(0.00, 0.26)	*0.009*

Table 1: Predictors of high alcohol intake at T2 in patients (n=232)

	Odds Ratio	95% CI	P
>4(men) & >3 (women) units/day alcohol at T1	12.4	(4.83, 31.5)	***<0.001***
Age (years)	0.99	(0.95, 1.03)	*0.601*
Female sex (versus male)	1.02	(0.39, 2.63)	*0.975*
SIMD Quintile			
1	1.00		
2	4.87	(0.48, 49.5)	*0.181*
3	3.23	(0.33, 31.5)	*0.313*
4	1.23	(0.15, 10.1)	*0.847*
5	1.96	(0.24, 15.8)	*0.525*
Any medical conditions (versus none)	0.66	(0.23, 1.89)	*0.441*
Abnormal diagnosis (versus normal)	0.83	(0.29, 2.34)	*0.725*
Raw MHLC Internal score	1.00	(0.92, 1.08)	*0.988*
Raw MHLC Chance score	0.97	(0.88, 1.07)	*0.556*
Raw MHLC Powerful others score	1.00	(0.93, 1.08)	*0.905*
Raw Alcohol self-efficacy score	0.70	(0.58, 0.84)	***<0.001***
Constant	3.74	(0.04, 360.3)	*0.572*

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Article
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Y
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Y
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Y
Objectives	3	State specific objectives, including any prespecified hypotheses	Y
Methods			
Study design	4	Present key elements of study design early in the paper	Y
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Y
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Y
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	**NA**
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Y
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Y
Bias	9	Describe any efforts to address potential sources of bias	Y
Study size	10	Explain how the study size was arrived at	Y
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Y
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Y
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	Y
		(*d*) If applicable, explain how loss to follow-up was addressed	Y
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Y
		(b) Give reasons for non-participation at each stage	-
		(c) Consider use of a flow diagram	Y
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Y
		(b) Indicate number of participants with missing data for each variable of interest	Y
		(c) Summarise follow-up time (eg, average and total amount)	-
Outcome data	15*	Report numbers of outcome events or summary measures over time	NA
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear	Y

		which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	Y
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	Y
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Y
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Y
Generalisability	21	Discuss the generalisability (external validity) of the study results	Y
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Y

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

Do health behaviours change after colonoscopy? A prospective cohort study on diet, alcohol, physical activity and smoking among patients and their partners.

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Do health behaviours change after colonoscopy? A prospective cohort study on diet, alcohol, physical activity and smoking among patients and their partners.

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ABSTRACT

Objectives

We hypothesised that colonoscopy triggers changes for the better in health behaviours. Our objective was to describe diet, alcohol, physical activity and tobacco use prospectively i.e. before and 10 months after colonoscopy for patients and their partners.

Design

Prospective cohort study of health behaviour change in patients and their partners before and 10 months after colonoscopy. Comparison groups are patients receiving a normal result notification (NRN) versus patients receiving an abnormal result notification (ARN) such as, colorectal cancer, polyps or diverticulitis. Health behaviour change of patients and partners (controls) are also compared.

Setting

5 Scottish hospitals.

Participants

Of 5,798 colonoscopy registrations, 2,577 (44%) patients met eligibility criteria of whom 565 (22%) were recruited; 460 partners were also recruited.

Measures

International Physical Activity Questionnaire, Scottish Collaborative Group Food Frequency Questionnaire (includes alcohol), smoking status, age, sex, education, household income,

employment status, Scottish Index of Multiple Deprivation (SIMD), Body Mass Index, medical conditions, result of the colonoscopy (ARN or NRN), Multidimensional Health Locus of Control Scale (MHLC), behaviour-specific self-efficacy scales.

Results

57% of patients were male, mean age 60.8 years (SE 0.5) and 43% were from more affluent areas. 72% (n=387) of patients received an ARN and 28% (n=149) a NRN. Response rate to the second questionnaire at 10 months was 68.9%. Overall, 27% of patients consumed less than 5 measures of fruit & vegetables per day, 20% exceeded alcohol limits, 50% had low levels of physical activity and 21% were obese. At 10 month follow-up, a 5% reduction in excessive alcohol consumption and an 8% increase in low levels of physical activity were observed among patients; no significant behavioural changes occurred in their partners. Baseline high alcohol consumption and low physical activity were the strongest predictors of these behaviours at follow-up. Additionally, low alcohol self-efficacy and increasing age were associated with poorer health-related behaviours at follow-up for alcohol and physical activity, respectively.

Conclusions

Colonoscopy can be regarded as a teachable moment for patients, being associated with marginal beneficial changes in some health behaviours. Yet, colonoscopy is also associated with negative changes in health behaviours. Further work is needed to explore how services can optimize increases in beneficial health behaviours and mitigate increases in harmful ones.

Article summary

Article focus

- Colonoscopy is an increasingly common investigation that might trigger spontaneous behavioural changes in patients.
- Little is known about health behaviour change following colonoscopy, particularly in the UK.
- We carried out a prospective cohort study of patients who underwent colonoscopy and their partners.

Key messages

- There is a high prevalence of unhealthy behaviours in colonoscopy patients.
- We observed marginal but statistically significant reductions in excessive alcohol consumption but also decreases in physical activity following colonoscopy.
- There may be opportunities to encourage spontaneous improvements in health behaviours among colonoscopy patients and to mitigate harmful behaviours.

Strengths and limitations of this study

- This is the first prospective cohort study on health behaviours in colonoscopy patients in the UK.
- We obtained a large sample size and high follow-up rate and were able to use

patients' partners as controls.

- Selection biases may have led to our sample comprising healthier patients than in the general colonoscopy population.

INTRODUCTION

Illnesses and interactions with health services may motivate patients to change their health behaviours for the better. Such "teachable moments" have been described for changes in smoking behaviour following life transitions, such as pregnancy, and health events, such as screening for lung cancer.[1,2,3,4,5,6,7,8,9,10] A recent review of the literature concludes that while the term "teachable moment" is used imprecisely – to describe either an opportunity for behavioural change or an event associated with actual change - there is evidence that beneficial behavioural changes can be actively created through appropriate clinician-patient interactions.[11] To our knowledge, evidence from the UK that patients who undergo screening for cancer are likely to make improvements in health behaviour is limited to a single pilot study of a health promotion intervention delivered during colorectal cancer screening.[12] The evidence from UK observational research that there are spontaneous health behaviour changes after a cancer diagnosis is limited to analyses of population surveys that depend on self-reported cancer diagnosis and found little evidence that a cancer diagnosis motivates health-protective changes.[13] Relatives of cancer patients may also change their behaviour in response to a familial diagnosis, but the evidence is limited to one study on breast cancer.[14]

Colonoscopy is mainly performed for the diagnosis of colon and rectal cancer and current UK rates of 80 procedures per 10,000 population are likely to increase in the future as screening by flexible sigmoidoscopy is introduced.[15] The number of colonoscopies performed through the Scottish bowel screening programme almost doubled from 5,358 in 2009 to 9,296 in 2011; in England, 368,162 colonoscopies were carried out in 2009-10.[16,17] We hypothesised

that colonoscopy represents both concepts of a teachable moment for beneficial health behaviour change: it may be a time of concern about a cancer diagnosis and thus be associated with spontaneous change,[1,18] and it may also present an opportunity for clinicians to promote improvements in behaviours. An abnormal colonoscopy result may be more likely to trigger beneficial changes in behaviour, so we compared behaviours between participants with normal and abnormal test results. Our aim was to describe health-related behaviours before and after a colonoscopy among patients and their partners. Our objective was to carry out a prospective observational study on colonoscopy patients and their partners using self-reported questionnaire survey data immediately before and ten months after colonoscopy. As self-efficacy and locus of control are central to several health behaviour theories, including the Health Belief Model,[19] Social Cognitive Theory[20] and Protection Motivation Theory,[21] we assessed their roles using validated questionnaires and also recorded physical activity, tobacco smoking, diet and alcohol consumption. We hypothesised that study participants with high scores of self-efficacy and with 'internal' locus of control would change health behaviours for the better following colonoscopy. Although there is no cut-off score to define persons as being high or low self-efficacious Ralph Schwarzer, an expert in self-efficacy measurement, recommends conducting a median split, which is to dichotomize the study sample.[35] 'Health-Internals' believe that the locus of control for health is internal and that one stays or becomes healthy or sick as a result of his or her behaviour whereas 'health-externals' believe that factors which determine their health are such things as 'powerful others' and 'chance' over which they have little control.

