Int J Public Health (2015) 60:881–890
DOI 10.1007/s00038-015-0740-5

REVIEW

Breast cancer screening in England and the United States: a comparison of provision and utilisation

Joseph Williams · Linda Garvican · Anna N. A. Tosteson · David C. Goodman · Tracy Onega

Received: 9 March 2015 / Revised: 4 September 2015 / Accepted: 10 September 2015 / Published online: 7 October 2015

Abstract
Objectives Comparing breast cancer screening across countries within the context of some of the benefits and harms offers the opportunity to improve effectiveness through mutual learning.
Methods This paper describes the provision of breast cancer screening in England and the United States. The various recommendations for accessing breast cancer screening in the two countries are set out and the organisation of services including quality assurance, incentives and performance mechanisms considered.
Results In the United States, younger women are routinely screened; they are less likely to benefit and more likely to be harmed. The utilisation of breast cancer screening amongst eligible women is broadly comparable in the two countries. However, there are differences in technical performance; the reasons for these including radiological reading procedures and cultural factors are explored.
Conclusions Despite a well-functioning screening programme, breast cancer mortality and survival in England are poor relative to other countries. Emphasis for American improvement should be on reducing false-positive recall rates, while the English NHS could supplement existing efforts to understand and improve comparatively poor survival and mortality.

Keywords Breast cancer · Screening · Mammography · England · United States

J. Williams (✉)
Care Quality Commission, London, England
e-mail: Joe.Williams@cqc.org.uk

L. Garvican
South East Coast Cancer Screening QA Reference Centre, Public Health England, Battle, England

A. N. A. Tosteson · D. C. Goodman · T. Onega
The Dartmouth Institute for Health Policy and Clinical Practice at the Dartmouth School of Medicine at Dartmouth, Lebanon, NH, USA

A. N. A. Tosteson · T. Onega
Norris Cotton Cancer Center, Geisel School of Medicine at Dartmouth, Lebanon, NH, USA

Introduction

Screening aims to identify people at an earlier stage in a disease's natural history than if they were to present with symptoms (Raffle and Gray 2007). Mammography screening is widely used for screening to find breast cancer before a lump can be felt. Many consider it appropriate for early detection of breast cancer because of the association between stage at diagnosis (or tumour size) and survival (Elmore et al. 2005a; Tabár et al. 2011). Despite the wealth of evidence on the subject, the value of mammography screening remains controversial and divisive. There is contention around the ages at which women should be screened, the strength of the mortality benefit evidence, and the extent of the harms including overdiagnosis.

Comparing breast cancer screening across countries within the context of some of the benefits and harms offers the opportunity to improve effectiveness through mutual learning. This paper will describe the provision of breast cancer screening in England and the United States and explore how effective delivery of population-based breast cancer screening can maximise benefits and minimise harms.

Methods

The policies, organisation and structures of the English and American breast screening programmes were investigated by literature review. In England, most of these documents are published centrally and available through the national programme website, rather than in peer-reviewed journals. Annual population coverage and performance statistics by provider are published.

In the USA policy set by the United States Preventive Services Task Force was reviewed together with guidelines published by professional bodies and cancer charities. Funding mechanisms were compared. Performance data were obtained from peer-reviewed publications of small studies and surveys as there is no national data collection system.

Results

England

Organisation

The breast cancer screening programme in England is organised at a national level by the National Health Service (NHS). Breast screening services are commissioned against a national service specification (Department of Health 2013) by NHS England in collaboration with Public Health England.

The service includes systematic call and recall of eligible women based on their registration with a general practitioner. This is undertaken through the National Health Application Infrastructure Services (NHAIS) call/recall database, more often called the 'Exeter system'. Regular analysis of coverage is undertaken to "identify groups of women who either access breast screening at lower levels, or do not access services at all" (Department of Health 2013). The screening takes place at one of 80 Breast Screening Units (BSU) in England. Access to screening and any subsequent diagnosis and treatment is provided at no cost to women screened under the NHS.

National Health Service recommendation

Women between the ages of 50 and 70 years are eligible for breast cancer screening in England and are systematically invited to be screened every 3 years (NHS Breast Cancer Screening Programme 2005). Women over the age of 70 who wish to be screened can request a mammogram at their local unit every 3 years. The ages are being extended to 47 and 73, as part of a randomised trial (NHS Breast Cancer Screening Programme 2010).

Younger women who have been identified as being at high risk of developing breast cancer due to either genetic mutations (National Institute for Health and Care Excellence 2013) or previous supradiaphragmatic radiotherapy are managed through the same programme. These women can be referred from genetics or oncology services to mammographic and MRI surveillance at appropriate intervals (NHS Breast Screening Programme 2013).

Independent review 2012

A review of breast screening by an independent panel was set up in response to the debate about the effectiveness of breast screening and criticism of the information given to women (Bewley 2011; Richards 2011). The panel was commissioned by the National Cancer Director for England and Cancer Research UK to develop an up-to-date assessment of both the benefits and the harms associated with population breast screening programmes. They considered the relative and absolute mortality benefits and balanced these against the harms caused through overdiagnosis. An overdiagnosed breast cancer is a case "diagnosed by screening that would not otherwise have come to attention in the woman's lifetime" (The Independent UK Panel on Breast Cancer Screening 2012). The panel concluded that "the UK breast screening programmes confer significant benefit and should continue" (The Independent UK Panel on Breast Cancer Screening 2012). This serves to reinforce the provision of breast cancer screening in the UK, while acknowledging that the reduction in breast cancer deaths is at the cost of overdiagnosis in a ratio estimated at three overdiagnoses for each life saved (The Independent UK Panel on Breast Cancer Screening 2012).

