Screening for prevention and early diagnosis of cancer

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Abstract

The poor outcomes for cancers diagnosed at an advanced stage has been the driver behind research into techniques to detect disease before symptoms are manifest. For cervical and colorectal cancer, detection and treatment of 'pre-cancers' can prevent the development of cancer; a form of primary prevention. For other cancers – breast, prostate, lung, and ovarian – screening is a form of secondary prevention; aiming to improve outcomes through earlier diagnosis. International and national expert organizations regularly assess the balance of benefits and harms of screening technologies, issuing clinical guidelines for population-wide implementation. Psychological research has made important contributions to this process, assessing the psychological costs and benefits of possible screening outcomes (e.g. the impact of false positive results), and public tolerance of overdiagnosis. Cervical, colorectal and breast screening are currently recommended, and prostate, lung and ovarian screening under active review. Once technologies and guidelines are in place, delivery of screening is implemented according to the healthcare system of the country, with invitation systems and provider recommendations playing a key role. Behavioral scientists can then take up the baton to understand how individuals make screening decisions, including the impact of knowledge, perceived cancer risk, worry and normative beliefs about screening. This information is used to develop strategies to promote screening uptake. This article describes current cancer screening options, discusses behavioral research designed to reduce under-screening and minimize inequalities, and considers the issues that are being raised with informed decision-making and the development of risk-stratified approaches to screening.

Cancer Screening

Until the latter part of the 20th century, cancer was diagnosed only when symptoms of tumor growth were manifest. In many cases, the cancer would already have spread, limiting the efficacy of surgical or radiological treatment. Symptomatic presentation is still the predominant route to diagnosis across all cancers but for some cancer sites, tests have been developed to identify tissue changes that are indicative either of cancer precursors or early stage tumors. Where there is a recognizable precursor stage (e.g. cervical intraepithelial neoplasia (CIN), colorectal polyps) removal of abnormal tissue prevents the development of cancer and could therefore be termed primary prevention. Where the target is an early stage tumor (e.g. in mammography or fecal occult blood testing), screening is termed secondary prevention because it is designed to improve long-term outcomes by treating the cancer when it is more likely to be localized.

The first cancer screening test was developed by George Papanicolaou, whose 1943 book provided a method of identifying both pre-cancerous and malignant cervical cells. At around the same time, the value of x-rays to diagnose early breast cancers began to be recognized, with screening mammography becoming a viable option once lower-dose x-ray machines were available. Guaiac had been used to detect occult blood lost from colorectal cancers in stool samples, but in 1958 Dr Eric Mueller successfully impregnated guaiac resin onto a filter paper, which was the basis of the commercially-developed Hemmocult (fecal occult blood; FOB) test.

In 1968, the World Health Organization published a set of criteria to guide decisions about whether to introduce population-based screening (Wilson & Jungner, 1968). They argued that for a screening test to be worthwhile, the condition must be an important public health problem, whose natural history is well understood, and with an identifiable early stage at which treatment is demonstrably more effective. The test itself must be acceptable, with adequate infrastructure for follow-up, and any risk of harm from the test must be outweighed by the likelihood of benefit. Screening for cervical, breast and colorectal cancers has been judged to meet these criteria, and all three are recommended in international guidelines and implemented to varying degrees in all middle and higher income countries. By the 1980s, screening took pride of place as one of the major public health advances against cancer.

This article will begin with an introduction to cancer screening programs, focusing primarily on two countries, the US and the UK, with very different healthcare systems (Fuchs & Schaeffer, 2012), then discuss demographic and psychological predictors of screening participation. The final sections will discuss recent debates about screening, issues of public communication, and likely new directions.

Cancer Screening Programs

Cervical.

Cervical cancer is still the third most common female cancer worldwide (Globocan, 2008). However, incidence and mortality rates have reduced dramatically in countries that provide screening; and the reductions are

even more striking taking account of the increased exposure to cervical cancer risk factors that followed the sexual revolution of the 1960s (Peto, Gilham, Fletcher, & Matthews, 2004). Cytological examination of exfoliated cells from the cervix (the Papanicolaou (Pap) test) is still the most widely used test, primarily focused on identifying very early neoplastic changes, termed pre-cancers. If abnormalities are detected, the Pap test is followed up with a colposcopy examination and in some cases biopsy to confirm the grade of abnormality. Treatment involves removal of abnormal cells using excisional or destructive techniques (Jordan et al., 2009).

The discovery that infection with high-risk human papillomavirus (HPV) is the primary cause of cervical cancer (Walboomers et al., 1999) has been one of the great breakthroughs in cancer, for which Harald zur Hausen won the Nobel Prize in 2008. It led to the development of vaccines to prevent HPV infection (Harper et al., 2006; Villa et al., 2005), which will ultimately reduce the need for frequent screening and may even eradicate the disease. Testing for HPV DNA in the cervix is also being introduced both as a primary screen and to triage women with abnormal cytology. HPV testing has the additional advantage that tissue samples can be self-collected and mailed for analysis; potentially reducing some of the barriers to cervical screening uptake, particularly in less developed countries. The recommended age-range and frequency of cervical screening varies internationally, but it usually begins between 20 and 30 years, and is repeated every 3-5 years until age 60-65 (International Cancer Screening Network, 2008b). There are no randomized controlled trials of the efficacy of Pap test screening, but the well-understood course of the disease, the acceptability and safety of the test to identify pre-cancerous changes, the availability of effective and low risk treatment for pre-cancers, and the reduction in incidence that followed introduction of screening, together make it one of the most successful of all cancer screening methods.

Breast.

