Research Article

Internet Use and Cancer-Preventive Behaviors in Older Adults: Findings from a Longitudinal Cohort Study

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Abstract

Background: The Internet is a key provider of health information, but little is known about its associations with cancer-preventive behaviors. This study investigated the associations between Internet use and cancer-preventive behaviors among older adults.

Methods: Data were taken from Waves 1 to 5 (2002–2011) of the English Longitudinal Study of Aging, a cohort study of men and women 50 years or older in England, United Kingdom. Internet use was recorded at each wave. Breast and colorectal screening, fruit and vegetable consumption, physical activity, and smoking were recorded at Wave 5. Social, cognitive, and physical function variables recorded at Wave 1 were analyzed as predictors of Internet use and included as covariates in analyses linking Internet use to behavior.

Results: Of 5,943 respondents, 41.4% did not report any Internet use, 38.3% reported using it in one to three waves ("intermittent users"), and 20.3% used it in all waves ("consistent users"). Internet use was higher in younger, male, White, wealthier, more educated respondents, and those without physical limitations. Multivariable analysis showed that consistent users were more likely than "never users" to report CRC screening, weekly moderate/vigorous physical activity, and five or more daily servings of fruit and vegetables, and less likely to report smoking. There was no significant association between Internet use and breast screening.

Conclusions: Internet use showed a quantitative association with cancer-preventive behaviors even after controlling for various social, cognitive, and physical correlates of Internet use.

Impact: Promoting Internet use among older adults from all backgrounds could contribute to improving cancer outcomes and reducing inequalities. *Cancer Epidemiol Biomarkers Prev; 22(11); 2066–74. ©2013 AACR.*

Introduction

Primary and secondary prevention behaviors have key roles in cancer control (1–7), yet adherence is suboptimal. Fewer than two thirds of eligible adults in England take up the offer of colorectal cancer (CRC) screening (8), with similar figures for the United States and other countries (9–11). In many countries, no more than one third of adults meet the recommendations for fruit and vegetable intake (12, 13), even fewer (less than a fifth) meet physical activity recommendations (14, 15), and around 1 in 5 continue to smoke (16, 17).

The Internet has the potential to provide behavioral advice and support on a huge scale. Results from the Health Information and National Trends Survey (HINTS) in the United States and an Australian survey show the public to be increasingly engaged with online health information (18–21). In the cancer field, use of online information by cancer survivors is well documented (22–26), and the Internet is being used as a resource for cancer-related information in the general population (27). These findings are complemented by evidence that online behavior change materials can achieve comparable effects to print-based or telephone modalities (28, 29).

One worry about the increasing use of the Internet as a source of health information is its potential to disenfranchise those who lack Internet access or competence. Data from the United Kingdom show that population subgroups such as women and those with a low income are less likely to use the Internet (30). However, the largest group of individuals who report no Internet use is older adults. More than 15% of all UK individuals of ages 55 to 64 have never used the Internet, increasing to 33.4% and 65.5% in the 65 to 74 and 75+ groups, respectively. Similar observations have been made in the United States, with evidence of digital exclusion among older, less educated, and ethnic minority citizens (31). Internet use in older

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Note: Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (http://cebp.aacrjournals.org/).

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people is a particular issue in the context of cancer prevention because people are more likely to develop cancer in older age (32, 33) and increasingly face decisions about taking part in cancer control behaviors such as breast and colorectal screening. Health communication experts have expressed concern that this could lead to significant inequalities in access to health information and advice and ultimately widen disparities in cancer outcomes (34).

In this study, we used longitudinal data from a population-based cohort of adults in England of ages 50 years or older to further investigate the digital-divide among older adults by observing the prevalence and sociodemographic predictors of Internet use over an 8-year period. This cohort also enabled us to establish whether Internet use was implicated in lifestyle behaviors (e.g., fruit and vegetable intake, exercise, and smoking) and healthcare-related decisions (e.g., cancer screening), some of which are specific to this group. We controlled for known sociodemographic predictors of Internet use including non-pension wealth, as well as cognitive function. We controlled for cognitive function because it declines in older age (35) and theoretical frameworks and empirical data suggest that it makes an independent contribution to explain the ability to process health information over and above literacy and other socioeconomic status markers (36, 37).

