Evaluation of the UK breast screening programmes

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National breast screening programmes were set up in the UK in the early 1990s. Although they are quality-assured and publish process measures of performance, there is a lack of data linking the screening process to breast cancer mortality. A new analysis of trends in England and Wales suggests that the effect of screening has been to reduce mortality by 8% over 10 years in those eligible for screening in 1990.

**Key words:** breast cancer, mammography, predicted mortality, screening, trends

**Introduction**

In 1986, the Forrest Report recommended that breast screening be introduced in the UK using triennial single-view mammography [1]. The recommendations were accepted and national screening programmes were set up. In England, the programme began inviting women for screening in 1990, and national coverage was achieved by 1993 (although the first round was not completed in some districts until 1995 [2]). The programme invites women aged 50–64 years and provides screening on request to older women. Currently, two-view mammography is used when women are first screened, with a single view thereafter. However, by 2003 all women will have two-view mammography and by 2004 women will be invited up to age 70 years.

**Screening in England**

Just over 90 screening units in England aim to screen some 4.4 million women. The units are coordinated by the National Cancer Screening Office, and quality is checked by eight regional multidisciplinary teams. Summary results are published each year by the Department of Health [3]. Coverage, as measured by the proportion of women screened within the last 3 years, is around 75% nationally (in women aged 55–64 years), but is considerably less in London. Some 73% of those invited for a first screen attend, but the attendance rate is much higher in those who have been screened previously (89%).

Overall referral rates are 5.2%, but vary between the eight regions (from 3.9% to 5.9%). Referral rates are higher (8.3%) on first screens than on subsequent screens (3.9%). Cancer detection rates too are higher on first screens, with an increase in both micro-invasive cancers and those with a diameter >15 mm (Table 1). Overall, 63% of screen-detected cancers are <15 mm in diameter (including microinvasive).

Analysis of 10,079 screen-detected breast cancers in the UK found 75% to be node-negative. The overall 5-year survival was 93% (89% at 8 years) [4].

**Effect of screening on mortality rates**

It would be naïve to expect a sudden fall in breast cancer mortality rates in women aged 50–64 years following the introduction of screening. The gradual introduction of screening and the fact that mortality in any one year is largely due to cancer diagnosed several years earlier means that the full effect of screening will take many years to become apparent. For instance, if we suppose that screening reduces the mortality from new breast cancer in those screened by 35% and that from 1993 onwards coverage was 75%, then by 2000 overall mortality rates would only have been reduced by about 15%. Additionally, interpretation of trends is complicated by not knowing what would have happened in the absence of screening.

Despite these difficulties, Blanks et al. [5] attempted to estimate the effect of screening on breast cancer mortality rates in England and Wales. They fitted a log-linear age-cohort model to the annual number of breast cancer deaths in 5-year age groups between 1971 and 1989 and extrapolated the fit to the years 1990–1999. They found that extrapolation overestimated the mortality at all ages and reasoned that the changing rates of mortality were due to a combination of changing incident rates, down-staging unrelated to screening *per se*, better treatment and mammographic screening.

They assumed that the effects of the first three of these would be the same (on the log-linear scale) in all age groups and interpreted any excess deviation between the extrapolated and the observed rates in those covered by the invitations of the screening programme as being due to screening. More precisely, they assumed that there would be no screening effect in women aged 50–54 or 70–79 years in 1990–1995 and in those aged 50–54 and 75–79 years in 1996–1999. Screening would affect women aged 55–69 years. Women aged 70–74 years in 1996–1999 were excluded from the analysis. Mortality rates fell substantially in all age groups, but the additional reduction in those groups invited for...
screening was 3.2% in 1992–1994 and 6.4% in 1997–1999. They concluded that 6 years after achieving national coverage, the screening programme was having a small but significant effect on mortality rates in the age groups invited for screening.

With effects of this magnitude, results are sensitive to the precise model used. Excluding data prior to 1971 and the use of 5-year age and cohort groups both influence the estimates, as does the decision to exclude deaths in women aged <50 and >80 years. The latter is confounded by adjustments made to account for changes made in 1984 and 1993 to the way cause of death was coded in England and Wales. These changes had little effect on women aged <75 years, but a substantial effect on older women. Undoubtedly, this effect would be greatest in women aged >80 years, but the correction factor derived for women aged >75 years was applied to those aged 75–79 years in this study.