METHODS

Study design

We conducted a prospective cohort study of health behaviour change in patients and their partners before and 10 months after colonoscopy. Comparison groups are patients receiving a normal result notification (NRN) versus patients receiving an abnormal result notification (ARN) such as, colorectal cancer, polyps or diverticulitis. Health behaviour change of patients and partners (controls) are also compared.

Setting

Colonoscopy clinics in five hospitals within three Health Board areas in Scotland, UK. Recruitment occurred between September 2010 and August 2011.

Participants

Patients were invited by an advert for the study enclosed along with their colonoscopy appointment letter from the hospital. On attendance for colonoscopy, clinic staff obtained verbal consent for patients (and, if present, their partners) to allow the Research Assistant (RA) to approach them. If a patient did not wish to be approached by the RA, consent was sought to retain non-identifiable data (age, sex and sector level of the postcode) to assess selection bias. The RA asked consenting participants to complete the baseline (T1) questionnaire and written consent form at home and return both in a pre-paid addressed envelope. Patients whose partners were not present were asked to provide the name and contact details of their partner who was subsequently contacted by the RA by telephone about the study.

Eligibility criteria

Patient inclusion criteria were: i) referred for colonoscopy, ii) no past history of cancer, iii) ≥18 years old, iv) has a partner. Partner inclusion criteria: i) ≥18 years old, ii) no history of cancer.

Primary outcome

The primary outcome measure was the extent of change in individual health behaviours before colonoscopy and 10 months later. Consequently, we selected measures that ranked individuals along a distribution of amount of physical activity, dietary and alcohol intake, and tobacco use.

Variables, measures and data sources

Information was self-reported by participants or obtained from medical records.

Heath-related behaviour variables

The International Physical Activity Questionnaire[22,23] was used to categorise participants into low, moderate or high levels of PA using Metabolic Equivalent of Task (MET) scores. The Scottish Collaborative Group Food Frequency Questionnaire (SCG FFQ)[24,25] was used to measure intakes of foods and alcohol. Current smokers were defined as those who had smoked at least 100 cigarettes in their entire life and currently smoked.

An aggregate risk behaviour score was calculated based on generally accepted requirements for risk factor reduction for most of the main chronic diseases and specifically for prevention of colorectal cancer because colonoscopy is a main investigation for colorectal cancer symptoms.[26,27] Specifically, we defined high risk behaviour using Scottish government recommendations[28,29,] as follows: <5 measures/day of fruit and vegetables; <3 portions/day of bread; >4 (men) and >3 (women) units/day of alcohol; current smoker; and low physical activity (equivalent to less than thirty minutes of moderate intensity activity on at least 4 days of the week). For the purpose of this study, a 'measure' as defined in the SCG FFQ was assumed to be equal to a 'portion' of fruit or vegetables.

Demographic variables

Participants self-reported their age, sex, level of education, household income, employment status, and postcode (to calculate Scottish Index Multiple Deprivation (SIMD[30])).

Clinical variables

Body Mass Index (BMI) was calculated by dividing weight (kg) by height squared (m^2) using self-reported values. Participants were categorised as obese if BMI≥30.0 kg/m^2. Participants self-reported their medical conditions currently being treated by a doctor. Result of the colonoscopy was obtained from patient medical records. Patients were categorised as receiving a normal result notification (NRN) or abnormal result notification (ARN) such as, colorectal cancer, polyps or diverticulitis.

Psychological variables

Participants' perceived control over their health-related behaviours was measured using the Multidimensional Health Locus of Control Scale[31,32]. The instrument measures three dimensions of control: internal, powerful others and chance. Participants' self-efficacy was measured using four separate self-efficacy scales (smoking, diet, alcohol, PA) recommended by Schwarzer and colleagues.[33] There is no cut-off score to define persons as being high or low self-efficacious so we split the sample at the median, as recommended by Schwarzer.[34]

Data collection

The baseline (T1) questionnaire was administered to patients who attended a colonoscopy clinic between September 2010 and August 2011. A pre-paid envelope was provided for participants to return the questionnaire after completing it at home. Participants were requested to report health behaviours before colonoscopy. There was no cut-off date for

returning the baseline questionnaire. The follow-up questionnaire (T2) was posted 10 months after the clinic date for colonoscopy, between July 2011 and June 2012.

Bias

We attempted to minimise information biases by using, where possible, validated questionnaires and to minimise selection biases by inviting all colonoscopy patients to participate.

Statistical analysis

Statistical analysis was carried out using Stata/SE 11.2 software. Means ± standard errors or medians [interquartile range (IQR)] were presented as appropriate following visual assessment of histograms of continuous variables. Differences in characteristics and behaviours between groups were assessed using Pearson's chi-squared test for categorical measures and either T-tests or Mann-Whitney tests for continuous variables as appropriate. Differences in continuous variables between T1 and T2 were assessed using a paired T-test or the Wilcoxon signed-rank test. Differences in categorical variables between T1 and T2 were assessed in SPSS version 20 using the McNemar-Bowker test for variables with 3 or more categories, and the McNemar test for binary variables. To predict health-related behaviour at T2 logistic regression models were undertaken.

Statistical power

Our sample size was based on answering the research question '*Do health behaviours change after a major health threat?'* We used the variable physical activity to calculate statistical power because it has the strongest association with colorectal cancer survival and detecting colorectal cancer is one of the main reasons for colonoscopy referral. This paper reports a comparison of changes in health behaviours of patients with NRN and ARN

following colonoscopy. However, the study had initially aimed to detect an increase in physical activity of 25 or greater MET hours in patients diagnosed with cancer at colonoscopy compared to non-cancer patients, and samples of 46 cancer and 46 non-cancer patients would have been required. The effect size was derived from Satia,[35] and sample size calculations assumed conventional values of α=0.05 and β=0.20 (giving a power, or 1- β, of 80%). Thus, our study numbers exceeded those required by the initial sample size calculation.

RESULTS

Of 5,798 colonoscopy registrations, 2,577 patients (44%) met eligibility criteria for the study of whom 565 (22%) eligible patients and 460 partners were recruited (**Error! Reference source not found.**). Recruited patients compared to non-recruited patients were significantly older (60.3 ± 0.5 versus 57.2 ± 0.4), more affluent (Carstairs decile 1 and 2, 43% versus 29%) and a higher proportion male (57% males versus 50% male). 72% (n=387) of patients received an ARN and 28% (n=149) a NRN. Overall, 68.9% (n=706) of participants returned a second, follow-up questionnaire at T2. The median times for both patients and partners to return the baseline questionnaire was 12 days.

{Please insert Figure 1 here}

At baseline (T1), a higher proportion of patients with abnormal result notification (ARN) were male, older, retired, and with a household income under £20,000 compared to patients with normal result notification (NRN) - Table 1. Overall 27% consumed less than five measures a day of fruit/vegetable, 20% exceeded recommended alcohol limits, 50% had low levels of physical activity and 21% were obese. Higher proportions of ARN patients were

not meeting these recommendations but the difference was only significant for physical activity. Only 11% of patients reported current smoking. When combined, overall 52% of participants had 2 or more risk behaviours, which comprised 55% of ARN and 42% of NRN.