In line with national estimates (30), we predicted that lower Internet use would be associated with older age, lower socioeconomic status (assessed by education and income), lower cognitive and physical function, and being unmarried. The literature discussed above led us to hypothesize that increasing Internet use would be associated with greater enactment of cancer-preventive behaviors.

Materials and Methods

The data for the present analysis were from respondents in Waves 1 to 5 (2002–2003, 2004–2005, 2006–2007, 2008–2009, and 2010–2011) of the English Longitudinal Study of Aging (ELSA), a biennial, national, population-based cohort study established in 2002 to study health and aging in England (38). ELSA is harmonized with the Health and Retirement Study in the United States (39). ELSA participants are adults of ages 50 and above who had taken part in an annual government health survey, the Health Survey for England, which carries out annual home-based interviews of a stratified random sample of all households in England. Wave 1 of ELSA (the baseline for the present analyses) included 11,392 core members, 96% of all those who had been recruited from the Health Survey for England between 1998 and 2001 (40). Sample members were not eligible for follow-up at Wave 5 if they had since died, asked not to be revisited, or moved out of Great Britain. From the 8,982 eligible members, 6,242 (study response rate = 69.5%) were interviewed in Wave 5 of ELSA, which was the first wave to include questions on cancer screening (see Fig. 1).

Measures

Internet use. Internet use was recorded at each wave as part of the self-completed questionnaire. Respondents were given a checklist of eight items relating to social and leisure activities (voting, reading a daily newspaper, having a hobby, traveling in the United Kingdom, traveling abroad, going on day trips, using the Internet and/or email, owning a mobile phone, none of the above) and were asked to check the options applicable to them. We categorized respondents according to the total number of waves in which they checked "I use the Internet and/or email." Never users were those who did not check the Internet item in any of the waves, intermittent users were those who checked the Internet item at least once, and consistent users were those who checked the Internet item in all four waves[1].

Primary and secondary cancer-preventive behaviors. As part of the interviewer-administered main interview, respondents were asked whether they had ever completed a home-testing kit for CRC screening as part of the "NHS (National Health Service) Bowel Screening Programme" (yes/no)[2]. Women were also asked if they had ever had a mammogram as part of the "NHS Breast Screening Programme" (yes/no).

Both questions referred to the organized screening programs in which invitations to screening are issued from health service registers at predetermined intervals to people in a prespecified age range. The CRC screening program was fully implemented in England in 2010, inviting men and women biennially from ages 60 to 69, with the first invitation sent between the 60th and 61st birthday (the upper age limit is currently being extended). For analyses of CRC screening, we only included adults of ages 62 to 69 at Wave 5 to ensure that they would have been in the eligible age range. The breast-screening program has been running since 1988, with women invited every 3 years from ages 50 to 69 (the age bands have recently been widened). We selected women of ages 58 to 72 at wave 5 for analyses of predictors of breast screening to be sure that they would have received at least one invitation within the study period.

Physical activity was assessed during the interview by asking how many times a week did respondents engage in each of vigorous, moderate, and mild physical activity (more than once a week, once a week, 1–3 times a month, hardly ever, or never). Examples were given for each level of activity. Physical activity was recorded to categorize respondents according to whether or not they reported at least one episode of moderate or vigorous episode activity