Breast cancer is the most commonly diagnosed cancer in women worldwide (Globocan, 2008) with rising incidence in many wealthy developed nations, partly as a consequence of changes in reproductive practices and lifestyle but probably also as a result of detection of early breast cancers through screening. The only widely recommended screening test is mammography, which uses x-rays of the breasts to detect tumors before they become palpable lumps.[1] Eleven randomized controlled trials of mammography were carried out between 1963 and 1991 in North America, Scandinavia and the UK. Meta-analyses have mostly found that the relative risk reduction for breast cancer mortality associated with mammography is around 20% given adequate follow-up (Independent UK Panel on Breast Cancer Screening, 2012), but there is little evidence of any effect on all-cause mortality and much debate about the balance of harms and benefits (Gotzsche & Nielsen, 2011).

[1] Breast self-examination, which was recommended at one time, is now widely understood to be ineffective and its promotion has been discontinued in favour of advocating more general 'breast awareness' (Kosters & Gotzsche, 2003)

Most guidelines recommend that breast screening should start around age 50 and continue until around age 70, with a recommended frequency of every one to three years (International Cancer Screening Network, 2008a). Survival rates have improved where breast screening is introduced, but reductions in breast cancer mortality have not been as high as expected; indicating that a proportion – and some would argue a substantial proportion – of the screen-detected breast cancers could be described as 'overdiagnosis'. Given the intensive surgical, radiotherapy and chemotherapy protocols that are used for breast cancer treatment, the possibility that significant numbers of women are 'over-treated' has raised considerable concern in the oncology community (see 'Balancing the Risks and Benefits of Screening').

Colorectal.

Colorectal cancer (CRC) is the third most common cancer worldwide taking both sexes together (Globocan, 2008). CRC screening uses a range of testing modalities. The first to be in widespread use was the fecal occult blood (FOB) test, a stool test in which the samples can be collected at home and mailed for analysis. If blood is detected, a diagnostic colonoscopy is recommended. The first randomized controlled trial demonstrated a 33% reduction in CRC mortality with annual screening and a 6% (non-significant) reduction with biennial screening (Mandel et al., 1993). Long term results from biennial screening in the Nottingham trial showed a 13% reduction in mortality at 19 year follow-up (Scholefield, Moss, Mangham, Whynes, & Hardcastle, 2012). FOB is the test modality used in the UK program and in many other European and Asian countries, although the recommended age and frequency varies. There is now a newer stool-based test, the fecal immunochemical test (FIT) which is more straightforward for the user, and provides the option to vary test sensitivity. The main outcome is earlier detection of cancers, i.e. secondary rather than primary prevention.

However, like cervical cancer, CRC has a well-established pre-cancerous stage. Endoscopic visualization of the entire colon is regarded as the best available test to detect both cancers and pre-cancers. Polyps can be removed during endoscopy, preventing the development of CRC. To date there are no RCTs of colonoscopy screening; but the public health case has been made on the basis of the natural history and case-control studies (Levin et al., 2008). Flexible sigmoidoscopy (FS) is an alternative test that can be done without sedation and performed by nurses or other trained healthcare professionals. It only examines the distal colon, but this is where most polyps form, and individuals found to have multiple or higher-risk polyps can be followed up with colonoscopy. Trials in the UK and the US have demonstrated reductions in incidence as well as mortality (Atkin et al., 2010; Schoen et al., 2012), and a single FS at age 55 is now being introduced into the UK screening program. The USPSTF recommends people age 50 to 75 years follow one of the three regimes: colonoscopy every ten years; FS every five years plus an FOB test every three years; or an FOB test every year.

Prostate.

Prostate cancer occupies a unique position in the screening spectrum. It is the second most common cancer in men worldwide (Globocan, 2008), and the second most common cause of male cancer death in many

countries (ACS, 2012a; CR-UK, 2012). A blood test measuring serum levels of prostate specific antigen (PSA) is widely used as an indicator of prostate cancer risk, alongside a digital rectal examination (DRE) to assess the prostate. This is followed up with a biopsy if PSA and DRE suggest high risk. However many prostate cancers are slow-growing and unlikely to cause problems within a man's lifetime, while treatments for prostate cancer have significant negative side-effects. The USPSTF has therefore recently recommended against screening, concluding that 'the benefits of PSA-based screening for prostate cancer, as currently used and studied in randomized, controlled trials, do not outweigh the harms' (Moyer, 2012). Given the high rates of PSA testing in the US (41% of men aged over 50 reported a recent PSA test (Swan et al., 2010)), adherence to the new recommendation will involve substantial behavior change. PSA testing is not recommended in the UK, but asymptomatic men can discuss PSA testing with their primary care doctor, and once they understand the risks, may elect to have the test. Uptake rates in the UK are substantially lower than in the US; one study found that 6% of men age 45-89 years had had a PSA test in 2007 (Williams et al., 2011).

Lung and ovarian.

There are active research efforts to develop other screening tests, with lung and ovarian cancer being important targets. Lung cancer is the most common cause of cancer death worldwide (Globocan, 2008). Generally diagnosed in late stages, when prognosis is poor, early identification has the potential for significant health benefits. Trials of lung cancer screening include the use of low-dose computed tomography, chest x-rays, and sputum cytology, with efforts focused on high-risk groups: smokers and people with pre-existing lung disease (Oken et al., 2011; Marcus et al., 2006; Aberle et al., 2013). A recent review of low-dose computed tomography screening concluded that it may be beneficial for very high risk individuals, but the harms are not well enough understood (Bach et al., 2012). The USPSTF has recently recommended annual screening for 55-80 years olds with a history of heavy smoking (USPSTF, 2013).