USA

Organisation

There is no centrally organised breast cancer screening programme in the United States. Rather than being invited, women can self-refer for screening and are advised to speak with their doctor to discuss screening appointments (Centers for Disease Control and Prevention 2014a). Many insurance plans and providers remind their customers of the services that are available to them, and providers can market mammography directly to the public.

Medicare

Medicare is a government-funded health insurance programme that primarily covers people aged over 65 years. Medicare pays for some preventive health care services,

including one screening mammogram every 12 months and one clinical breast exam every 24 months (American Cancer Society 2014a). However, there may be a charge (deductible and co-pay) if a further diagnostic mammogram or other investigation is required (American Cancer Society 2014a). Supplemental (i.e. private or Medicaid, the insurance for low-income patients) insurance often reimburses for these out of pocket costs.

Insurance based in younger women

Women under the age of 65 can access breast cancer screening with the costs covered as part of their insurance. Many states require that "private insurance companies, Medicaid, and public employee health plans provide coverage and reimbursement for specific health services and procedures" (American Cancer Society 2014b). As at September 2014, the only state without a law ensuring that private health plans cover or offer coverage for screening mammograms is Utah (American Cancer Society 2014b).

Medicaid and National Breast and Cervical Cancer Early Detection Program

Medicaid is a government-run health programme for families and individuals with low income. All state Medicaid programmes cover screening mammograms (American Cancer Society 2014b). The National Breast and Cervical Cancer Early Detection Program (NBCCEDP) also provides free or low-cost mammograms to low-income women with little or no health insurance. Costs of treatment are covered through Medicaid for those women diagnosed with cancer through the Centers for Disease Control and Prevention's (CDC's) National Breast and Cervical Cancer Early Detection Program (Centers for Disease Control and Prevention 2014b).

Introduction of the Affordable Care Act

The introduction of the Affordable Care Act will likely increase access to mammography in the United States by reducing of the number of uninsured women, the expansion of Medicaid, and elimination of cost sharing (Centers for Disease Control and Prevention 2014b; Levy et al. 2012).

Recommendations

There are a number of recommendations regarding breast cancer screening in the United States. The American Cancer Society, the American College of Radiology, and the American Congress of Obstetricians and Gynecologists recommend annual mammography beginning at age 40 (Smith et al. 2003; Mainiero et al. 2013; American College of Obstetricians and Gynecologists 2011). The National Cancer Institute (2014) recommends that women age 40 or older have screening mammograms every 1 to 2 years.

In 2009, the United States Preventive Services Task Force (USPSTF) updated their recommendations on breast cancer screening. Their 2002 recommendation had been for screening mammography every 1 to 2 years for women aged 40 and older (United States Preventive Services Task Force 2002). The updated guidelines recommended biennial screening between 50 and 74 years, and recommended against routine screening mammography in women aged 40–49 years (United States Preventive Services Task Force 2009) (Table 1).

Critics attacked the "expertise, motivations, and independence of the scientists and clinician experts" (Stubbs 2009) as well as their reliance on mathematical models rather than outcomes data (Woolf 2010). Publication of these recommendations coincided with the announcement of President Obama's healthcare reforms and was

Table 1 Summary of recommendations for breast cancer screening in England and the USA

	England—NHS[1]	USA				
		USPSTF[2]	American Cancer Society[3]	American College of Radiology[4]	American Congress of Obstetricians and Gynecologists[5]	National Cancer Institute[6]
Age	50–70	50–74	40+	40+	40+	40+
Screening interval	3 years	2 years	Annual	Annual	Annual	1–2 years

[1] NHS Breast Cancer Screening Programme (2005)

[2] United States Preventive Services Task Force (2009)

[3] Smith et al. (2003)

[4] Mainiero et al. (2013)

[5] American College of Obstetricians and Gynecologists (2011)

[6] National Cancer Institute (2014)

perceived as the onset of rationing among some groups (Gerber et al. 2010; Welch et al. 2011). As a result of the debate, the second part of the recommendation was revised to state that the "decision to start regular, biennial screening mammography before the age of 50 years should be an individual one and take patient context into account, including the patient's values regarding specific benefits and harms" (United States Preventive Services Task Force 2009).

The effect of competing authoritative voices is uncertain, but it may impede the development of coordinated and effective screening programmes (Wilson and Lavis 2013). Physicians and clinical groups, within the same provider organisation, could recommend different testing regimes to their patients depending on which guidelines they choose to follow. One study found that the screening mammography rate decreased by 4.3 % in 2010, the year after the USPSTF recommendations were issued (Sharpe et al. 2013). Surveys suggested, however, that the USPSTF breast cancer screening recommendation had not been widely adopted (Pace et al. 2013) and did not affect screening patterns (Howard and Adams 2012).