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[1]We also split the intermittent Internet user group into those who were current or former users of the Internet. However, analyses did not reveal any differences between the two subgroups on study outcomes and so we decided to collapse them to increase the power to detect differences between the three remaining categories.
[2]The home-based fecal occult blood test is the only colorectal cancer screening modality currently available in the NHS.
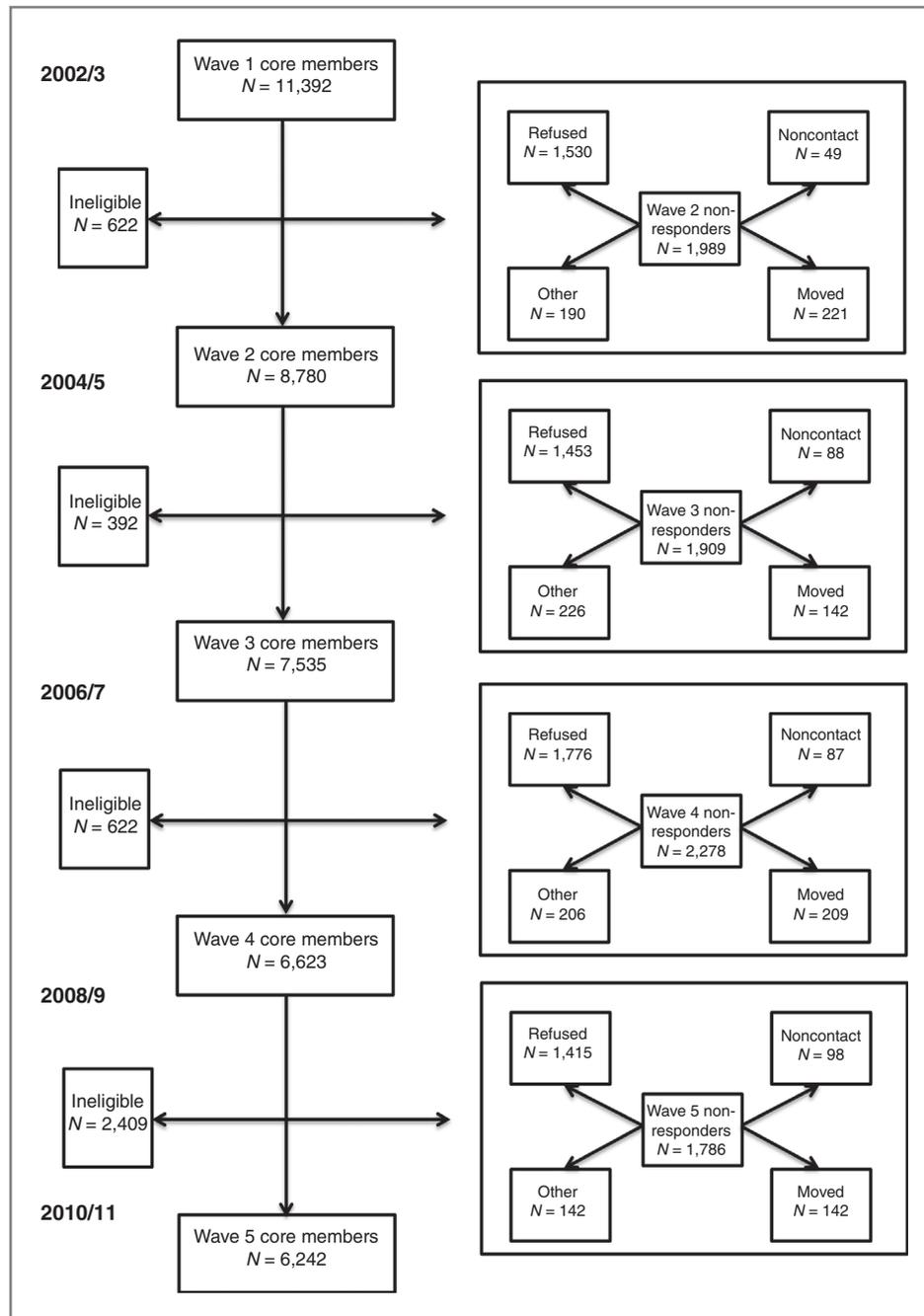
Figure 1. Recruitment and retention in the ELSA, waves 1–5.

a week. Fruit and vegetable consumption was assessed in the self-completion questionnaire. Respondents were asked "using the measures below, how much of the following did you eat yesterday" and to indicate the numbers from a list of small (measured in handfuls), medium and large, and very large (measured in slices) fruits and vegetables. The list also included dried, frozen, or canned fruit and vegetables, mixed dishes, and juice. Consumption data were recategorized to indicate whether or not respondents ate at least five servings a day. Respondents were also interviewed about their smoking behavior and categorized according to their current smoking status (yes/no).