{Please insert Table 1 here}

There were no significant differences between patients with abnormal and normal results with respect to self-efficacy for smoking cessation, physical activity, diet and alcohol (Table 2). Partners of patients with normal results were more likely to have low self-efficacy for smoking cessation.

{Please insert Table 2 here}

Overall, there was a 5% reduction in respondents who exceeded alcohol consumption guidance and an 8% increase in the proportion with low physical activity - Table 3. The proportionate increase in low physical activity was similar in patients with abnormal and normal colonoscopy results but statistically significant only among those with abnormal findings (which might be explained by the larger sample size in the abnormal category). When risk behaviours were aggregated, there was no overall change in behaviours in any patient group. We found no significant change in health behaviours of partners, irrespective of the colonoscopy result of the patient (data not shown).

{Please insert Table 3}

We used multiple logistic regression analyses to explore predictors of the two behaviours that changed significantly over time: low physical activity and high alcohol intake - Table 4. Low physical activity at baseline was the strongest predictor of low physical activity at T2 among patients and increasing age was also associated with lower physical activity. Sex, socio-economic circumstances, co-morbidities, colonoscopy findings and self-efficacy did not predict changes in physical activity over time.

{Please insert Table 4}

Excessive alcohol consumption at T2 was most strongly determined by excessive consumption at baseline - Table 5. Lower self-efficacy at T1 was associated with higher alcohol consumption at T2. Age, sex, socio-economic circumstances, co-morbidities and colonoscopy findings were not associated with higher alcohol intake at follow-up.

{Please insert Table 5}

DISCUSSION

Colonoscopy was associated with marginal spontaneous changes (that is, without a behavioural intervention) in some health-related behaviours. We found that there was a 5% reduction in excessive alcohol consumption (a beneficial change) but an 8% increase in low levels of physical activity (a change for the worse) 10 months after colonoscopy. There were no significant changes in health behaviours among patients' partners, suggesting that behavioural changes in colonoscopy patients were not necessarily part of wider trends that might influence health behaviours. No behavioural advice was given to patients as part of their investigations, and thus colonoscopy might be regarded as a teachable moment in which spontaneous changes are triggered. However, colonoscopy also represents an interaction with health services that might be optimized to encourage improvements in

health-related behaviours. At baseline, we found that ARN patients and their partners scored significantly higher than the NRN patients and partners on the MHLC Powerful Others scale, indicating that ARN patients and partners believed more strongly that health professionals were responsible for their health and health outcomes. Thus, ARN patients in particular, may be receptive to health promotion advice from health professionals.

Our conclusion that colonoscopy can be regarded as a teachable moment is similar to a recent systematic review of eleven articles about the impact of cancer screening (nine of which investigated the impact of lung screening on smoking cessation) which concluded that cancer screening 'might' be a teachable moment for health behaviour change[36]. Research about change in health behaviours after diagnosis of chronic health conditions indicate at best, only modest changes.[37] Thus, based on current evidence it remains uncertain if, and the extent to which major health events represent teachable moments. Health behaviours are likely to be influenced by a complex mix of factors, so that in addition to any beneficial teachable moment effects, ongoing symptoms that prompted colonoscopy may also affect behaviour. These may explain reductions in high levels of physical activity and concomitant increases in low levels.

We found that baseline health behaviours for low physical activity and excessive alcohol consumption were the strongest predictors of the same behaviours 10 months after colonoscopy but, additionally, increasing age predicted lower physical activity and lower self-efficacy around alcohol predicted excessive alcohol consumption at follow-up. Among our patient sample, 11% smoked, which is much lower than the Scottish general adult population prevalence of 23%.[38]

This study found that a low level of PA at the time of colonoscopy and older age were predictive of a low level of PA 10 months post-colonoscopy. Further, high alcohol intake at the time of colonoscopy and low alcohol self-efficacy were predictive of high alcohol intake post-colonoscopy. Of note, fatalism (MHLC Chance score) was not predictive of any differential health behavior change. ARN was not predictive of health behaviour change following this health event, which is in contrast to studies of smokers under-going screening for lung disease.[39,40] A cross-sectional study of over 10,000 smokers at 2-3 years post-screening for COPD found that those with a first-time positive result were significantly more likely to stop smoking than those with a negative result[39]. A cross-sectional study of 134 active smokers who underwent spiral CT screening found that 62% of those with a positive result either stopped or decreased smoking, whereas only 46% with a negative result did so.[40] Thus, the effect of test results following screening for disease on health-related behaviour appears to vary according to type of screen (e.g., colonoscopy versus spiral CT), reason for screening (e.g., colon disease versus lung disease) and health-related behaviour (e.g., alcohol versus smoking).

Our study has strengths and limitations. This is the first prospective observational study to report health-related behaviours of patients and their partners before and 10 months after colonoscopy. We used validated questionnaire survey tools, obtained a relatively large sample for a prospective cohort study and achieved high follow-up rates of 69%. There are however, several study limitations. First, the sample may not be representative of all patients population undergoing colonoscopy. The response rate of eligible patients was 22%, and there was some selection bias towards a more affluent, older and male population. Socio-economic affluence may explain why our sample had lower smoking prevalence than the general population. Patients who participate in the newly introduced national colorectal cancer screening programme also may be more likely to be motivated to change in their

behaviour. Second, while participants were requested to self-report health behaviours before the colonoscopy and as soon as possible thereafter, the baseline questionnaire was completed after the colonoscopy when participants may already have been influenced and starting to make some changes and there was no cut-off date for returning the baseline questionnaire. Thus, the observed changes for the better or worse in health behaviours may be an under-estimation of the extent of change. Third, although valid and reliable survey instruments were used, self-reported data are susceptible to expectation biases and other misclassification effects.[41] However, our principal interest was in behavioural change rather than absolute prevalences of behaviours, and thus over- or under-reporting of certain behaviours would not necessarily invalidate our findings on whether they changed after colonoscopy. The observed decreases in excessive alcohol consumption and in physical activity following colonoscopy may not be caused by the procedure but by other confounding factors that we have not identified. We are not aware of any health promotion activity associated with colonoscopy as it was delivered within the participating hospitals and our questionnaires were designed not to imply any favourable behaviours. The fact that there were no observed changes in partners and no differences between ARN and NRN patients suggests that the observed behavioural changes in patients was related to the colonoscopy.

Health care settings are recognised as important loci for promoting health behaviour change[42,43,44] and health events have been conceptualised as a teachable moment, particularly in relation to smoking cessation.[1,2,3,4,5,6,7,8,9,10] Conceptualising health events as teachable moments may be appealing to policymakers and clinicians because they represent an opportunity to introduce low-intensity interventions to change modifiable risk health-related behaviours to prevent disease and a recent review has identified 9 lifestyle interventions at the point of cancer screening to take advantage of this health event as a

teachable moment , including 2 studies of a multiple lifestyle intervention offered to people who had undergone colonoscopy and had adenomas removed.[45,46]

For future research, developing and testing the effect of low intensity interventions (e.g., self-efficacy enhancement) to further reduce alcohol consumption may be appropriate because patients appear to spontaneously reduce alcohol consumption following colonoscopy, whereas more intense interventions may be required for health-related behaviours that do not change (e.g., diet) or change for the worse (e.g., physical activity). Qualitative to understand why patients spontaneously change some health behaviours but not others following a major health event will add to understanding about the utility of teachable moments for public health.