Evidence suggests mammography has more risks than benefits for women in their forties of average risk (Armstrong et al. 2007). Women of this age are less likely to benefit because disease grows faster before menopause (Gilliland et al. 2000) and the cancer is more difficult to detect in denser breasts, which are most prevalent in premenopausal women (Mandelson et al. 2000). Despite evidence against routine screening for this group, almost half of American women in their forties have a mammogram each year (Pace et al. 2013). This highlights how recommendations regarding screening access and the resulting behaviours of providers and individuals are based on values rather than evidence. It is worth considering the extent to which the acquisition of these values within American society is influenced by the industry that depends for its commercial success on these demands (Raffle and Gray 2007). To Americans, it may seem that collectivist societies deny women the right to breast screening under the age of 50 "for financial reasons or, at best, for paternalistic reasons to protect the majority from harm" (Raffle and Gray 2007). Raffle and Gray (2007) question whether the American medical profession is "humouring demand for their own financial ends" or "members of a can-do society" determined to tackle disease with all of the powers at their disposal.

There is now tension between the public health success of creating awareness and fostering uptake of mammography screening in the United States over the past several decades, with emerging evidence of population-wide breast cancer screening in an era of advanced technology. This evidence is interpreted and applied heterogeneously, creating a varied landscape of guidelines, recommendations, values, and beliefs.

Quality assurance, performance, and incentives

England

The NHS Breast Screening Programme (NHSBSP) is coordinated at a national level by the NHS Cancer Screening Programmes, now part of new statutory body Public Health England which began operating in April 2013. This coordination includes developing standards and measures to assess the programme's performance and outcomes. The regional Quality Assurance Reference Centres (QARCs) continuously monitor performance against these measures and conduct detailed audits, as well as organising the multidisciplinary quality assurance visits that are carried out at each site at least once every 3 years. They also have a service development role in providing specialist expertise through the staff team and a network of professional leads in each clinical area. The emphasis on quality optimises cancer detection whilst minimising the number of false positives.

The NHSBSP collect and validate detailed comparative performance statistics on all breast screening units. These are analysed and published by Health and Social Care Information Centre (2014). Measures include the percentage of invited women who attend and indicators of screening quality, for example recall for assessment and cancer detection rates. There are also detailed national clinical standards for all professional groups. The regional QARCs ensure that screening providers "meet national programme standards, or have plans in place to meet them" (Department of Health 2013).

Standards are set at both "minimum" and "achievable" levels. Performance below a minimum standard would be investigated by a Quality Assurance team. The standards relate to the quantity of the mortality reduction by measuring attendance, the rate recall for further assessment, of invasive cancer detection, and maintenance of screening interval ("round length"). Aspirational levels would need to be achieved by 50 % of units for the programme "to achieve a reduction in mortality similar to that in the Swedish two county trial" (NHS Cancer Screening Programmes 2011).

The observed number of invasive cancers detected is compared to the expected number by applying criteria from the Swedish two county trial (Blanks et al. 1996). This is expressed as a ratio (standardised detection ratio) and used as a yardstick of performance (Information Centre for Health and Social Care 2014).

Centres for training of staff involved in the provision of breast cancer screening are regional. A number of accreditation systems are in place for the differing

professionals involved in the screening process. These include accreditation of readers (PERFORMS), pathologists (United Kingdom National External Quality Assessment Service), and laboratories (United Kingdom Accreditation Service or equivalent). The Royal College of Radiologists is responsible for professional standards and training in radiology, while standards for radiographers are specified by the Society and College of Radiographers.

The NHS Quality and Outcomes Framework is an incentive scheme for primary care practices in the England, rewarding them for how well they care for patients. It covers a range of clinical and organisational indicators, including four indicators relating to the national programme of screening for cervical cancer (National Institute for Health and Care Excellence 2014). Screening for breast cancer is not part of this framework, and as such, there are no additional financial incentives for primary care providers to encourage breast screening amongst their patients. However, screening coverage in each practice is monitored by regional commissioners through the National Cancer Intelligence Network Cancer Commissioning Toolkit.

USA

Under the Mammography Quality Standards Act (MQSA, 1992), all U.S. facilities that perform mammography must be certified by the Food and Drug Administration (FDA) regarding training for personnel mammography technique (U.S. Food and Drug Administration 2005). Inspections are undertaken by the FDA which certifies and accredits facilities based on judgments about compliance with the MQSA.

The MQSA requires that all mammography facilities be accredited. This is undertaken by the American College of Radiology's Mammography Accreditation Program. The Program provides peer review and feedback on "staff qualifications, equipment, quality control, quality assurance, image quality and radiation dose" (American College of Radiology 2014) but is not independent of the profession.

Primary care providers have a central role in inviting women for screening in the United States; the relationships between them and their patients are important. There are professional, reputational, and financial incentives for primary care physicians to refer their patients for breast cancer screening. Aspects of primary care provider performance are measured using the Healthcare Effectiveness Data and Information Set (HEDIS) from the National Committee for Quality Assurance. These are linked to each physician and service and are of interest to the insurers and employers; high performance may give the opportunity to access insurance plan networks. The percentage of women aged 50–74 years who had a mammogram in the previous 24 months is a 2014 HEDIS measure.

Accountable Care Organizations (ACOs) are groups of doctors, hospitals, and other health care providers, who aim to give coordinated high-quality care to their patients and share the savings that they achieve (Centers for Medicare and Medicaid Services 2014a). The percentage of women who had a screening mammogram is one of the measures used to judge the performance of the ACOs (Centers for Medicare and Medicaid Services 2014b). These measures give fiscal incentives for the local systems to maximise the number of women accessing breast cancer screening in their patient population.