Ovarian cancer is one of the rarer female cancers, but typically presents at an advanced stage with extremely poor survival, making it the seventh most common cause of cancer death in women worldwide (Globocan, 2008) but the fourth and fifth most common in the UK and US respectively (ACS, 2012b; CR-UK, 2012). Because survival is good if the disease is detected early, there has been a longstanding interest in using transvaginal ultrasonography or serum levels of the tumor marker CA125 to give an indication of disease before symptoms are manifest. However, although there is some evidence for a survival benefit in screen detected cases, the largest randomized trial to date found no reduction in mortality (Buys et al., 2011). There was also significant morbidity as a consequence of follow-up investigations for women with false positive findings. The USPSTF has therefore consistently advised against population-based screening, although research efforts are in progress both to improve the screening technology and to risk-stratify the population and screen only higher risk groups for whom the risk/benefit payoff may be better (Gentry-Maharaj & Menon, 2012).

Organization of Screening

Countries with nationalized health systems, like the UK, have centrally organized screening programs where all eligible individuals are invited and re-invited at appropriate intervals using a 'call-recall' system. When eligibility or test interval recommendations change, this can be implemented easily in the call-recall system. Organized programs are also used in some managed health care plans in the US, but otherwise cancer screening in the US is opportunistic, and reliant on a physician recommendation or the individual's request to be screened. These factors can influence whether screening guidelines issued by national bodies like the USPSTF or the Centers for Disease Control and Prevention are followed.

Balancing Benefits and Risks of Screening

Physical Risks

Cancer screening is evaluated as a public health program; with evidence for efficacy coming primarily from demonstrating reduced risk (incidence, survival or mortality) in populations who have screening available. In common with other public health measures, the individual-level benefit cannot be estimated with any precision, but is likely to be small. Most individuals who undergo cancer screening are not only free of the target disease but never likely to develop it. This means that all those screened are exposed to the risk associated with the test, but only a minority stand to benefit in health terms; although reassurance of disease-free status can constitute a psychological benefit. Physical risks are therefore important. No screening modality is risk free: mammography involves x-ray exposure, colonoscopy and polyp removal are invasive procedures in which errors are possible, and treatment following an abnormal Pap test can cause cervical damage. Furthermore, none of the tests are 100% specific, so there are inevitably false positives with follow-up investigations that carry further risk; although public attitudes appear to be highly tolerant of false positives – with a 'better safe than sorry' perspective holding sway.

Overdiagnosis

Another concern is 'overdiagnosis'. The detection rate of pre-cancers (abnormal Pap tests, colorectal polyps) exceeds the expected rates of cervical and colorectal cancer, indicating that some of the apparent pathology must be non-progressive, but at present it is not possible to distinguish progressive from non-progressive abnormalities. However the risks of intervention in the case of pre-cancers within the recommended age groups is modest and there is consensus on the value of treatment. The situation is different in relation to overdiagnosis of breast cancer because cancer treatment involves significant loss to the patient's quality of life and risk to future health. The rising incidence rate of breast cancer since the introduction of screening, combined with the limited impact on mortality, suggest that a proportion – and perhaps a large proportion – of tumors detected are unlikely ever to have caused harm; so mammography programs may not be yielding the benefit that

was expected (Gotzsche & Nielsen, 2011; Bleyer & Welch, 2012). Ductal carcinoma in situ (DCIS) accounts for a significant proportion of screen-detected cancers, and although the risk of invasion is probably low, it is usually treated with surgery and radiation (Virnig, Tuttle, Shamliyan, & Kane, 2010). Given the psychological and physical costs of diagnosis and treatment, overdiagnosis of breast cancer is a major challenge. However, a recent UK review confirmed recommendations of the USPSTF (2009) and the Canadian Taskforce on Preventative Health Care (2011), that breast screening confers significant benefit, although it concluded that women need to be assisted to make an informed decision about screening participation, including understanding the risk of overdiagnosis (Independent UK Panel on Breast Cancer Screening, 2012).

Risk of Psychological Harm

In the past, a good deal of attention has been paid to the psychological costs of screening; particularly anxiety in advance of the test or while waiting for results, and distress if abnormalities are detected. The early literature on cervical screening, particularly results from qualitative studies, provided evidence of distress over abnormal results (Posner & Vessey, 1988). Despite attempts to improve the way that abnormal results are communicated, studies have continued to find that confusion and anxiety are common in women with abnormal cytology results and that distress can continue after colposcopic follow-up (Kitchener et al., 2004; Sharp et al., 2013). With the introduction of HPV testing to cervical screening protocols, qualitative studies have identified concern about acquisition and transmission of a sexually transmitted infection and a need for high quality information (Hendry et al., 2012). Quantitative findings have been more mixed, with some studies finding adverse psychological outcomes associated with HPV testing (Maissi et al., 2004) and others not (McCaffery et al., 2010; Kitchener et al., 2008). More research is still needed to quantify the associated psychological costs and develop appropriate educational materials to minimize adverse effects.

In contrast to cervical screening, there has been little evidence that colorectal screening has significant psychological costs. FS screening, with or without follow-up colonoscopy, has not been associated with post-screening anxiety in the trial context despite the invasive nature of the test (Wardle et al., 2003b). A small study of colonoscopy found a decrease in anxiety post-screening (Condon, Graff, Elliot, & Ilnyckyj, 2008).

The greatest psychological cost of screening is likely to derive from false-positive results, particularly where the test gives an indication of an early cancer rather than a pre-invasive condition. In the mammography context, most of the evidence suggests that an abnormal result understandably causes significant anxiety in the short-term while longer-term adverse effects are comparatively rare and can be minimized with appropriate information (Brett, Bankhead, Henderson, Watson, & Austoker, 2005). The impact of a false positive mammogram on future screening attendance is mixed, with US, Canadian and European studies showing different patterns of re-attendance (Brewer, Salz, & Lillie, 2007).