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Registrations

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Contributors: GH designed and managed the study, obtained ethics approval and drafted the paper. DM designed and managed the study, obtained ethics approval and revised the paper. RO, NC, AC, KS, BD and AB designed the study and revised the paper. LM designed the study, wrote the statistical analysis plan, cleaned and analysed the data and revised the paper. SF advised on the statistical analysis plan and analysed the data. All authors have full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

Competing interests: All authors had no support from any organisation for the submitted work, no financial relationships with any organisations that might have an interest in the submitted work in the previous three years and no other relationships or activities that could appear to have influenced the submitted work.

Ethics: The study received West of Scotland Medical Research Ethics Committee approval (REC REF 10/S0709/24). All participants provided written informed consent. The study was funded by the Chief Scientist Office Scotland and the study sponsor was the University of Stirling. The researchers acted independently from the funder and sponsor.

Study hypothesis: The study hypothesis that major health events are teachable moments triggering spontaneous health-related behaviour change arose before inspection of the data. The main hypothesis was that colorectal cancer diagnosis is a teachable moment. This article reports a further study hypothesis, which was that colonoscopy is a teachable moment.

Data sharing statement: The relevant anonymised patient level data are available on reasonable request from the corresponding author. Participant consent was not obtained but the presented data are anonymised and risk of identification is low.

Table Error! Main Document Only.. **Patient and partner baseline characteristics.**

	Patients (n=536)				Partners of patients (n=438)		
	All (n=536)	**ARN (n=387)**	**NRN (n=149)**	**p[1]**	**ARN (n=318)**	**NRN (n=120)**	**p[2]**
Sex: Male	308 (57)	236 (61)	72 (48)	***0.008***	121 (38)	56 (47)	*0.101*
Female	228 (43)	151 (39)	77 (52)		197 (62)	64 (53)	
Age (years): mean ± SE	60.8 ± 0.5	62.1 ± 0.6	57.6 ± 1.1	***<0.001***	62.0 ± 0.6	56.8 ± 1.2	***<0.001***
SIMD quintile:							
1 (most deprived)	41 (8)	31 (8)	10 (7)	*0.979*	26 (9)	9 (8)	*0.425*
2	76 (14)	56 (15)	20 (14)		40 (13)	9 (8)	
3	91 (17)	65 (17)	26 (18)		48 (16)	25 (22)	
4	131 (25)	93 (25)	38 (26)		78 (26)	28 (24)	
5 (least deprived)	186 (35)	134 (35)	52 (36)		113 (37)	44 (38)	
Highest level of education: School completed	282 (53)	208 (54)	74 (50)	*0.578*	171 (54)	51 (43)	*0.092*
College/University	197 (37)	137 (35)	60 (40)		120 (38)	55 (46)	
Postgrad degree completed	57 (11)	42 (11)	15 (10)		26 (8)	14 (12)	
Employment status:							
Self-employed/paid emp.	231 (43)	153 (40)	78 (52)	***0.010***	128 (41)	71 (59)	***0.001***
Not employed	14 (3)	11 (3)	3 (2)		3 (1)	5 (4)	
Retired from paid work	252 (47)	196 (51)	56 (38)		154 (49)	38 (32)	
Looking after family-home	22 (4)	12 (3)	10 (7)		24 (8)	4 (3)	
Long term sick or disabled	15 (3)	13 (3)	2 (1)		7 (2)	2 (2)	
Household income:							
Under £20,000	138 (30)	108 (32)	30 (25)	***0.040***	85 (31)	29 (28)	***0.002***
£20,000-29,999	99 (21)	79 (23)	20 (17)		71 (26)	12 (12)	
£30,000-39,00	60 (13)	46 (13)	14 (12)		43 (16)	13 (13)	
£40,000-49,000	61 (13)	42 (12)	19 (16)		25 (9)	13 (13)	
£50,000 and above	104 (23)	66 (19)	38 (31)		53 (19)	37 (36)	
Physical activity (MET-minutes/week)		4152 [1997, 7668]	4381 [2157, 7338]	*0.801*	4250 [1980, 8406]	4134 [1964, 8178]	*0.917*
Risk behaviour							
1. <5 measures/day of fruit & vegetables	93 (27)	70 (28)	23 (25)	0.493	62 (29)	20 (27)	0.764
2. <3 measures/day of bread & consume white bread only	75 (15)	54 (15)	21 (15)	0.989	49 (16)	12 (10)	0.126
3. >4 (men) & >3 (women) units/day of alcohol	88 (20)	67 (22)	21 (17)	0.267	36 (14)	26 (28)	0.002
4. Current smoker	54 (11)	36 (10)	18 (13)	0.320	36 (12)	19 (17)	0.169

5. Low physical activity level	203 (50)	159 (54)	44 (40)	0.009	135 (53)	40 (41)	0.050
6. Obese (BMI≥30.0 kg/m2)	92 (21)	70 (23)	22 (18)	0.355	44 (19)	25 (26)	0.205
Risk behaviour score group	154 (48)	102 (45)	52 (58)	0.026	88 (45)	31 (44)	0.930
1 or less	164 (52)	127 (55)	37 (42)		108 (55)	39 (56)	
2 or more							

[1]P-value for difference between patients; [2]P-value for difference between partners

Table Error! Main Document Only.: **Self-efficacy and multidimensional health locus of control scores at baseline (ARN and NRN patients and their partners): median [IQR]**

	Patients			Partners of patients		
	ARN (n=387)	**NRN (n=149)**	**p[1]**	**ARN (n=318)**	**NRN (n=120)**	**p[2]**
Smoking cessation self-efficacy[3]						
Score (range 5 - 20)	12 [9, 16]	13 [9, 18]	*0.355*	11 [9, 14]	10 [7, 12]	*0.055*
Low (5 - 12): n (%)	20 (51)	8 (42)	*0.512*	20 (54)	14 (82)	***0.045***
High (13 - 20): n (%)	19 (49)	11 (58)		17 (46)	3 (18)	
Physical activity self-efficacy						
Score (range 5 - 20)	14 [11, 15]	14 [12, 18]	*0.073*	14 [11, 17]	14 [10, 16]	*0.948*
Low (5 - 14): n (%)	205 (55)	76 (52)	*0.530*	163 (53)	65 (56)	*0.588*
High (15 - 20): n (%)	167 (45)	70 (48)		144 (47)	51 (44)	
Diet self-efficacy						
Score (range 5 - 20)	15 [14, 18]	15 [14, 20]	*0.121*	15 [14, 19]	15 [12, 20]	*0.875*
Low (5 - 15): n (%)	230 (62)	84 (59)	*0.566*	191 (62)	73 (64)	*0.731*
High (16 - 20): n (%)	144 (39)	59 (41)		116 (38)	41 (36)	
Alcohol resistance self-efficacy						
Score (range 3 - 12)	9 [7, 12]	10 [7, 12]	*0.657*	11 [8, 12]	10 [7, 12]	*0.530*
Low (3 - 10): n (%)	187 (55)	71 (55)	*0.956*	133 (48)	55 (51)	*0.511*
High (11 - 12): n (%)	151 (45)	58 (45)		146 (52)	52 (49)	
MHLC Internal						
Score (range 6 - 36)	25 [22, 28]	26 [21, 29]	*0.381*	26 [22, 28]	26 [22, 29]	*0.696*
Low (6 - 25): n (%)	203 (53)	72 (49)	*0.415*	152 (48)	59 (50)	*0.783*
High (26 - 36): n (%)	183 (47)	76 (51)		164 (52)	60 (50)	
MHLC Chance						
Score (range 6 - 36)	17 [13, 21]	17 [13, 21]	*0.335*	18 [14, 22]	17 [13, 22]	*0.788*
Low (6 - 17): n (%)	197 (51)	83 (56)	*0.332*	154 (49)	61 (51)	*0.638*
High (18 - 36): n (%)	189 (49)	66 (44)		162 (51)	58 (49)	
MHLC Powerful others						
Score (range 6 - 36)	18 [14, 23]	17 [12, 21]	***0.032***	18 [13, 22]	15 [11, 20]	***0.018***
Low (6 - 17): n (%)	186 (48)	77 (52)	*0.442*	154 (49)	75 (63)	***0.008***
High (18 - 36): n (%)	199 (52)	71 (48)		162 (51)	44 (37)	