Comparing utilisation of services and performance

As of 31 March 2013, 76.4 % of English women aged 53–70 had been screened in the previous 3 years (Information Centre for Health and Social Care 2014). Screening rates differed between regions, and was significantly lower in London. The programme explains that this is because the population here is "harder to reach due to its diverse and mobile nature" (NHS Cancer Screening Programmes 2012).

Between 72.4 % (Centers for Disease Control and Prevention 2012) and 79.7 % (Miller et al. 2012) of American women aged 50–74 self-reported having been screened for breast cancer in the previous 2 years (2010 interviews). These rates differed significantly by race, ethnicity and insurance status. Of women in this age group with no health insurance, between 38.2 % (Centers for Disease Control and Prevention 2012) and 50.4 % (Miller et al. 2012) reported having a mammogram within the previous 2 years. 14.9 % of women aged 45–64 years reported being uninsured at time of interview (2012 interview) (Cohen and Martinez 2013).

When comparing screening rates between the two countries, it is important to note that data from England is calculated from recorded activity, while in U.S. it is estimated within regions or health plans or based on self-reported behaviours from national surveys. Women are known to over-report having had a recent mammogram (Rauscher et al. 2008).

Access to mammography is high in the United States despite there being no population-based programme. This is due to the characteristics of the health system including fee-for-service reimbursement, insurer performance incentives, medical malpractice liability, and increasing access to subsidised services.

Technical performance: sensitivity and specificity

Smith-Bindman et al. (2005) analysed nearly 5 million mammograms to compare the performance of mammography screening in the USA and the UK. They estimated that over a 20-year period of screening, the "percentage of women who would be recalled for additional testing was nearly threefold higher in the USA." Another study estimated that almost half (49 %) of women aged 40–69 years in the United States will have at least one false-positive mammogram after ten screens (Elmore et al. 1998). Smith-Bindman et al. (2005) found that despite the differing regimes, "no substantial differences in the rates of detection of large cancers" were observed. A higher number of small invasive and in situ cancers were found in the USA (Smith-Bindman et al. 2005). Since this study the NHSBSP has converted to digital mammography and cancer detection rates have increased further (Information Centre for Health and Social Care 2014) (Table 2).

Other studies of screening performance have similar findings when comparing American and European systems. Elmore et al. (2003) found that North American screening programmes "appear to interpret a higher percentage of mammograms as abnormal than programmes from other countries without evident benefit in the yield of cancers detected". Hofvind et al. (2012) highlighted "higher sensitivity and specificity" in Norway compared to Vermont. The experience of having a false-positive screening mammogram can result in avoidable and harmful procedures, cause psychological distress, reduce the likelihood that women will return for their next round of screening (Bond et al. 2013; Goossens et al. 2014), and is costly as a result of additional appointments and testing (Elmore et al. 1998).

Reasons for differing performance

In their international comparison, Youlden et al. (2012) found "the coordination of activities across the entire pathway", including monitoring of clinical quality, was essential for screening programme to attain quality outcomes.

Smith-Bindman et al. (2005) considered that the success of the NHS programme relative to the American system is primarily as a result of this "centralized programme of continuous quality improvement." The NHSBSP in England has controls to guard against overinvestigation and overtreatment. These include monitored standards for maximum positive rates, recall rates, and intervention rates.

Making comparison with prior images significantly reduces false-positive findings (Burnside et al. 2002; Yankaskas et al. 2011; Roelofs et al. 2007). BSUs in England always have access to prior images. In the USA, a woman would need to return to the same provider in order for these comparisons to be made consistently.

Radiological reading procedures

Double vs single reading In the English NHS system, reading of mammograms by two film readers is mandatory (NHS Cancer Screening Programmes 2011). In the United States, single reading, increasingly with CAD, is the norm (Bond et al. 2013; Onega et al. 2010). There is evidence that double reading with arbitration increases detection rate and decreases recall rate (Hofvind et al. 2012; Taylor and Potts 2008; Garvican and Field 2001).

Table 2 Coverage and performance of breast cancer screening in England and the USA

	Coverage of eligible population		Recall rates		Cancers detected among 1000 women screened for 20 years[6]			Mammography devices per million population[9]
			First screening mammogram	Subsequent screens	All	Large invasive[7]	DCIS[8]	
England	76.4 %[1]		7.6 %[4]	2.9 %[4]	43.0	8.7	8.3	9.0
USA	72.4 %[2]	79.7 %[3]	13.3 %[5]	8.0 %[5]	55.1	8.1	12.3	40.2

[1] Previous 3 years (as at 31/03/2013) Age 53–70 (Information Centre for Health and Social Care 2014)

[2] Previous 2 years at time of survey (National Health Interview Survey 2010), age 50–74 (Centers for Disease Control and Prevention 2012)

[3] Previous 2 years at time of survey (Behavioral Risk Factor Surveillance System 2010), age 50–74 (Miller et al. 2012)

[4] 2012–2013 (Information Centre for Health and Social Care 2014)

[5] (Smith-Bindman et al. 2005)

[6] Modeled from four years of data (Smith-Bindman et al. 2005)