Present evidence indicates that, whatever its shortcomings, the public perceive screening to be a bulwark against an otherwise unpredictable and often fatal disease, and value it highly. Such is public fear of cancer, that negative results can be psychologically beneficial by virtue of the reassurance provided (Brett et al., 2005; Korfage et al., 2012). Even women with personal experience of false positive results appear extremely tolerant of a procedure that involves very many false positives to save one life from breast cancer (Schwartz, Woloshin, Sox, Fischhoff, & Welch, 2000); for reviews see Brett et al. (2005) and Cullen, Schwartz, Lawrence, Selby and Mandelblatt (2004).

Optimizing Screening Participation

Assessing and improving screening participation rates, both overall, and in underserved groups, is a key focus of research. The National Health Interview Survey (NHIS) carries out annual assessments of self-reported adherence to USPSTF screening recommendations. In 2010, 72% of women reported mammography within the recommended period, and 83% cervical screening, but only 59% of men and women were up-to-date with CRC screening (CDC, 2012); although the possibility of selection bias into the NHIS and inaccurate self-reporting of screening history mean that these figures are likely to be overestimates (Rauscher, Johnson, Cho, & Walk, 2008). Data on attendance in the UK National Screening Programs come from National Health Service records and are not subject to any self-report bias. They indicate that breast screening uptake for the most recent invitation was 77%, cervical screening coverage was 78%, and colorectal screening uptake was 54% (The The Health and Social Care Information Centre, 2013a, 2013b; von Wagner et al., 2011).

Socio-Demographic Predictors of Screening Participation

Understanding socio-demographic patterning of screening participation is important for a number of reasons. Any health technology where uptake is unequal across groups runs the risk of creating or widening health inequalities. Monitoring uptake across demographic groups therefore helps to ensure that underserved populations are not being disadvantaged, and identifies target groups for more active promotion.

Gender.

CRC screening participation was expected to be lower in men than women in the light of the widespread assumption that men are less willing to engage with health care systems. However, there was no gender difference in NHIS 2010 results (CDC, 2012). Examining specific screening modalities, BRFSS data found men reported slightly higher uptake of FOB testing than women, while women reported slightly higher uptake of colonoscopy (Joseph, King, Miller, & Richardson, 2012), but the differences were no more than one or two percentage points. The slight shifts from one analysis to another are also seen in the UK: FOB testing in the national screening program is higher in women than men (von Wagner et al., 2011), but FS uptake in the UK

Flexible Sigmoidoscopy Trial was higher in men (Wardle, Miles, & Atkin, 2005). On the whole, men are proving less disadvantaged in screening than was expected.

Age.

Within the USPSTF recommended age range, NHIS 2010 found no significant age differences in breast screening participation (CDC, 2012), with similar findings in a survey in the UK (Moser, Patnick, & Beral, 2009). Cervical screening participation is higher in younger women in the US (CDC, 2012), while the reverse appears to be true in England (NHS Cervical Screening Programme, 2011), possibly due to a specific decline in uptake in the youngest age-group; a phenomenon has been noted in several countries but is not yet well-understood (Lancucki et al., 2010). Participation in CRC screening is higher among older people in the US (CDC, 2012) and the UK (von Wagner et al., 2011). These results indicate that older adults are being reasonably well served by screening programs.

Socioeconomic Status.

Socioeconomic inequalities have been observed across almost all health behaviors and screening is no exception. Screening participation is higher in higher socioeconomic status (SES) groups wherever in the world it is studied, and whether SES markers relate to material resource (e.g. income), social status (occupation), or education, and for all forms of cancer screening. Recent US data show a strong association between self-reported mammography participation and both education and income, in addition to an effect of insurance status (Miller, King, Joseph, & Richardson, 2012), and similar associations with income and education are found in Great Britain (Moser et al., 2009). Reported cervical screening uptake is lower among women with less education and without insurance in the US (CDC, 2012), and recorded coverage is lower in more deprived geographic areas in the UK (Bang, Yadegarfar, Soljak, & Majeed, 2012). Likewise, self-reported CRC screening is positively associated with education, income and insurance in the US (Joseph et al., 2012), and FOB test completion ranged from 35% in the most deprived quintile of neighborhoods in the UK to over 70% in the least deprived (von Wagner et al., 2011). Importantly, none of these effects reflect a specifically low participation in the most deprived group, but rather a linear association across the distribution of SES. SES differences are a largely unmet challenge for research and implementation, and raise the specter of growing inequalities in cancer mortality in years to come.

Race/Ethnicity.

In both the US and the UK, there is evidence for ethnic disparities in screening participation. In the UK, breast, cervical and colorectal screening rates are all higher in White than non-White groups even after controlling for available markers of SES (Bansal, Bhopal, Steiner, & Brewster, 2012; Bang et al., 2012; von Wagner et al., 2011). NHIS data show that African Americans have lower CRC screening rates but similar rates of breast and cervical screening to non-Hispanic white Americans, while Hispanics are less likely to be up-to-date with breast, cervical or CRC screening (CDC, 2012). Understanding and tackling racial disparities in screening uptake should be a key issue for future research.

Overall, there is an urgent need for research aimed at understanding the processes underpinning the observed demographic patterning of screening behavior to inform the development of interventions to address inequalities.

Physician Endorsement

The role of health professionals in recommending screening or endorsing screening programs has received research attention as a possible 'cue to action' or injunctive norm within the context of social cognition models described below, and as part of more pragmatically-driven attempts to increase screening participation. The organizational context affects the way this is done. In the UK, general practitioners can provide endorsement by putting their names to screening invitations issued in the call-recall system; a strategy that has been found to increase participation in the CRC program (Hewitson, Ward, Heneghan, Halloran, & Mant, 2011). They also play a direct role in delivering cervical screening and are incentivized to achieve high coverage among their patients. In the US, where screening is mainly opportunistic, healthcare providers are directly involved in recommending screening to patients, and prompting them to do so has been shown to be an effective means of increasing uptake (Balas et al., 2000). Thus it is sometimes clinicians rather than patients who are the targets of behavioral interventions.