[1]P-value for difference between patients

[2]P-value for difference between partners

[3]Current smokers only

Table Error! Main Document Only.**: Change in patient risk behaviours between T1 and T2: n (%)**

	All patients (n=418)*			ARN (n=387)			NRN (n=149)		
	T1	**T2**	**p[1]**	**T1**	**T2**	**p[1]**	**T1**	**T2**	**p[2]**
Risk behaviour									
<5 measures/day of fruit & vegetables	38 (23)	40 (24)	*0.845*	28 (24)	30 (26)	*0.815*	9 (20)	7 (15)	*0.687*
<3 measures/day of bread & consume white bread only	46 (12)	43 (11)	*0.766*	34 (13)	30 (11)	*0.585*	11 (11)	10 (10)	*1.000*
>4 (men) & >3 (women) units/day of alcohol	58 (21)	45 (16)	***0.047***	41 (22)	31 (17)	*0.064*	14 (17)	13 (16)	*1.000*
Current smoker	27 (8)	24 (7)	*0.250*	15 (6)	13 (5)	*0.500*	10 (10)	9 (9)	*1.000*
Low physical activity level	131 (50)	150 (58)	***0.003***	98 (54) 24 (13)	112 (61)	***0.019***	25 (40)	29 (46)	*0.055*
Moderate physical activity	37(14)	41(16)		61(33)	28 (15)		9 (14)	11 (17)	
High physical activity	92 (35)	69 (27)			43 (24)		29 (46)	23 (37)	
Obese (BMI≥30.0 kg/m²)	56 (19)	64 (22)	*0.152*	43 (21)	49 (24)	*0.238*	10 (14)	11 (15)	*1.000*
Risk behaviour score group (number of risk behaviours)									
1 or less	84 (54)	80 (51)	*0.572*	52 (49)	47 (44)	*0.359*	29 (67)	30 (70)	*1.000*
2 or more	73 (47)	77 (49)		55 (51)	60 (56)		14 (33)	13 (30)	

[1]P-value for difference between T1 and T2 in patients with an abnormal diagnosis

[2]P-value for difference between T1 and T2 in patients with a normal diagnosis

* Includes patients with missing diagnosis.

Table Error! Main Document Only.**: Predictors of low physical activity at T2 in patients (n=268)**

	Odds Ratio	95% CI	P
Low PA at T1 (versus high)	26.2	(9.57, 71.7)	***<0.001***
Age (years)	1.07	(1.02, 1.12)	***0.005***
Female sex (versus male)	0.73	(0.29, 1.81)	*0.495*
SIMD Quintile			
1	1.00		
2	0.98	(0.14, 6.67)	*0.981*
3	1.65	(0.23, 11.8)	*0.618*
4	4.93	(0.77, 31.6)	*0.093*
5	1.70	(0.29, 10.1)	*0.558*
Any medical conditions (versus none)	1.13	(0.44, 2.93)	*0.801*
ARN (versus NRN)	1.17	(0.44, 3.13)	*0.749*
Raw MHLC Internal score	0.96	(0.88, 1.05)	*0.421*
Raw MHLC Chance score	0.99	(0.91, 1.07)	*0.775*
Raw MHLC Powerful others score	1.06	(0.98, 1.15)	*0.126*
Raw Physical activity self-efficacy score	0.99	(0.96, 1.02)	*0.517*
Raw Time spent sitting per day (including motor vehicle)	1.00	(0.99,1.00)	*0.922*
Constant	0.004	(0.00, 0.26)	*0.009*

Table Error! Main Document Only.**: Predictors of high alcohol intake at T2 in patients (n=232)**

	Odds Ratio	95% CI	P
>4(men) & >3 (women) units/day alcohol at T1	12.4	(4.83, 31.5)	***<0.001***
Age (years)	0.99	(0.95, 1.03)	*0.601*
Female sex (versus male)	1.02	(0.39, 2.63)	*0.975*
SIMD Quintile			
1	1.00		
2	4.87	(0.48, 49.5)	*0.181*
3	3.23	(0.33, 31.5)	*0.313*
4	1.23	(0.15, 10.1)	*0.847*
5	1.96	(0.24, 15.8)	*0.525*
Any medical conditions (versus none)	0.66	(0.23, 1.89)	*0.441*
Abnormal diagnosis (versus normal)	0.83	(0.29, 2.34)	*0.725*
Raw MHLC Internal score	1.00	(0.92, 1.08)	*0.988*
Raw MHLC Chance score	0.97	(0.88, 1.07)	*0.556*
Raw MHLC Powerful others score	1.00	(0.93, 1.08)	*0.905*
Raw Alcohol self-efficacy score	0.70	(0.58, 0.84)	***<0.001***
Constant	3.74	(0.04, 360.3)	*0.572*

Do health behaviours change after colonoscopy? A prospective cohort study on diet, alcohol, physical activity and smoking among patients and their partners.

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ABSTRACT

Objectives

We hypothesised that colonoscopy triggers changes for the better in health behaviours. Our objective was to describe diet, alcohol, physical activity and tobacco use prospectively i.e. before and 10 months after colonoscopy for patients and their partners.

Design

Prospective cohort study of health behaviour change in patients and their partners before and 10 months after colonoscopy. Comparison groups are patients receiving a normal result notification (NRN) versus patients receiving an abnormal result notification (ARN) such as, colorectal cancer, polyps or diverticulitis. Health behaviour change of patients and partners (controls) are also compared.

Setting

5 Scottish hospitals.

Participants

Of 5,798 colonoscopy registrations, 2,577 (44%) patients met eligibility criteria of whom 565 (22%) were recruited; 460 partners were also recruited.

Measures

International Physical Activity Questionnaire, Scottish Collaborative Group Food Frequency Questionnaire (includes alcohol), smoking status, age, sex, education, household income, employment status, Scottish Index of Multiple Deprivation (SIMD), Body Mass Index,

medical conditions, result of the colonoscopy ~~(abnormal result notification~~ (ARN~~)~~ or ~~normal result notification (~~NRN~~)~~), Multidimensional Health Locus of Control Scale (MHLC), behaviour-specific self-efficacy scales.

Results

57% of patients were male, mean age 60.8 years (SE 0.5) and 43% were from more affluent areas. 72% (n=387) of patients received an ARN and 28% (n=149) a NRN. Response rate to the second questionnaire at 10 months was 68.9%. Overall, 27% of patients consumed less than 5 measures of fruit & vegetables per day, 20% exceeded alcohol limits, 50% had low levels of physical activity and 21% were obese. At 10 month follow-up, a 5% reduction in excessive alcohol consumption and an 8% increase in low levels of physical activity were observed among patients; no significant behavioural changes occurred in their partners. Baseline high alcohol consumption and low physical activity were the strongest predictors of these behaviours at follow-up. Additionally, low alcohol self-efficacy and increasing age were associated with poorer health-related behaviours at follow-up for alcohol and physical activity, respectively.

Conclusions

Colonoscopy can be regarded as a teachable moment for patients, being associated with marginal beneficial changes in some health behaviours. Yet, colonoscopy is also associated with negative changes in health behaviours. Further work is needed to explore how services can optimize increases in beneficial health behaviours and mitigate increases in harmful ones.