[7] Larger than 2 cm

[8] Ductal carcinoma in situ

[9] Commonwealth Fund (UK 2009, USA 2008) (Squires 2012)

Interpretive volume Studies have shown an association between increased volume and lower recall (Buist et al. 2011; Elmore et al. 2009). NHS readers must "undertake a minimum of 5000 screening and/or symptomatic cases per year" (NHS Cancer Screening Programmes 2011). In the USA, the Mammography Quality Standards Act requires that the interpreting physicians interpret at least 960 mammographic examinations every 2 years (U.S. Food and Drug Administration 2002). This relatively low number was "chosen with the intent of maximizing access" (National Research Council 2005). As part of their examination of high health care costs in the United States, The Commonwealth Fund (2012) compared the availability of imaging devices in a selection of Organisation for Economic Co-operation and Development (OECD) countries. They report that there were 9.0 mammograph devices per million population in the UK (2009) and 40.2 per million in the United States (2008).

Cultural differences—litigation

The differences in the way that the English and American systems are organised and quality assured account for some of the variations in performance. In addition, cultural differences should be considered.

Units in England that responded to a 2002 NHS Breast Screening Programme survey highlighted fear of litigation as a possible explanation for the vacancies in radiologist posts (NHS Breast Screening Programme 2002). Courts in England have awarded compensation to patients who had received false-negative cervical screening results (Wilson 2000), however, these incidences are very rare.

Raffle and Gray (2007) propose that because American individuals are responsible for the costs of their care, "the law is used as a means of seeking finance in a way that substitutes in effect for the safety net of the welfare state". A study concluded that heightened concern amongst American radiologists about medical malpractice legal action "may be a key reason that recall rates are higher in the United States than in other countries" (Elmore et al. 2005b). As Cassels noted (2012), American physicians tend to be punished "for sins of omission, not sins of commission". The enthusiastic promotion of cancer screening may be responsible for unrealistic expectations of screening (Wilson 2000), and make it difficult for defendant radiologists to prevail in a malpractice lawsuit (Mavroforou et al. 2006).

Schwartz et al. (2004) found that public enthusiasm for cancer screening "is not dampened by false-positive test results or the possibility that testing could lead to unnecessary treatment". It may be that in the United States if there is any "potential for health improvement for an individual, then that potential should be realized" no matter "how many resources would be needed and no matter if some women are harmed" (Raffle and Gray 2007).

Discussion

The English National Health Service is more efficient in detecting breast cancer through screening than the American system. A combination of organisational factors including rigorous quality assurance and stringent radiological reading procedures helps to reduce the number of false-positive results—the American system is less effective in minimising these harms. Cultural factors, in particular the threat of litigation, influence the heightened recall rates in the United States. The additional abnormalities that the American mammograms reveal are mostly small invasive and in situ cancers, with the potential to lead to more overdiagnosis and overtreatment. Values, influenced by commercial interest, may take precedence over evidence in the development of recommendations about screening. The complex and contradictory landscape of guidelines result in younger American women being routinely screened; they are less likely to benefit and more likely to be harmed.

The differences of the two screening systems should be considered in the wider context of efforts to improve women's health. Reductions in breast cancer mortality may be more as a result of other factors including advances in treatment than screening programmes (Autier et al. 2011; Kalager et al. 2010).

Estimated age-standardised breast cancer incidence and mortality are higher in the UK (incidence 89.1 per 100,000; mortality 18.6 per 100,000) than the USA (incidence 76.0 per 100,000; mortality 14.7 per 100,000) (Ferlay et al. 2010). Women are diagnosed at a similar stage in the UK, but survival is lower than women with the same stage of disease in other countries (Walters et al. 2013; Møller et al. 2010). Some of the excess breast cancer deaths in England may be a result of poor symptom awareness, leading to late diagnosis in frail women (Møller et al. 2010; Lambert et al. 2011). A range of other factors influence England's relatively poor survival rates including delays in diagnosis and treatment, treatment variation, and comorbidity, particularly in older people (Foot and Harrison 2011).

Population-based approaches to breast cancer screening in the United States could learn from European programmes, including the English one. Emphasis should be on reducing false-positive recall rates while maintaining appropriate cancer detection. Despite a well-functioning screening programme, breast cancer mortality is higher in England than the United States. The NHS could supplement existing efforts (Foot and Harrison 2011; International Cancer Benchmarking Partnership; International Cancer Screening Network) to understand and

improve comparatively poor survival and mortality through improving symptom awareness and learning from other systems, including the United States.

Compliance with ethical standards

Conflict of interest None of the authors declared any conflicts of interest.