Here we fit the alternative model: rate = exp\[f(age) + g(year of birth) + h(current year) + k(years since first covered by screening programme)\], where \(f, g, h\) and \(k\) are all smooth functions to be estimated from the data using Poisson regression. Data on mortality in single years of age from 1971 to 2000 were used. The time since first eligible for screening was calculated from 1990 or age 51 years, whichever was later. Figure 1 shows the estimate of the function \(\exp(k)\). Zero years since first screened refers to mortality in 1990 for the cohort eligible for screening in 1990. The results are in general agreement with the analysis of Blanks et al. [5], but are slightly more favourable for screening and emphasise how the effect of screening increases over time. By 2000, breast cancer mortality rates in women eligible for screening in 1990 were about 8% lower than predicted in the absence of screening.

Further understanding of the effect of screening will require more detailed data. In particular, one would like to be able to study mortality from cancers diagnosed after the introduction of screening. Additionally, if mortality data were linked to information on screening invitations, one could more accurately look at the time since first screening invitation. A UK audit of screen-detected cancers has been conducted [4]. Although the results are encouraging, since interval cancers are not included it is not possible to make inference on the effectiveness of the UK screening programmes. Had the audit included all cancers, it would be possible to compare the rate of poor prognosis tumours in screened and unscreened women.

### Predicted mortality reduction

McCann et al. [2] studied breast cancers diagnosed in East Anglia between 1989 and 1996 in women born between 1925 and 1943. Tumours were divided into 112 prognostic groups based on size, grade and nodal status, and predicted 88-month survival of non-screen-detected cancers was compared with predicted 124-month survival in screen-detected cases. The 36-month difference was to allow for the lead time of screen detection. The study covered two rounds of screening. Cancers detected on the first screen (\(n = 571\)) were excluded. There were 451 pre-invitation cancers compared with 156 in non-attendees, 382 interval cancers (before the second screen) and 412 cancers detected on the second screen. The predicted relative mortality [95% confidence interval (CI)] from cancers detected in invited women compared with those not invited for screening was 0.85 (95% CI 0.78–0.93). Although the authors report relative predicted mortality separately for cancers diagnosed in women aged <55 and ≥55 years, this analysis is biased since screen-detected cancers in women aged 52–54 years at first screen will be included in the older age group, whereas interval cancers in such women may have been diagnosed before age 55 years. It should also be noted that the denominator for the mortality rates in this study is the number of women with cancer, not the number of women years of follow-up pre- and post-invitation to screening. Thus the assumption that on average the number of interval cancers plus cancers detected on the second screen will be equal to the number of cancers detected over the same period in unscreened women is untested.

### Monitoring in the future

Despite the collection of detailed data on the results of mammography and characteristics of screen-detected tumours, little is
done at a national level to evaluate the effectiveness of service screening in the UK. To address the latter, one needs to monitor interval cancer rates, advanced cancer rates and predicted mortality rates. Interval cancer rates should be recorded as a function of time since last screening and could be looked at separately in different age groups and by the number of previous mammograms. Advanced cancer rates could be compared between those never screened and screened individuals with none, one, or two or more screens in the previous 4 years.

Predicted mortality rates have the advantage of providing information on the mortality benefit from screening without having to wait for mortality statistics. They depend critically on the assumption that, after adjusting for known prognostic factors and lead time, survival is independent of the mode of diagnosis (never screened, screen-detected or interval) and this should be examined prospectively. Predicted breast cancer mortality rates could be compared between cohorts screened or not screened within the previous 4 years. Adjustment should, however, also be made for socioeconomic status which influences uptake of screening services, incidence of breast cancer and survival from breast cancer.

**Conclusions**

Breast screening in the UK is well organised and has achieved population coverage of around 75%. However, the benefits of screening in terms of the reduction in breast cancer mortality appear (with some uncertainty) to be less than anticipated. It is difficult to quantify the effectiveness of screening by analysing trends in population mortality. It is essential to continuously evaluate the effectiveness of screening programmes and this requires more detailed national statistics than are currently available in the UK.

**References**