Article summary

Article focus

- Colonoscopy is an increasingly common investigation that might trigger spontaneous behavioural changes in patients.
- Little is known about health behaviour change following colonoscopy, particularly in the UK.
- We carried out a prospective cohort study of patients who underwent colonoscopy and their partners.

Key messages

- There is a high prevalence of unhealthy behaviours in colonoscopy patients.
- We observed marginal but statistically significant reductions in excessive alcohol consumption but also decreases in physical activity following colonoscopy.
- There may be opportunities to encourage spontaneous improvements in health behaviours among colonoscopy patients and to mitigate harmful behaviours.

Strengths and limitations of this study

- This is the first prospective cohort ~~observational~~ study on health behaviours in colonoscopy patients in the UK.

- We obtained a large sample size and high follow-up rate and were able to use patients' partners as controls.
- Selection biases may have led to our sample comprising healthier patients than in the general colonoscopy population.

INTRODUCTION

Illnesses and interactions with health services may motivate patients to change their health behaviours for the better. Such "teachable moments" have been described for changes in smoking behaviour following life transitions, such as pregnancy, and health events, such as screening for lung cancer.[1,2,3,4,5,6,7,8,9,10] A recent review of the literature concludes that while the term "teachable moment" is used imprecisely – to describe either an opportunity for behavioural change or an event associated with actual change - there is evidence that beneficial behavioural changes can be actively created through appropriate clinician-patient interactions.[11] To our knowledge, evidence from the UK that patients who undergo screening for cancer are likely to make improvements in health behaviour is limited to a single pilot study of a health promotion intervention delivered during colorectal cancer screening.[12] The evidence from UK observational research that there are spontaneous health behaviour changes after a cancer diagnosis is limited to ~~retrospective~~ analyses of population surveys that depend on self-reported cancer diagnosis and found little evidence that a cancer diagnosis motivates health-protective changes.[13] Relatives of cancer patients may also change their behaviour in response to a familial diagnosis, but the evidence is limited to one study on breast cancer.[14]

Colonoscopy is mainly performed for the diagnosis of colon and rectal cancer and current UK rates of 80 procedures per 10,000 population are likely to increase in the future as screening by flexible sigmoidoscopy is introduced.[15] The number of colonoscopies performed through the Scottish bowel screening programme almost doubled from 5,358 in 2009 to 9,296 in 2011; in England, 368,162 colonoscopies were carried out in 2009-10.[16,17] We hypothesised that colonoscopy represents both concepts of a teachable moment for beneficial health

behaviour change: it may be a time of concern about a cancer diagnosis and thus be associated with spontaneous change,[11,18] and it may also present an opportunity for clinicians to promote improvements in behaviours. An abnormal colonoscopy result may be more likely to trigger beneficial changes in behaviour, so we compared behaviours between participants with normal and abnormal test results. Our aim was to describe health-related behaviours before and after a colonoscopy among patients and their partners. Our objective was to carry out a prospective observational study on colonoscopy patients and their partners using self-reported questionnaire survey data immediately before and ten months after colonoscopy. As self-efficacy and locus of control are central to several health behaviour theories, including the Health Belief Model,[19] Social Cognitive Theory[20] and Protection Motivation Theory,[21] we assessed their roles using validated questionnaires and also recorded physical activity, tobacco smoking, diet and alcohol consumption. We hypothesised that study participants with high scores of self-efficacy and with 'internal' locus of control would change health behaviours for the better following colonoscopy. Although there is no cut-off score to define persons as being high or low self-efficacious Ralph Schwarzer, an expert in self-efficacy measurement, recommends conducting a median split, which is to dichotomize the study sample.[35] 'Health-Internals' believe that the locus of control for health is internal and that one stays or becomes healthy or sick as a result of his or her behaviour whereas 'health-externals' believe that factors which determine their health are such things as 'powerful others' and 'chance' over which they have little control.

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METHODS

Study design

We conducted a prospective cohort study of health behaviour change in patients and their partners before and 10 months after colonoscopy. Comparison groups are patients

receiving a normal result notification (NRN) versus patients receiving an abnormal result notification (ARN) such as, colorectal cancer, polyps or diverticulitis. Health behaviour change of patients and partners (controls) are also compared.

~~Prospective cohort study of health behaviours of patients referred for colonoscopy and their partners.~~

Setting

Colonoscopy clinics in five hospitals within three Health Board areas in Scotland, UK. Recruitment occurred between September 2010 and August 2011.

Participants

Patients were invited by an advert for the study enclosed along with their colonoscopy appointment letter from the hospital. On attendance for colonoscopy, clinic staff obtained verbal consent for patients (and, if present, their partners) to allow the Research Assistant (RA) to approach them. If a patient did not wish to be approached by the RA, consent was sought to retain non-identifiable data (age, sex and sector level of the postcode) to assess selection bias. The RA asked consenting participants to complete the baseline (T1) questionnaire and written consent form at home and return both in a pre-paid addressed envelope. Patients whose partners were not present were asked to provide the name and contact details of their partner who was subsequently contacted by the RA by telephone about the study.

Eligibility criteria

Patient inclusion criteria were: i) referred for colonoscopy, ii) no past history of cancer, iii) ≥18 years old, iv) has a partner. Partner inclusion criteria: i) ≥18 years old, ii) no history of cancer.

Primary outcome

The primary outcome measure was the extent of change in individual health behaviours before colonoscopy and 10 months later. Consequently, we selected measures that ranked individuals along a distribution of amount of physical activity, dietary and alcohol intake, and tobacco use.

Variables, measures and data sources

Information was self-reported by participants or obtained from medical records.

Heath-related behaviour variables

The International Physical Activity Questionnaire[22,23] was used to categorise participants into low, moderate or high levels of PA using Metabolic Equivalent of Task (MET) scores. The Scottish Collaborative Group Food Frequency Questionnaire (SCG FFQ)[24,25] was used to measure intakes of foods and alcohol. Current smokers were defined as those who had smoked at least 100 cigarettes in their entire life and currently smoked.

An aggregate risk behaviour score was calculated based on generally accepted requirements for risk factor reduction for most of the main chronic diseases and specifically for prevention of colorectal cancer because colonoscopy is a main investigation for colorectal cancer symptoms.[26,27] Specifically, we defined high risk behaviour using Scottish government recommendations[28,29,~~30~~] as follows: <5 measures/day of fruit and vegetables; <3 portions/day of bread; >4 (men) and >3 (women) units/day of alcohol; current smoker; and low physical activity (equivalent to less than thirty minutes of moderate intensity activity on at least 4 days of the week). For the purpose of this study, a 'measure' as defined in the SCG FFQ was assumed to be equal to a 'portion' of fruit or vegetables.

Demographic variables

Participants self-reported their age, sex, level of education, household income, employment status, and postcode (to calculate Scottish Index Multiple Deprivation (SIMD[31])).

Clinical variables

Body Mass Index (BMI) was calculated by dividing weight (kg) by height squared (m^2) using self-reported values. Participants were categorised as obese if BMI≥30.0 kg/m^2. Participants self-reported their medical conditions currently being treated by a doctor. Result of the colonoscopy was obtained from patient medical records. Patients were categorised as receiving a normal result notification (NRN) or abnormal result notification (ARN) such as, colorectal cancer, polyps or diverticulitis.