Individual Determinants of Cancer Screening Participation

A major challenge to behavioral science is to understand why upwards of 2 in 10 women do not participate in breast or cervical screening, and 4 in 10 men and women do not participate in CRC screening. Comparisons between the US and the UK can give clues to potential barriers. Even if US data overestimate slightly, participation rates do not differ dramatically from UK statistics. One implication of this is that factors other than cost (which is not an issue in the UK) must be a deterrent. The other is that a call-recall program in which all eligible adults receive invitations and reminders (as practiced in the UK), does not achieve complete coverage or eradicate disparities.

The lower rate of participation in CRC than breast or cervical screening has attracted particular attention. CRC screening participation is low in women as well as men, so the effect is not due to men being unfamiliar with screening. One explanation put forward in the US is that the variety of CRC screening options (colonoscopy, FS, FOB), compared with just one test for cervical and breast screening, leads to confusion or decision delay (Calderwood & Roy, 2013). However, the similarity of uptake rates in the US and in UK where currently only FOB testing is offered, suggests that this is not the full explanation.

Behavioral research has mostly been concerned both with understanding the determinants of uptake and identifying modifiable psychological variables as targets for intervention.

Cognitive constructs – knowledge, attitudes and beliefs.

Many of the social psychological theories developed in the 1970s and '80s have been applied to cancer screening participation. These models broadly assume a process of deliberative decision-making based on weighing up the 'pros' and 'cons' of screening; these include the perceived threat of the cancer, the perceived efficacy of the test, the difficulty of participation, and the social norms around testing. Model based applications have used the Health Belief Model (Bish, Sutton, & Golombok, 2000), the Theories of Reasoned Action and Planned Behavior (Cooke & French, 2008), the Transtheoretical Model (Spencer, Pagell, & Adams, 2005), and Protection Motivation Theory (Orbell & Sheeran, 1998), to predict screening intentions or screening attendance. Constructs from these models are also frequently included as 'stand-alone' items in studies of cancer screening.

Knowledge.

Knowledge, both of the risk of cancer and of screening as a strategy to reduce risk, is assumed to be a necessary, though not sufficient, precursor to participation. People with higher knowledge of cancer and cancer screening have higher uptake (Berkowitz, Hawkins, Peipins, White, & Nadel, 2008; Rakowski et al., 2006). A study in the UK indicated very poor awareness of the high prevalence of CRC, which could contribute to lower uptake of CRC screening (Juszczyk, Simon, Waller, Ramirez, & Wardle, 2011). Differential knowledge about cancer screening may also be a mediator of SES differences in participation.

Probably the most important aspect of knowledge is that screening is designed for the asymptomatic population, and therefore good health or a healthy lifestyle should not in themselves be reasons to decline screening. However, lack of symptoms has consistently been associated with lower perceived risk (see below) and lower uptake of cancer screening in both qualitative and quantitative research (Power, Miles, von Wagner, Robb, & Wardle, 2009; Schueler, Chu, & Smith-Bindman, 2008) and indicates a clear health education target.

The landscape of knowledge research is also changing with the emergence of the informed decision-making perspective. For people to make informed decisions about screening participation, they need to know more about it. This could include understanding the difference between screening as primary and secondary prevention, understanding why some potential screening programs are recommended and others not, and why specific age groups are selected, and recognizing the risks of overdiagnosis. These all bring challenges of communication, especially in populations with relatively low health literacy/numeracy, little interest in health issues, and decades of exposure to health promotion messages presenting the simple case for early detection.

Attitudes.

In broad terms, public attitudes towards screening are positive; some would say too positive (Schwartz, Woloshin, Fowler, Jr., & Welch, 2004). The public believes that screening helps detect cancer earlier and that early detection improves the chance of survival. People with stronger beliefs about the efficacy of screening are more likely to participate (Berkowitz et al., 2008). A negative screening result is also perceived as an important indicator of safety from a greatly feared disease, and again, the belief that screening will provide 'peace of mind'

is associated with higher likelihood of participation (Cantor, Volk, Cass, Gilani, & Spann, 2002; Power et al., 2009). In contrast, fatalistic beliefs – that health events are out of individual control or that cancer is always fatal – have been associated with lower uptake (Chavez, Hubbell, Mishra, & Valdez, 1997; Powe & Finnie, 2003; Schueler et al., 2008; Vernon, 1997).

Social norms.

Several social cognition models suggest that social norms may be important in understanding behavior. So-called 'injunctive norms' refer to the extent to which important others are perceived to endorse a behavior, while 'descriptive norms' are the extent to which other people are perceived to engage in the behavior. Recent intervention research suggests that manipulating the descriptive norm may be a way of increasing intentions to participate in screening (Sieverding, Matterne, & Ciccarello, 2010) – if a behavior is seen as normative, people may be more likely to participate, which could be an example of System 1 processing (see below). Injunctive norms have also been found to be important in predicting cancer screening intentions (Smith-McLallen & Fishbein, 2008), which is consistent with findings on physician endorsement and recommendation (see above).

Perceived risk.

Perceived risk features in most social cognition models and is often seen as the engine of preventive action, although associations with screening participation have been somewhat mixed. Higher perceived risk of breast cancer was positively associated with having a mammogram in 27 out of the 32 studies in a meta-analysis, although the effect size was small (Katapodi, Lee, Facione, & Dodd, 2004). Evidence for a relationship between perceived risk and cervical and CRC screening is less clear (Vernon, 1999). Part of the explanation for the low predictive value of perceived risk may be failure to control for past and anticipated future screening behavior in cross-sectional studies (Weinstein & Nicolich, 1993) and heterogeneous measurement of risk perceptions (Vernon, 1999). A recent study comparing different measures of perceived risk found that the 'feelings of risk' item '*If I don't get screened, I would feel very vulnerable to getting colon cancer sometime in my life'* had the strongest association with colonoscopy intention (Dillard, Ferrer, Ubel, & Fagerlin, 2012). The relationship with screening behavior is yet to be explored, although a study of vaccination found 'feelings of risk' was a stronger predictor than other measures of risk probability (Weinstein et al., 2007) and it is clear that affective responses to risk information play a major role in decision-making (Slovic, Peters, Finucane, & Macgregor, 2005).