References

American Cancer Society (2014a) Medicare coverage for cancer prevention and early detection. http://www.cancer.org/healthy/findcancerearly/cancerscreeningguidelines/medicare-coverage-for-cancer-prevention-and-early-detection. Accessed 10 Aug 2014

American Cancer Society (2014b) Breast cancer: early detection. http://www.cancer.org/acs/groups/cid/documents/webcontent/003165-pdf.pdf. Accessed 30 Oct 2014

American College of Obstetricians and Gynecologists (2011) Breast cancer screening. Washington (DC): American College of Obstetricians and Gynecologists (ACOG); Aug 11 p (ACOG practice bulletin; no. 122)

American College of Radiology (2014) Mammography Accreditation Program requirements. http://www.acr.org/~/media/ACR/Documents/Accreditation/Mammography/Requirements.pdf. Accessed 10 Aug 2014

Armstrong K, Moye E, Williams S, Berlin JA, Reynolds EE (2007) Screening mammography in women 40 to 49 years of age: a systematic review for the American College of Physicians. Ann Intern Med 146(7):516–526

Autier P, Boniol M, Gavin A, Vatten LJ (2011) Breast cancer mortality in neighbouring European countries with different levels of screening but similar access to treatment: trend analysis of WHO mortality database. BMJ 343:d4411

Bewley S (2011) The NHS breast screening programme needs independent review. BMJ 343:d6894

Blanks RG, Day NE, Moss SM (1996) Monitoring the performance of breast screening programmes: use of indirect standardisation in evaluating the invasive cancer detection rate. J Med Screen 3(2):79–81

Bond M, Pavey T, Welch K, Cooper C, Garside R, Hyde C (2013) Systematic review of the psychological consequences of false-positive screening mammograms. Evid Based Med 18:54–61

Buist DS, Anderson ML, Haneuse SJ, Sickles EA, Smith RA, Carney PA, Taplin SH, Rosenberg RD, Geller BM, Onega TL, Monsees BS, Bassett LW, Yankaskas BC, Elmore JG, Kerlikowske K, Miglioretti DL (2011) Influence of annual interpretive volume on screening mammography performance in the United States. Radiology 259(Issue 1):72–84

Burnside ES, Sickles EA, Sohlich RE, Dee KE (2002) Differential value of comparison with previous examinations in diagnostic versus screening mammography. AJR 179:1173–1177

Cassels A (2012) Seeking Sickness. Greystone Books, Vancouver

Centers for Disease Control and Prevention (2012) National Centre for Health Statistics, National Health Interview Survey. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6103a1.htm. Accessed 10 Aug 2014

Centers for Disease Control and Prevention (2014b) What screening tests are there? http://www.cdc.gov/cancer/breast/basic_info/screening.htm. Accessed 10 Aug 2014

Centers for Disease Control and Prevention (2014) National Breast and Cervical Cancer Early Detection Program. http://www.cdc.gov/cancer/nbccedp/about.htm. Accessed 10 Aug 2014

Centers for Medicare and Medicaid Services (2014a). http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/ACO/. Accessed 10 Aug 2014

Centers for Medicare and Medicaid Services (2014b) Accountable Care Organization 2014 program analysis quality performance standards narrative measure specifications. http://www.cms.gov/medicare/medicare-fee-for-service-payment/sharedsavingsprogram/downloads/aco-narrativemeasures-specs.pdf. Accessed 30 Oct 2014

Cohen RA, Martinez ME (2013) Health insurance coverage: early release of estimates from the National Health Interview Survey, 2012. National Center for Health Statistics. http://www.cdc.gov/nchs/data/nhis/earlyrelease/insur201306.pdf. Accessed 10 Aug 2014

Department of Health (2013) Public health functions to be exercised by NHS England, service specification No.24: Breast Screening Programme. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/192975/24_Breast_Screening_Programme__service_specification_VARIATION__130422_-NA.pdf. Accessed 30 Oct 2014

Elmore JG, Barton MB, Moceri VM, Polk S, Arena PJ, Fletcher SW (1998) Ten-year risk of false positive screening mammograms and clinical breast examination. New Eng J Med 338:1089–1096

Elmore JG, Nakano CY, Koepsell TD, Desnick LM, D'Orsi CJ, Ransohoff DF (2003) International variation in screening mammography interpretations in community-based programs. J Natl Cancer Inst 95(18):1384–1393

Elmore JG, Armstrong K, Lehman CD, Fletcher SW (2005a) Screening for breast cancer. JAMA 293:1245–1256

Elmore JG, Taplin SH, Barlow WE, Cutter GR, D'Orsi CJ, Hendrick RE, Abraham LA, Fosse JS, Carney PA (2005b) Does litigation influence medical practice? The influence of community radiologists' medical malpractice perceptions and experience on screening mammography. Radiology 236(1):37–46

Elmore JG, Jackson SL, Abraham L, Miglioretti DL, Carney PA, Geller BM, Yankaskas BC, Kerlikowske K, Onega T, Rosenberg RD, Sickles EA, Buist DS (2009) Variability in interpretive performance at screening mammography and radiologists' characteristics associated with accuracy. Radiology 253(3):641–651

Ferlay J, Shin HR, Bray F, Forman D, Mathers C, Parkin DM (2010) Estimates of worldwide burden of cancer in 2008: GLOBOCAN 2008. Int J Cancer 127(12):2893–2917

Foot C, Harrison T (2011) How to improve cancer survival: explaining England's relatively poor rates. The King's Fund, London

Garvican L, Field S (2001) A pilot evaluation of the R2 image checker system and users' response in the detection of interval breast cancers on previous screening films. Clin Radiol 56(10):833–837

Gerber AS, Patashnik EM, Doherty D, Dowling C (2010) A national survey reveals public skepticism about research-based treatment. Health Aff 29(10):1882–1884

Gilliland FD, Joste N, Stauber PM, Hunt WC, Rosenberg R, Redlich G, Key CR (2000) Biologic characteristics of interval and screen-detected breast cancers. J Natl Cancer Inst 92(9):743–749