Demographic and health variables. Demographic and health variables were taken from the Wave 1 interview and included: age (50–59, 60–69, 70–79, and above 80), sex, ethnic background (reported as White, mixed ethnic group, Black, Black British, Asian, Asian British, any other group, but categorized into White and non-White for the present analyses), and education on the basis of the highest level of qualification (no qualifications, below university degree level, and university degree equivalent). Total net

(nonpension) household wealth was based on detailed information about the value of all financial assets at the disposition of the household (i.e., houses, businesses, other physical assets, all forms of savings and investments) less debts; categorized into quintiles.

Physical capabilities were assessed by asking respondents about the degree to which any of six activities of daily living; dressing, walking across a room, bathing or showering, eating, getting in or out of bed, using the toilet; and seven instrumental activities of daily living; using a map to get around in a strange place, preparing a hot meal, shopping for groceries, making telephone calls, taking medication, doing work around the house or garden, and managing money, were impeded by health or physical problems (41). This variable was dichotomized into having limitations in any of the thirteen activities versus none.

Cognitive capabilities were assessed using a battery of interviewer-administered tests. These included two measures of memory and executive function known to be sensitive to age-related decline: verbal fluency (number of animals listed in 1 minute) and delayed recall (recall of 10 aurally presented words after a short period during which other unrelated questions were asked), both of which were entered separately as interval variables. The verbal fluency task is a widely used assessment of cognitive performance and has previously been validated (42). A working paper comparing both measures against other validated cognitive measures provides evidence for their concurrent validity (43).

Statistical analyses

We used multivariate ordered logistic regression to determine the associations between sociodemographic variables, physical and cognitive predictors (measured at Wave 1), and Internet use (never, intermittent, and consistent use across Waves 1–5). OR for achieving a higher level of Internet use with 95% confidence intervals (CI) adjusted for all other variables are presented.

A series of multivariable binary logistic regression analyses examined associations between Internet use across Waves 1 to 5 and each cancer prevention behavior (measured at Wave 5). ORs are presented for intermittent and consistent Internet use (vs. never) with 95% confidence and adjusted for potential confounding variables (i.e., significant predictors of Internet use).

Of 6,242 respondents who had responded to Waves 1 and 5, we excluded 270 individuals with missing data on age (4.3%) and 29 individuals (0.5%) who did not have data available on Internet use for any wave, restricting our core sample to 5,943. After accounting for missing values in covariates, the analytic sample for the multivariable ordered regression was 5,625. Respondents excluded from analysis for missing data were more likely to be women, older than 85 years of age, without educational qualifications, to have limitations in activities of daily living, and to be nonusers of the Internet.

For the model with breast screening as the outcome (potential eligible sample = 1,990 women of ages 58–72), data were unavailable for 708 women (64.4% response rate[3]). For the model with CRC screening as the outcome (potential eligible sample = 2,124 men and women of ages 62–69), data were unavailable for 750 people (64.7% response rate). For physical activity, data were missing for 3 persons (99% response rate). For fruit and vegetable consumption, data were not available for 579 respondents (91% response rate). For current smoking, data were missing for 115 cases (98% response rate). After accounting for missing cases in Internet use and other covariates, the analytic samples (n) for the five multivariable models were 1,207 (breast screening), 1,287 (CRC screening), 5,640 (physical activity), 5,141 (fruit and vegetables), and 5,534 (current smoking status).

Results

Internet use

Many respondents were Internet users, reporting either intermittent (38.2%) or consistent use (20.3%), but 41.4% were never users. The intermittent user group comprised 11.8% checking the Internet item in four waves, 8.3% checking it in three waves, 7.3% checking it in two waves, and 10.9% checking it in one wave. The never users comprised 41.4% that checked Internet in none of the 5 waves and the consistent users comprised 20.3% checking the Internet in all of the waves. Table 1 shows the distribution of Internet use by sociodemographic factors. In the multivariable regression analyses, men were more likely to report Internet use than women (OR, 1.41; 95% CI, 1.26–1.57). Respondents who were married at Wave 1 were more likely to report Internet use than those who were single, widowed, or divorced (OR, 1.30; 95% CI, 1.15–1.47). There was a significant incremental decline in the odds of Internet use by age, with 30.7% of 50- to 59-year-old respondents reporting consistent use, compared with 16.6%, 6.1%, and 2.3% of those of ages 60 to 69, 70 to 79, and above 80, respectively. There was also a significant association with education, with nearly half (46.2%) the respondents with a university degree reporting consistent Internet use compared with 23.4% and 4.7% of those with intermediate or no qualifications. A similar incremental association was seen with wealth quartiles.