The origins of perceived cancer risk are complex. Family history is clearly important (DiLorenzo et al., 2006; Montgomery, Erblich, DiLorenzo, & Bovbjerg, 2003) – although there are subtle themes of family contact which mean that perceived family history is not necessarily veridical. People discount relatives whose disease history is unknown, who died young from other causes (before they reached the age at which they might get a cancer diagnosis), and those with whom they have little contact (Robb, Miles, & Wardle, 2007). Awareness and beliefs about cancer and its risk factors also contribute. The public may have a different view of risk from the experts, with relatively less emphasis on early age of onset and less distinction between cancer sites. Furthermore

they may be relatively unaware of the fact that the earlier stages of cancer can be asymptomatic. Symptoms clearly influence perceived risk, with lack of symptoms a frequent explanation for the lack of need for screening (Oscarsson, Wijma, & Benzein, 2008), even though asymptomatic disease is the screening target. Individual characteristics seem also to inform perception of personal risk, including sociodemographic, health and lifestyle factors (e.g. McQueen, Vernon, Meissner, & Rakowski, 2008). The fact that cancer is such a dreaded disease is also likely to influence risk perceptions via the affect heuristic, with negative emotional responses making it difficult for people to process numerical risk information (Peters, McCaul, Stefanek, & Nelson, 2006)).

Cancer worry.

Cancer worry can be distinguished from general anxiety (Jensen, Bernat, Davis, & Yale, 2010). It is correlated with perceived risk but also appears to have some independent origins (Jensen et al., 2010; Lipkus et al., 2000; Moser, McCaul, Peters, Nelson, & Marcus, 2007). Levels of cancer worry are consistently found to be high. A US study from the 1960s indicated that almost a third of adults (31%) endorsed cancer as a significant cause for worry in their lives (Kirscht, Haefner, Kegeles, & Rosenstock, 1966), and a recent UK survey showed that 20% of people worried more about cancer than knife crime, debt or losing a job (CR-UK, 2010).

The relationship between cancer worry and cancer screening behaviors has not been entirely elucidated. Two contrasting hypotheses – that worry deters screening and that worry promotes screening – have both found support in empirical research (Hay, Buckley, & Ostroff, 2005). Data from the 2003 Health Information National Trends Survey (HINTS) suggested a positive association between worry and both breast and CRC screening (Moser et al., 2007). Similarly, a meta-analysis found a small but reliable association between higher levels of worry and greater screening participation (Hay, McCaul, & Magnan, 2006). However, cancer worry has also been found to be a barrier to screening, particularly among certain ethnic groups (Good, Niziolek, Yoshida, & Rowlands, 2010; Khankari et al., 2007; Friedman, Neff, Webb, & Latham, 1996). One possible explanation for these conflicting results is that the relationship between cancer worry and screening participation may be 'inverted U-shaped' (Hay et al., 2005; Consedine, Magai, Krivoshekova, Ryzewicz, & Neugut, 2004) with moderate levels of worry facilitating screening, and both high and low levels inhibiting it. This idea is supported in analyses of the UK FS Trial data where both low and high levels of worry were associated with lower attendance rates for FS screening, while individuals who reported being 'a bit worried' had the highest attendance rate (Sutton et al., 2000).

Interventions to Increase Screening Participation

While many psychological variables are consistently associated with actual or intended screening, their utility as targets for intervention is less certain. For example, risk perceptions seem resistant to a variety of different interventions designed to shift them (Weinstein & Klein, 1995; Weinstein et al., 2004; Robb, Campbell, Evans, Miles, & Wardle, 2008) and may not be a legitimate target because of adverse psychological effects.

Likewise promoting cancer worry would probably not be considered an appropriate approach; indeed ensuring that the offer of screening does not increase worry has been a specific concern of some interventions (Wardle et al., 2003a). As a result, many attempts to develop interventions to promote screening have taken a more a-theoretical approach, targeting structural and organizational factors rather than psychological barriers.

There have been several recent reviews on the effectiveness of interventions for breast, cervical and colorectal screening (Everett et al., 2011; Holden, Jonas, Porterfield, Reuland, & Harris, 2010; Rawl, Menon, Burness, & Breslau, 2012; Sabatino et al., 2012). They concur in finding strong evidence for the efficacy of client reminders across breast, cervical and CRC screening in the US. Other recommended strategies include reducing structural barriers and providing one-to-one education for breast and cervical screening. A systematic review of interventions to increase cervical screening uptake in the US found that invitation letters were effective and there was some evidence for the value of educational interventions (Everett et al., 2011).

A meta-analysis of tailored interventions, where breast screening messages were individually designed to address each woman's unique beliefs or characteristics found a slight benefit of tailored information (Sohl & Moyer, 2007), but the authors also noted that studies based on the Health Belief Model and including a physician recommendation had the strongest effects. A systematic review and meta-analysis of repeat breast screening found only modest effects of educational/motivational interventions, with odds ratios between 1.2 and 1.4 (Vernon, McQueen, Tiro, & del Junco, 2010). The authors concluded that for promoting regular mammography screening greater gains could be made by shaping behavior at the system level (e.g. insurance coverage and standards of preventive care).