Goossens M, Van Hal G, Van der Burg M, Kellen E, Van Herck K, De Grève J, Martens P, Van Limbergen E (2014) Quantifying independent risk factors for failing to rescreen in a breast cancer screening program in Flanders, Belgium. Prev Med 69:280–286

Hofvind S, Geller BM, Skelly J, Vacek PM (2012) Sensitivity and specificity of mammographic screening as practiced in Vermont and Norway. Br J Radiol 85(1020):e1226–e1232

Howard DH, Adams EK (2012) Mammography rates after the 2009 US Preventive Services Task Force breast cancer screening recommendation. Prev Med 55(5):485

Information Centre for Health and Social Care (2014) Breast Screening Programme, England, 2012–2013. http://www.hscic.gov.uk/catalogue/PUB13567. Accessed 10 Aug 2014

Kalager M, Zelen M, Langmark F, Adami HO (2010) Effect of screening mammography on breast-cancer mortality in Norway. N Engl J Med 363:1203–1210

Lambert PC, Holmberg L, Sandin F, Bray F, Linklater KM, Purushotham A, Robinson D, Møller H (2011) Quantifying differences in breast cancer survival between England and Norway. Cancer Epidemiol 35(6):526–533

Levy AR, Bruen BK, Ku L (2012) Health care reform and women's insurance coverage for breast and cervical cancer screening. Prev Chronic Dis 9:1545–1551 **(E159)**

Mainiero MB, Lourenco A, Mahoney MC, Newell MS, Bailey L, Barke LD, D'Orsi C, Harvey JA, Hayes MK, Huynh PT, Jokich PM, Lee SJ, Lehman CD, Mankoff DA, Nepute JA, Patel SB, Reynolds HE, Sutherland ML, Haffty BG (2013) ACR appropriateness criteria breast cancer screening. J Am Coll Radiol 10(1):11–14. doi:10.1016/j.jacr.2012.09.036

Mandelson MT, Oestreicher N, Porter PL, White D, Finder CA, Taplin SH, White E (2000) Breast density as a predictor of mammographic detection: comparison of interval- and screen-detected cancers. J Natl Cancer Inst 92(13):1081–1087

Mavroforou A, Mavrophorosb D, Michalodimitrakisa E (2006) Screening mammography, public perceptions, and medical liability. Eur J Radiol 57(3):428–435

Miller JW, King JB, Joseph DA, Richardson LC, Centers for Disease Control and Prevention (2012) Breast cancer screening among adult women—Behavioral Risk Factor Surveillance System, United States 2010. MMWR Morb Mortal Wkly Rep 61(Suppl):46–50

Møller H, Sandin F, Bray F, Klint A, Linklater KM, Purushotham A, Robinson D, Holmberg L (2010) Breast cancer survival in England, Norway and Sweden: a population-based comparison. Int J Cancer 127(11):2630–2638

National Cancer Institute (2014) Mammograms factsheet. http://www.cancer.gov/cancertopics/factsheet/detection/mammograms. Accessed 10 Aug 2014

National Institute for Health and Care Excellence (2013) Familial breast cancer: classification and care of people at risk of familial breast cancer and management of breast cancer and related risks in people with a family history of breast cancer

National Institute for Health and Care Excellence (2014) The Quality and Outcomes Framework. http://www.nice.org.uk/standards-and-indicators?tab=qof. Accessed 30 Oct 2014

National Research Council (2005) Improving breast imaging quality standards. The National Academies Press, Washington

NHS Breast Cancer Screening Programme (2005) Consolidated guidance on standards for the NHS Breast Screening Programme. http://www.cancerscreening.nhs.uk/breastscreen/publications/nhsbsp60.html. Accessed 30 Oct 2014

NHS Breast Cancer Screening Programme (2010) Age extension full randomised control trial. http://www.cancerscreening.nhs.uk/breastscreen/research-age-extension-full-rct-faqs.html. Accessed 10 Aug 2014

NHS Breast Screening Programme (2002) New ways of working: second report on implementation. http://www.cancerscreening.nhs.uk/breastscreen/publications/radiography.html. Accessed 10 Aug 2014

NHS Breast Screening Programme (2013) Guidelines on organising the surveillance of women at higher risk of developing breast cancer in an NHS Breast Screening Programme

NHS Cancer Screening Programmes (2011) Quality assurance guidelines for breast cancer screening radiology, second edition

NHS Cancer Screening Programmes (2012) NHS Breast Screening Programme 2012 annual review. http://www.cancerscreening.nhs.uk/breastscreen/publications/2012review.html. Accessed 10 Aug 2014

Onega T, Aiello Bowles EJ, Miglioretti DL, Carney PA, Geller BM, Yankaskas BC, Kerlikowske K, Sickles EA, Elmore JG (2010) Radiologists' perceptions of computer aided detection versus double reading for mammography interpretation. Acad Radiol 17(10):1217–1226

Pace LE, He Y, Keating NL (2013) Trends in mammography screening rates after publication of the 2009 US Preventive Services Task Force recommendations. Cancer 119(14):2518–2523

Raffle AE, Gray JAM (2007) Screening: evidence and practice. Oxford University Press, Oxford

Rauscher GH, Johnson TP, Cho YI, Walk JA (2008) Accuracy of self-reported cancer-screening histories: a meta-analysis. Cancer Epidemiol Biomarkers Prev 17(4):748–757