Better performance on the delayed recall and the verbal fluency measures was associated with higher Internet use (OR, 1.12, 95% CI, 1.08–1.15; OR, 1.02, 95% CI, 1.01–1.03, respectively). Respondents with limitations in physical capabilities were significantly less likely to report Internet

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[3]Due to logistical issues in Wave 5, questions on cancer screening were only included part way through the round of data collection, hence the low response rate.

Table 1. Sociodemographic associations with Internet use in the ELSA (Waves 1–5)

	% (n)			Ordinal regression for a higher level of Internet use (n = 5,625)
	Never users	Intermittent users	Consistent users	OR (95% CI)
All (n = 5,943)	41.4 (2,458)	38.31 (2,277)	20.3 (1,208)	
Gender				
Female (n = 3,337)	46.6 (1,555)	37.1 (1,237)	16.33 (545)	Reference
Male (n = 2,606)	34.7 (903)	39.9 (1,040)	25.4 (663)	1.41 (1.26–1.57)
Age at wave 1				
50–59 (n = 2,623)	23.5 (616)	45.8 (1,202)	30.7 (805)	Reference
60–69 (n = 1,997)	45.9 (917)	37.5 (749)	16.6 (331)	0.46 (0.40–0.52)
70–79 (n = 1,271)	67.7 (747)	26.3 (290)	6.1 (67)	0.21 (0.18–0.24)
Above 80 (n = 343)	81.3 (178)	16.4 (36)	2.3 (5)	0.13 (0.09–0.19)
Marital status				
Not married (n = 1,803)	54.5 (983)	32.4 (584)	13.1 (236)	Reference
Married (n = 4,139)	35.6 (1,475)	584 (1,692)	23.5 (972)	1.30 (1.15–1.47)
Total net (nonpension) household wealth				
Quartile 1 (least affluent, n = 1,460)	60.5 (884)	31.2 (456)	8.2 (120)	Reference
2 (n = 1,473)	47.3 (696)	36.6 (540)	16.1 (237)	1.43 (1.22–1.68)
3 (n = 1,473)	33.5 (494)	43.3 (637)	23.2 (342)	1.77 (1.51–2.08)
4 (most affluent, n = 1,472)	24.4 (359)	41.5 (611)	34.1 (502)	2.51 (2.12–2.97)
Ethnicity				
Non-White (n = 119)	55.5 (66)	35.3 (42)	9.2 (11)	Reference
White (n = 5,643)	40.8 (2,299)	38.0 (2,139)	21.2 (1,196)	2.46 (1.64–3.71)
Education				
No qualification (n = 2,011)	67.1 (1,350)	28.2 (567)	4.7 (94)	Reference
Intermediate (n = 3,071)	32.9 (1,011)	43.7 (1,342)	23.4 (718)	2.80 (2.46–3.2)
Degree (n = 857)	11.0 (94)	42.8 (367)	46.2 (396)	5.97 (4.94–7.21)
Cognitive function				
Mean (SE) delayed recall (n = 5,872)	3.85 (.39)	4.72 (.38)	5.24 (.49)	1.12 (1.08–1.15)
Mean (SE) verbal fluency (n = 5,872)	18.67 (.12)	21.20 (.13)	23.18 (.18)	1.02 (1.01–1.03)
Limitations in physical capabilities				
No (n = 4,664)	36.8 (1,718)	40.4 (1,868)	23.1 (1,078)	Reference
Yes (n = 1,275)	57.9 (738)	31.9 (407)	10.2 (130)	0.71 (0.62–0.82)

NOTE: Total n may vary due to missing data. Regression analyses controlled for all variables in the table.

use than those with no limitations (OR, 0.71; 95% CI, 0.62–0.82).