Patient navigation for cancer screening has been embraced in the US to address disparities in uptake of screening and cancer care more generally. Recent reviews have concluded that there is some evidence for efficacy, but many studies have methodological limitations and the definition of 'patient navigation' remains unclear, as do the 'active' components of the patient navigator interaction (Paskett, Harrop, & Wells, 2011; Wells et al., 2008).

Attention has also turned to use of the internet as a communication channel that may be as effective, and perhaps more cost-effective than traditional psycho-educational approaches. However, early indications are disappointing, and a recent randomized controlled trial comparing print and web-based educational information on CRC screening tailored to attentional style found no effect on uptake (Weinberg et al., 2012).

Dual Process Models as a Framework for Guiding Screening Interventions?

The growth in interest in Dual Process Models of decision-making, which distinguish between System 1 (intuitive, fast, emotion-focused) and System 2 (deliberative, slow, reflective) processing (e.g. Kahneman, 2011), could have application in the area of screening behavior. Provision of information that encourages people to engage in deliberative decision-making is most likely to engage System 2 (e.g. print and screen-based psycho-

educational materials). This may be particularly appropriate where the risks and benefits of screening are finely balanced (e.g. in PSA testing where individual preferences and values are germane to the testing decision), although the heuristics and biases inherent in emotion-laden decisions must be taken into account when designing communication strategies for this types of decision. It is clear that even when making a deliberative decision, affective responses can play a major role (Peters et al., 2006; Slovic et al., 2005). In the case of cervical screening or endoscopic CRC screening, where there is little disagreement about the public health benefits, trying to engage System 1 may be appropriate. Interventions such as provider recommendations, invitations and reminders may encourage people to make a 'default' decision to attend without the need to fully evaluate the case for screening themselves. Indeed, these approaches have provided the strongest evidence for efficacy in recent reviews.

Interventions that focus on making it easier to participate in screening and reducing the burden of deliberative decision-making are somewhat at odds with moves towards informed decision-making (see below). However, the reliance the public place on provider recommendations (Brawarsky, Brooks, Mucci, & Wood, 2004; Waller et al., 2012), the positive impact of invitation letters (Cole et al., 2007; de Jonge et al., 2008; Everett et al., 2011), and the findings that many non-attenders would like to go for screening but simply don't get round to it (Waller, Bartoszek, Marlow, & Wardle, 2009), suggest that these approaches are legitimate and should be explored further. Applying theory from cognitive psychology is beginning to advance the science in this area. Important steps have been made by considering the way that heuristic short-cuts can influence risk perceptions, decision-making and behavior in the cancer prevention context (Peters et al., 2006). Reyna's 'Fuzzy Trace Theory' (Reyna, 2008) has been helpful in beginning to conceptualize the way that people extract the 'gist' from health information and use it to make intuitive, System 1-type decisions.

Informed Decision-Making

When screening programs were first introduced, the emphasis was on maximizing uptake to achieve the greatest possible public health benefit. Much of the psychological research described above was carried out from that perspective. However, as part of a more general paradigm shift in clinical practice, there has been growing interest in informed decision-making (IDM) in the screening context. Although there is no universally accepted definition of IDM, it has been conceptualized as occurring when a person has adequate knowledge about the intervention in terms of its likely risks and benefits as well as its limitations and uncertainties, and makes a decision that is in line with their personal values and preferences (Mullen et al., 2006). In many lower-income countries, access to screening is still the primary concern and there are few debates about IDM, but in wealthier countries with established screening programs, there is increasing concern about whether the public understands the limitations of cancer screening. This has been driven partly evidence of overdiagnosis and partly by a belief that the benefits of screening have been over-sold in public health communications.

The advantages of the IDM approach are that it recognizes non-participation as a legitimate choice and aims to help people understand the possible risks as well as the likely benefits. However, little is known about how information on the risks and benefits of screening is understood by the public and what impact it will have on decision-making, although it is increasingly clear that affective responses to risk information play an important role (Slovic et al., 2005). There is particular concern that it could have a differential impact depending on the respondent's educational background and health literacy/numeracy. A recent trial in Australia compared standard information on FOB testing with a decision-aid designed to facilitate IDM in a population with relatively low levels of education. The intervention increased the indicators of IDM, but significantly reduced participation (Smith et al., 2010). In contrast, there was no impact on participation in a similar study in a more educated German population (Steckelberg, Hulfenhaus, Haastert, & Muhlhauser, 2011). Any intervention that might widen health inequalities must be treated with caution.

Entwistle and colleagues describe an alternative approach to screening communication that they term 'consider an offer' (Entwistle et al., 2008). This allows screening to be recommended but encourages the public to consider the trustworthiness of the source, and seek further information if they need to. This approach appears to be consistent with public preferences in the UK to have a clear recommendation from the National Health Service (Waller et al., 2012). It is also compatible with the US system in which a health provider may recommend a particular screening test but be able to discuss different options (Anhang, Zapka, Edwards, & Taplin, 2010; Zapka et al., 2011).

It may be possible to tailor the style of communication to the screening test being offered. The scientific consensus is that there is insufficient evidence of benefit to recommend population-based PSA testing, so an IDM approach for men who request a PSA test may be appropriate. Similarly, the finely balanced risks and benefits of mammography could make an IDM approach the right one for breast screening. Women need to consider their personal preferences and values around overdiagnosis to make a decision about participation; although it may be difficult to provide information that can counter the very high levels of enthusiasm for screening (Schwartz et al., 2004).

For screening tests where the benefits are more certain, and particularly those that test for pre-cancers, the 'consider an offer' approach where participation is the 'default' could be seen as more appropriate. Wheeler and colleagues suggest a 'libertarian paternalistic' approach where framing, defaults, and other ideas from behavioral economics are used to help people make a 'good' decision (Wheeler, Szymanski, Black, & Nelson, 2011). This is also consistent with the notions of 'bounded rationality' (Gigerenzer & Goldstein, 1996) or 'intellectual outsourcing' (Appiah, 2005), which suggest that it some circumstance it can be rational not to spend valuable time making a personal decision, but rather to delegate the process by following the advice of a trusted source. Fuzzy Trace Theory also suggests that this is the way people often make decisions, using categorical 'gist' information to inform choices, rather than more detailed 'verbatim' information (Reyna, 2008).