Psychological variables

Participants' perceived control over their health-related behaviours was measured using the Multidimensional Health Locus of Control Scale[32,33]. The instrument measures three dimensions of control: internal, powerful others and chance. Participants' self-efficacy was measured using four separate self-efficacy scales (smoking, diet, alcohol, PA) recommended by Schwarzer and colleagues.[34] There is no cut-off score to define persons as being high or low self-efficacious so we split the sample at the median, as recommended by Schwarzer.[35]

Data collection

The baseline (T1) questionnaire was administered to patients who attended a colonoscopy clinic between September 2010 and August 2011. A pre-paid envelope was provided for participants to return the questionnaire after completing it at home. Participants were requested to report health behaviours before colonoscopy. There was no cut-off date for

returning the baseline questionnaire. The follow-up questionnaire (T2) was posted 10 months after the clinic date for colonoscopy, between July 2011 and June 2012.

Bias

We attempted to minimise information biases by using, where possible, validated questionnaires and to minimise selection biases by inviting all colonoscopy patients to participate.

~~Sample size and S~~statistical analysis

Statistical analysis was carried out using Stata/SE 11.2 software. Means ± standard errors or medians [interquartile range (IQR)] were presented as appropriate following visual assessment of histograms of continuous variables. Differences in characteristics and behaviours between groups were assessed using Pearson's chi-squared test for categorical measures and either T-tests or Mann-Whitney tests for continuous variables as appropriate. Differences in continuous variables between T1 and T2 were assessed using a paired T-test or the Wilcoxon signed-rank test. Differences in categorical variables between T1 and T2 were assessed in SPSS version 20 using the McNemar-Bowker test for variables with 3 or more categories, and the McNemar test for binary variables. To predict health-related behaviour at T2 logistic regression models were undertaken.

Statistical power

Our sample size was based on answering the research question '*Do health behaviours change after a major health threat?*' We used the variable physical activity to calculate statistical power because it has the strongest association with colorectal cancer survival and detecting colorectal cancer is one of the main reasons for colonoscopy referral. This paper reports a comparison of changes in health behaviours of patients with NRN and ARN

following colonoscopy. However, the study had initially aimed to detect an increase in physical activity of 25 or greater MET hours in patients diagnosed with cancer at colonoscopy compared to non-cancer patients, and samples of 46 cancer and 46 non-cancer patients would have been required. The effect size was derived from Satia,[36] and sample size calculations assumed conventional values of α=0.05 and β=0.20 (giving a power, or 1- β, of 80%). Thus, our study numbers exceeded those required by the initial sample size calculation.

RESULTS

Of 5,798 colonoscopy registrations, 2,577 patients (44%) met eligibility criteria for the study of whom 565 (22%) eligible patients and 460 partners were recruited (**Error! Reference source not found.**~~Figure 1~~). Recruited patients compared to non-recruited patients were significantly older (60.3 ± 0.5 versus 57.2 ± 0.4), more affluent (Carstairs decile 1 and 2, 43% versus 29%) and a higher proportion male (57% males versus 50% male). 72% (n=387) of patients received an ARN and 28% (n=149) a NRN. Overall, 68.9% (n=706) of participants returned a second, follow-up questionnaire at T2. The median times for both patients and partners to return the baseline questionnaire was 12 days.

{Please insert Figure 1 here}

At baseline (T1), a higher proportion of patients with abnormal result notification (ARN) were male, older, retired, and with a household income under £20,000 compared to patients with normal result notification (NRN) - **Error! Reference source not found.**~~Table 1~~. Overall 27% consumed less than five measures a day of fruit/vegetable, 20% exceeded recommended alcohol limits, 50% had low levels of physical activity and 21%

were obese. Higher proportions of ARN patients were not meeting these recommendations but the difference was only significant for physical activity. Only 11% of patients reported current smoking. When combined, overall 52% of participants had 2 or more risk behaviours, which comprised 55% of ARN and 42% of NA~~A~~RN.

{Please insert Table 1 here}

There were no significant differences between patients with abnormal and normal results with respect to self-efficacy for smoking cessation, physical activity, diet and alcohol (Table 2). Partners of patients with normal results were more likely to have low self-efficacy for smoking cessation.

{Please insert Table 2 here}

Overall, there was a 5% reduction in respondents who exceeded alcohol consumption guidance and an 8% increase in the proportion with low physical activity - **Error! Reference source not found.**~~Table 3~~. The proportionate increase in low physical activity was similar in patients with abnormal and normal colonoscopy results but statistically significant only among those with abnormal findings (which might be explained by the larger sample size in the abnormal category). When risk behaviours were aggregated, there was no overall change in behaviours in any patient group. We found no significant change in health behaviours of partners, irrespective of the colonoscopy result of the patient (data not shown).

{Please insert Table 3}

We used multiple logistic regression analyses to explore predictors of the two behaviours that changed significantly over time: low physical activity and high alcohol intake - **Error! Reference source not found.**~~Table 4~~. Low physical activity at baseline was the strongest predictor of low physical activity at T2 among patients and increasing age was also associated with lower physical activity. Sex, socio-economic circumstances, co-morbidities, colonoscopy findings and self-efficacy did not predict changes in physical activity over time.

{Please insert Table 4}

Excessive alcohol consumption at T2 was most strongly determined by excessive consumption at baseline - **Error! Reference source not found.**~~Table 5~~. Lower self-efficacy at T1 was associated with higher alcohol consumption at T2. Age, sex, socio-economic circumstances, co-morbidities and colonoscopy findings were not associated with higher alcohol intake at follow-up.

{Please insert Table 5}

DISCUSSION

Colonoscopy was associated with marginal spontaneous changes (that is, without a behavioural intervention) in some health-related behaviours. We found that there was a 5% reduction in excessive alcohol consumption (a beneficial change) but an 8% increase in low levels of physical activity (a change for the worse) 10 months after colonoscopy. There were no significant changes in health behaviours among patients' partners, suggesting that behavioural changes in colonoscopy patients were not necessarily part of wider trends that might influence health behaviours~~temporal trends~~. No behavioural advice was given to

patients as part of their investigations, and thus colonoscopy might be regarded as a teachable moment in which spontaneous changes are triggered. However, colonoscopy also represents an interaction with health services that might be optimized to encourage improvements in health-related behaviours. At baseline, we found that ARN patients and their partners scored significantly higher than the NRN patients and partners on the MHLC Powerful Others scale, indicating that ARN patients and partners believed more strongly that health professionals were responsible for their health and health outcomes. Thus, ARN patients in particular, may be receptive to health promotion advice from health professionals.

Our ~~This~~ conclusion that colonoscopy can be regarded as a teachable moment is similar to a recent systematic review of eleven articles about the impact of cancer screening (nine of which investigated the impact of lung screening on smoking cessation) which concluded that cancer screening 'might' be a teachable moment for health behaviour change[37]. Research about change in health behaviours after diagnosis of chronic health conditions indicate at best, only modest changes.[38] Thus, based on current evidence it remains uncertain if, and the extent to which major health events represent teachable moments. Health behaviours are likely to be influenced by a complex mix of factors, so that in addition to any beneficial teachable moment effects, ongoing symptoms that prompted colonoscopy may also affect behaviour. These may explain reductions in high levels of physical activity and concomitant increases in low levels.