Internet use and cancer-preventive behaviors

Table 2 shows the bivariate associations between Internet use and cancer-preventive behaviors. Breast screening (ever) was high overall in the eligible age range (95% in women of ages 58–72), with little association with Internet use (93.9% in never users, 97.2% in intermittent users, and 97.5% in consistent users). However, CRC screening showed a strong association with Internet use with ever having had CRC screening going from 51.7% in never users, 62.5% in intermittent, and 72.9% in consistent users. Internet users were also more likely to report being physically active (59.0%, 77.9%, and 88.3% across never, intermittent, and consistent Internet use) and to eat at least five

portions of fruit and vegetables a day (52.9%, 59.0%, and 62.6%), and were less likely to be current smokers (13.3%, 11.4%, and 6.6%).

Table 3 shows the association between Internet use and cancer-preventive behaviors after controlling for all sociodemographic and cognitive variables (see Supplementary Appendix 1 for full results of the multivariable analyses). With the exception of breast screening, Internet use was significantly associated with all the cancer-preventive behaviors. Adults using the Internet in all waves were more than twice as likely to report CRC screening in Wave 5, and 1.5 times more likely to report being physically active than those who never used the Internet, with intermittent users in between. Consistent Internet users were more likely to report eating five portions of fruit and vegetables a day, and less likely to report being a smoker

Table 2. Internet use and cancer-preventive behaviors

| | Internet use | | | |
| | % (n) | | | P value for trend |
	Never users	Intermittent users	Consistent users	
Ever participated in breast screening				
No	6.1 (24)	2.8 (17)	2.5 (7)	0.01
Yes	93.9 (368)	97.2 (583)	97.5 (278)	
Ever participated in CRC screening				
No	48.4 (176)	37.5 (245)	27.1 (94)	<0.001
Yes	51.7 (188)	62.5 (408)	72.9 (253)	
Weekly moderate or vigorous physical activity				
No	41.0 (1,008)	22.1 (502)	11.8 (142)	<0.001
Yes	59.0 (1,449)	77.9 (1,774)	88.3 (1,066)	
Daily intake of at least five servings of fruit and vegetables				
No	47.1 (990)	41.0 (860)	37.4 (448)	<0.001
Yes	52.9 (1,110)	59.0 (1,235)	62.6 (750)	
Current smoking status				
No	86.7 (2,083)	88.6 (1,980)	93.4 (1,112)	<0.001
Yes	13.3 (319)	11.4 (256)	6.6 (79)	

in Wave 5 than those who never used the Internet during the study period (OR, 1.24; 95% CI, 1.04–1.48, and OR, 0.56; 95% CI, 0.41–0.76, respectively).

Discussion

In this large, population-based cohort of older adults in England, individuals who consistently used the Internet over an 8-year period were significantly more likely than nonusers to engage in a range of primary and secondary cancer-preventive behaviors. For most behaviors, the association was quantitative, with consistent users more likely to be adherent than intermittent users, and intermittent users more likely to be adherent than never users. The associations remained significant after controlling for a wide range of potential demographic, cognitive, and physical correlates of Internet use and health behaviors.

To our knowledge, no population-based studies have shown that Internet use is associated with these behavioral outcomes. Although we identified a higher prevalence of Internet use than national estimates of older adults (30), we also identified a clear "digital divide". Specifically older, less wealthy, non-White, and less physically able individuals were less likely to use the Internet, consistent with population-based data (30, 31). These results indicate the potential of Internet use to exacerbate inequalities in cancer outcomes (44) but also the scope for efforts to reduce the digital divide to improve health disparities.

The longitudinal design of this study enabled us to include a prospective element to our findings by showing that individuals who had intermittent Internet exposure showed an intermediate level of cancer-preventive

Table 3. Multivariate logistic regression linking Internet use with cancer-preventive behaviors

| | Intermittent | | Consistent | |
	OR (95% CI)	P value	OR (95% CI)	P value
Ever participated in breast screening (n = 1,207)	1.50 (0.70–3.17)	0.29	1.38 (0.49–3.88)	0.54
Ever participated CRC screening (n = 1,287)	1.41 (1.05–1.90)	0.02	2.13 (1.47–3.09)	0.001
Weekly moderate or vigorous physical activity (n = 5,640)	1.19 (1.01–1.30)	0.03	1.50 (1.20–1.90)	<0.001
Daily intake of at least five servings of fruit and vegetables (n = 5,141)	1.12 (0.98–1.29)	0.11	1.24 (1.04–1.48)	0.02
Current smoking status (n = 5,534)	0.81 (0.66–1.01)	0.06	0.56 (0.41–0.76)	<0.001