Richards M (2011) An independent review is under way. BMJ 343:d6843

Roelofs AA, Karssemeijer N, Wedekind N, Beck C, van Woudenberg S, Snoeren PR, Hendriks JH, Rosselli del Turco M, Bjurstam N, Junkermann H, Beijerinck D, Séradour B, Evertsz CJ (2007) Importance of comparison of current and prior mammograms in breast cancer screening. Radiology 242(1):70–77

Schwartz LM, Woloshin S, Fowler FJ, Welch HG (2004) Enthusiasm for cancer screening in the United States. JAMA 291(1):71–78

Sharpe RE, Levin DC, Parker L, Rao VM (2013) The effect of the controversial US Preventive Services Task Force recommendations on the use of screening mammography. J Am Coll Radiol 10(1):21–24

Smith RA, Saslow D, Sawyer KA, Burke W, Costanza ME, Evans WP 3rd, Foster RS Jr, Hendrick E, Eyre HJ, Sener S, American Cancer Society High-Risk Work Group, American Cancer Society Screening Older Women Work Group; American Cancer Society Mammography Work Group; American Cancer Society Physical Examination Work Group; American Cancer Society New Technologies Work Group; American Cancer Society Breast Cancer Advisory Group (2003) American Cancer Society guidelines for breast cancer screening: update 2003. Women's Health Research Faculty Publications

Smith-Bindman R, Ballard-Barbash R, Miglioretti DL, Patnick J, Kerlikowske K (2005) Comparing the performance of mammography screening in the USA and the UK. J Med Screen 12:1

Squires DA (2012) Explaining high health care spending in the United States: an international comparison of supply, utilization, prices, and quality. Commonwealth Fund

Stubbs JW (2009) Statement on the politicization of evidence-based clinical research, in American College of Physicians (database online). http://www.acponline.org/pressroom/pol_ebcr.htm?hp. Accessed 10 Aug 2014

Tabár L, Vitak B, Chen TH, Yen AM, Cohen A, Tot T, Chiu SY, Chen SL, Fann JC, Rosell J, Fohlin H, Smith RA, Duffy SW (2011) Swedish two-county Trial: impact of mammographic screening on breast cancer mortality during 3 decades. Radiology 260(3):658–663. doi:10.1148/radiol.11110469 **(Epub 2011 Jun 28)**

Taylor P, Potts HWW (2008) Computer aids and human second reading as interventions in screening mammography: two systematic reviews to compare effects on cancer detection and recall rate. Eur J Cancer 44(6):798–807

The Independent UK Panel on Breast Cancer Screening (2012) The benefits and harms of breast cancer screening: an independent review. Cancer Research UK and the Department of Health, London

United States Preventive Services Task Force (2002) Screening for breast cancer. http://www.uspreventiveservicestaskforce.org/Page/Document/RecommendationStatementFinal/breast-cancer-screening-2002. Accessed 10 Aug 2014

United States Preventive Services Task Force (2009) Screening for breast cancer. http://www.uspreventiveservicestaskforce.org/uspstf/uspsbrca.htm. Accessed 10 Aug 2014

U.S. Food and Drug Administration (2002) Mammography Quality Standards Act Regulations, Sec. 900.12 quality standards. http://www.fda.gov/Radiation-EmittingProducts/MammographyQualityStandardsActandProgram/Regulations/ucm110906.htm. Accessed10 Aug 2014

U.S. Food and Drug Administration (2005) Mammography facility surveys, mammography equipment evaluations, and medical physicist qualification requirements under MQSA. http://www.fda.gov/downloads/MedicalDevices/…/ucm094411.pdf. Accessed 30 Oct 2014

Walters S, Maringe C, Butler J, Rachet B, Barrett-Lee P, Bergh J, Boyages J, Christiansen P, Lee M, Wärnberg F, Allemani C, Engholm G, Fornander T, Gjerstorff ML, Johannesen TB, Lawrence G, McGahan CE, Middleton R, Steward J, Tracey E, Turner D, Richards MA, Coleman MP, ICBP Module 1 Working Group (2013) Breast cancer survival and stage at diagnosis in Australia, Canada, Denmark, Norway, Sweden and the UK, 2000–2007: a population-based study. Br J Cancer 108(5): 1195–1208

Welch GH, Schwartz L, Woloshin S (2011) Overdiagnosed: making people sick in the pursuit of health. Beacon Press, Boston

Wilson RM (2000) Screening for breast and cervical cancer as a common cause for litigation. BMJ Int Edit 320(7246):1352–1353

Wilson MG, Lavis JN (2013) Evidence brief: supporting optimal screening approaches in Canada. McMaster Health Forum, Hamilton

Woolf SH (2010) The 2009 breast cancer screening recommendations of the US Preventive Services Task Force. JAMA 303(2): 162–163

Yankaskas BC, May RC, Matuszewski J, Bowling JM, Jarman MP, Schroeder BF (2011) Effect of observing change from comparison mammograms on performance of screening mammography in a large community-based population. Radiology 261:762–770

Youlden DR, Cramb SM, Dunn NAM, Muller JM, Pyke CM, Baade PD (2012) The descriptive epidemiology of female breast cancer: an international comparison of screening, incidence, survival and mortality. Cancer Epidemiol 36:237–248