The IDM debate in screening is highly polarized. It involves ethical as well as psychological and medical considerations, but psychology has an important role to play in understanding the impact of different types of information on attitudes, beliefs and screening behavior, as well as public preferences for involvement in decisions about screening.

Communicating with the Public about Changes to Screening Recommendations

In the context of generally positive attitudes, difficulties can arise when screening recommendations change in response to new scientific evidence. Recent examples include increasing the age of the first cervical screen in England from 20 to 25 years in 2003; the recommendation against PSA-based screening for prostate cancer from the USPSTF in the US in 2011; and the recommendation against routine mammography screening for women under 50 years by the USPSTF in 2009. In all cases there was public outcry at the reduced availability of screening. Psychological theory has been useful in understanding this phenomenon (Arkes & Gaissmaier, 2012). One factor is the greater impact of anecdotal stories compared with statistical information; thus statistically reasoned explanations of the change in recommendation may have limited potency compared with stories about the value of the test from friends or family. Similarly, personal experience has a greater impact than epidemiological evidence. Another issue is that people think about risks at an individual level and not at the level of the whole population as do epidemiologists. Overdiagnosis in the breast screening program is a good example. The evidence comes from the mismatch between the rising rate of screen diagnosed disease and the limited decrease in mortality. But many non-experts are baffled by the idea that scientists can know that overdiagnosis occurs without being able to tell any individual whether or not they are overdiagnosed (Waller, Douglas, Whitaker, & Wardle, 2013).

Health professionals are susceptible to the same cognitive biases. When the cervical screening age was increased to 25 in England, there was resistance from the gynecology community (Herbert, Holdsworth, & Kubba, 2008). Many clinicians would have had experience of treating young women for cervical cancer, which is likely to have made it difficult to accept the arguments against screening very young women. In the US where changes to screening recommendations have to be implemented by individual clinicians rather than in an organized program, communicating the rationale for change is of vital importance. If gynecologists are used to carrying out annual Pap tests, for example, persuading them that a 2 or 3 year interval is safe can be challenging, particularly as there is likely to be demand for more frequent screening from patients (Sirovich, Woloshin, & Schwartz, 2005). Such overuse has been reported to be widespread in the US, with relatively few physicians reporting behavior that is consistent with national guidelines for cervical screening (Yabroff et al., 2009). Overuse has also been found in CRC screening, although underuse is a problem too (Holden et al., 2010).

Future Directions

Cancer screening is an evolving technology and the role that psychologists can play will change with advances in biomedicine. One important future direction is the use of risk-stratified screening; potentially reducing harms by targeting screening to groups who stand to gain more. This would be novel in the UK's system of national provision of screening (currently limited only by age and sex). It may appear to be more compatible with the US approach in which discussions with a provider already include consideration of risk, although the risk stratification algorithms for population screening will not necessarily map onto individuals' sense of increased risk. Population-Based Research Optimizing Screening through Personalized Regimens is an NCI-sponsored research initiative taking this approach. In one study, participants used touchscreen computers to help them assess their own risks of CRC, using questions about health and family history, and the program made a recommendation for the type of CRC screening. Studies in the UK are using a combination of genetic, life-course and family risk information to offer risk stratified screening for breast (Evans et al., 2012) and ovarian cancer (PROMISE) (CR-UK, 2013). These initiatives raise issues that psychology is well-placed to investigate including public understanding of risk information, the social and psychological consequences of being diagnosed as having higher vs. lower risk, and the implications for preventive behaviors (Meisel et al., 2013). Psychological expertise could also help to identify methods of framing and presenting risk information to improve understanding, promote healthy behavior change and minimize distress.

Combining screening with cancer prevention education is another likely development. Screening makes cancer particularly salient and could therefore offer an opportunity for other prevention or early detection advice (Howell et al., 2012; Senore, Giordano, Bellisario, Di, & Segnan, 2012). The term 'teachable moment' is widely used (Brawley, 2009; Red et al., 2010), although research has yet to define its parameters and determine whether information is best transmitted before or after the screening result, whether it should be specific to the cancer concerned or general, and whether it should focus only on early detection or could include primary prevention through lifestyle change. There have been some small scale studies demonstrating the utility of preventive advice given alongside screening (Baker & Wardle, 2002; Robb, Power, Kralj-Hans, Atkin, & Wardle, 2010) but there is considerable scope to take advantage of screening as an opportunity to engage with brief face-to-face education on primary and secondary prevention.

The basic concepts involved in screening may need to be better understood by the public in the future as we move away from 'paternalistic' approaches, to systems in which consumers plays an active role. Direct-to-consumer marketing may become more common. More screening tests will become available and people will be required to make judgments about whether to have a test based not only on their knowledge of its risks and benefits but also their own values and preferences. Psychologists have a vital role to play in developing strategies for communicating screening information in a way that is understandable and helpful in decision-making.

Conclusion

Over the last 30 years, screening has become a major element of cancer control through a combination of primary and secondary prevention. Behavioral science has helped to understand non-participation and optimize communication about the harms and benefits of screening. More needs to be done to understand the social patterning of screening participation and to reduce social inequalities. Developments in psychological theory, particularly dual process models, will be useful in enhancing public communication about screening and, where appropriate, promoting uptake. As new screening technologies are developed and risk stratification and informed decision making become an increasingly important part of medical practice, there will be an even greater need to discover how to communicate complex risk information, and a key role for behavioral science in developing effective communication strategies to optimize screening behavior.

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