NOTE: Controlling for age, gender (except breast cancer screening), marital status, total net (nonpension) household wealth, ethnicity, education, cognitive, and physical capabilities (see Supplementary Appendix 1 available as supplementary data online for full set of results of the multivariate regression analyses).

behaviors. Although a more rigorous study design would be needed to assess causality in the data, there are several potential explanations for an association between Internet use and cancer-preventive behaviors that warrant further investigation in datasets where suitable measures are available.

For example, population-based studies have shown that people frequently use the Internet to seek information about their health (18, 19, 21). People may therefore be deliberately seeking information about cancer and following the advice they find. They may also be incidentally exposed to health information when browsing the Web (known as "information scanning"; ref. 45). The characteristics of individuals that predispose to information technology acceptance may also be conducive to early adoption of cancer prevention messages (46), resulting in the association between Internet use and cancer control behaviors. The fact that the observed associations were robust to controls for a wide range of demographic, health, and cognitive factors implicated in the early adoption process goes some way toward ruling out confounding. However, other factors not measured in this study that are associated with both Internet use and cancer control behaviors might be responsible for the reported relationships.

This study had additional limitations. Reliance on a single question about Internet use meant that we did not know people's reasons for going online, or the types of information sought. Although seeking health information is a common purpose for online searches in the United States (21), little is known about this in the United Kingdom, and some of our respondents may have used the Internet primarily for e-mail. Our Internet use variable was based on the number of waves in which respondents checked the Internet/email item on the checklist of social and leisure activities and where data were missing, we assumed that the respondent did not use the Internet on that wave, but this may have led us to underestimate Internet use. The behavioral data were self-reported which limits their reliability (47–49). Screening prevalence may also have been underestimated because we did not explore the possibility that a small minority of individuals may have undergone screening procedures outside the NHS. In common with other cohort studies (38), ELSA shows a "healthy participant" bias compared with the general population (8, 12, 14, 17, 50) and its focus on older adults means that results cannot be generalized to younger samples. But in terms of strengths, ELSA is a well-characterized cohort, making it possible to assess Internet use over a long period of time, and examine associations with behavior net of a wide range of potential confounders.

Internet use is likely to become even more important in the future, as developments in technology set the stage for many new opportunities in health information. Web 2.0 is an interactive platform that provides access to information in a variety of styles and formats and makes it possible to tailor health recommendations to individual's needs and preferences (51). The value of tailored Web-based health information was highlighted in a recent meta-analysis of 88 interventions using computer algorithms to tailor information on smoking, physical activity, diet, and mammography, which showed that dynamic tailoring across repeated contacts increased the likelihood of behavior change compared with static tailoring (28).

There are, inevitably, shortcomings of Internet-based health information (34). It is largely unregulated and therefore has the potential to adversely influence public perceptions of cancer or contradict evidence-based cancer control messages (52). Because of limitations in the questions about Internet use, our data cannot be used to evaluate the quality of information accessed by our respondents. It would therefore be premature to use the nature of the association to make any inferences about the general quality of health-related information on the Internet. Our data do however make a case for policy makers and researchers to increase overall access to the Internet and to find ways to develop peoples' information evaluation skills (21).

This prospective study of older adults in England showed that digital literacy was associated with greater adherence to primary and secondary cancer-preventive behaviors. Action to promote Internet use among today's older adults from all social and ethnic backgrounds could contribute to improving cancer outcomes and reducing inequalities.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Authors' Contributions

Conception and design: A.J. Xavier, E. d'Orsi, J. Wardle, P. Demakakos, S.G. Smith, C. von Wagner
Development of methodology: A.J. Xavier, E. d'Orsi, J. Wardle, P. Demakakos, S.G. Smith, C. von Wagner
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