We found that baseline health behaviours for low physical activity and excessive alcohol consumption were the strongest predictors of the same behaviours 10 months after colonoscopy but, additionally, increasing age predicted lower physical activity and lower self-efficacy around alcohol predicted excessive alcohol consumption at follow-up. Among

our patient sample, 11% smoked, which is much lower than the Scottish general adult population prevalence of 23%.[39]

This study found that a low level of PA at the time of colonoscopy and older age were predictive of a low level of PA 10 months post-colonoscopy. Further, high alcohol intake at the time of colonoscopy and low alcohol self-efficacy were predictive of high alcohol intake post-colonoscopy. Of note, fatalism (MHLC Chance score) was not predictive of any differential health behavior change. ARN was not predictive of health behaviour change following this health event, which is in contrast to studies of smokers under-going screening for lung disease.[40,41] A cross-sectional study of over 10,000 smokers at 2-3 years post-screening for COPD found that those with a first-time positive result were significantly more likely to stop smoking than those with a negative result[4035]. A cross-sectional study of 134 active smokers who underwent spiral CT screening found that 62% of those with a positive result either stopped or decreased smoking, whereas only 46% with a negative result did so.[4136] Thus, the effect of test results following screening for disease on health-related behaviour appears to vary according to type of screen (e.g., colonoscopy versus spiral CT), reason for screening (e.g., colon disease versus lung disease) and health-related behaviour (e.g., alcohol versus smoking).

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Our study has strengths and limitations. This is the first prospective observational study to report health-related behaviours of patients and their partners before and 10 months after colonoscopy. We used validated questionnaire survey tools, obtained a relatively large sample for a prospective cohort study and achieved high follow-up rates of 69%. There are however, several study limitations. First, the sample may not be representative of all patients population undergoing colonoscopy. The response rate of eligible patients was 22%, and there was some selection bias towards a more affluent, older and male population.

Socio-economic affluence may explain why our sample had lower smoking prevalence than the general population. Patients who participate in the newly introduced national colorectal cancer screening programme also may be more likely to be motivated to change in their behaviour. Second, while participants were requested to self-report health behaviours before the colonoscopy and as soon as possible thereafter, the baseline questionnaire was completed after the colonoscopy when participants may already have been influenced and starting to make some changes and there was no cut-off date for returning the baseline questionnaire. Thus, the observed changes for the better or worse in health behaviours may be an under-estimation of the extent of change. Third, although valid and reliable survey instruments were used, self-reported data are susceptible to expectation biases and other misclassification effects.[42] However, our principal interest was in behavioural change rather than absolute prevalences of behaviours, and thus over- or under-reporting of certain behaviours would not necessarily invalidate our findings on whether they changed after colonoscopy. The observed decreases in excessive alcohol consumption and in physical activity following colonoscopy may not be caused by the procedure but by other confounding factors that we have not identified. We are not aware of any health promotion activity associated with colonoscopy as it was delivered within the participating hospitals and our questionnaires were designed not to imply any favourable behaviours. The fact that there were no observed changes in partners and no differences between ARN and NRN patients suggests that the observed behavioural changes in patients was related to the colonoscopy.

Health care settings are recognised as important loci for promoting health behaviour change[43,44,45] and health events have been conceptualised as a teachable moment, particularly in relation to smoking cessation.[1,2,3,4,5,6,7,8,9,10] Conceptualising health events as teachable moments may be appealing to policymakers and clinicians

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because they represent an opportunity to introduce low-intensity interventions to change modifiable risk health-related behaviours to prevent disease and a recent review has identified 9 lifestyle interventions at the point of cancer screening to take advantage of this health event as a teachable moment , including 2 studies of a multiple lifestyle intervention offered to people who had undergone colonoscopy and had adenomas removed.[46,47]

For future research, developing and testing the effect of low intensity interventions (e.g., self-efficacy enhancement) to further reduce alcohol consumption may be appropriate because patients appear to spontaneously reduce alcohol consumption following colonoscopy, whereas more intense interventions may be required for health-related behaviours that do not change (e.g., diet) or change for the worse (e.g., physical activity). Qualitative to understand why patients spontaneously change some health behaviours but not others following a major health event will add to understanding about the utility of teachable moments for public health.

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Registrations

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Contributors: GH designed and managed the study, obtained ethics approval and drafted the paper. DM designed and managed the study, obtained ethics approval and revised the paper. RO, NC, AC, KS, BD and AB designed the study and revised the paper. LM designed the study, wrote the statistical analysis plan, cleaned and analysed the data and revised the paper. SF advised on the statistical analysis plan and analysed the data. All authors have full

access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

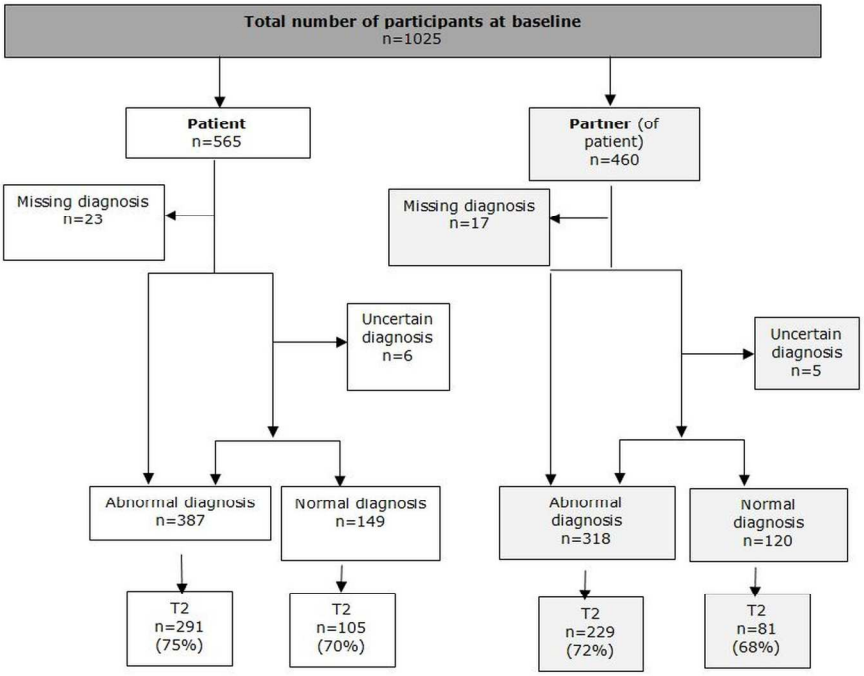
Competing interests: All authors had no support from any organisation for the submitted work, no financial relationships with any organisations that might have an interest in the submitted work in the previous three years and no other relationships or activities that could appear to have influenced the submitted work.

Ethics: The study received West of Scotland Medical Research Ethics Committee approval (REC REF 10/S0709/24). All participants provided written informed consent. The study was funded by the Chief Scientist Office Scotland and the study sponsor was the University of Stirling. The researchers acted independently from the funder and sponsor.

Study hypothesis: The study hypothesis that major health events are teachable moments triggering spontaneous health-related behaviour change arose before inspection of the data. The main hypothesis was that colorectal cancer diagnosis is a teachable moment. This article reports a further study hypothesis, which was that colonoscopy is a teachable moment.

Data sharing statement: The relevant anonymised patient level data are available on reasonable request from the corresponding author. Participant consent was not obtained but the presented data are anonymised and risk of identification is low.

Figure 1: Recruitment of participants



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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Article
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Y
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Y
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Y
Objectives	3	State specific objectives, including any prespecified hypotheses	Y
Methods			
Study design	4	Present key elements of study design early in the paper	Y
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Y
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Y
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	**NA**
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Y
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Y
Bias	9	Describe any efforts to address potential sources of bias	Y
Study size	10	Explain how the study size was arrived at	Y
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Y
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Y
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	Y
		(*d*) If applicable, explain how loss to follow-up was addressed	Y
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Y
		(b) Give reasons for non-participation at each stage	-
		(c) Consider use of a flow diagram	Y
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Y
		(b) Indicate number of participants with missing data for each variable of interest	Y
		(c) Summarise follow-up time (eg, average and total amount)	-
Outcome data	15*	Report numbers of outcome events or summary measures over time	NA
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear	Y

		which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	Y
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	Y
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Y
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Y
Generalisability	21	Discuss the generalisability (external validity) of the study results	Y
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Y

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.