

ORIGINAL ARTICLE

## Mammography activity in Norway 1983 to 2008

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### Abstract

**Background.** In Norway, an organized screening mammography program, the Norwegian Breast Cancer Screening Program (NBCSP) started in four counties in 1996 and became nationwide in 2004. We collected data on pre-program screening activity, and in view of this activity we evaluated the potential impact of the program on breast cancer mortality in Norway. **Methods.** We searched data sources on mammography activity in Norway. Three data sources reported on examination activity, and two on self-reported examinations. We aimed at calculating annual number of women examined by mammography from 1983 to 2008, and coverage rate in program and non-program Norwegian counties. **Results.** The annual number of women examined increased from 5000 in 1983 to 110 000 in 1993 to reach its maximum of 131 000 in 2002, excluding program examinations. The annual number of women examined in the organized program increased from 1996 to a steady state about 190 000 in 2004. Prior to start of the organized program, 40% of women in target age groups reported to have had mammography examination. During the years 1996–2002, 64% of first participants in the organized program reported to have been examined previously. Assuming that the Norwegian program would in absence of prior screening have decreased breast cancer mortality by 25%, and that the activity in- and outside the organized program were equally effective, the measured effect of the organized program would under actual circumstances be a reduction of 11%. **Conclusion.** The example of Norway illustrates that although monitoring of screening outcome is highly warranted, this may be seriously jeopardized if use of mammography examinations was widespread prior to implementation of an organized program.

The Norwegian Breast Cancer Screening Program (NBCSP) was implemented in 1996. It started out as a pilot program in four counties (Rogaland, Oslo, Hordaland, and Akershus), and the national roll out ended in 2004. The program targets women aged 50 to 69 years with biennial screening, and the program has been well received by Norwegian women with an overall participation rate of 78% [1]. After 10 years of operation, the Norwegian Ministry of Health wanted an evaluation of the NBCSP, and a research program was initiated via the Norwegian Research Council.

The purpose of screening mammography is to decrease the breast cancer mortality in the target population, and breast cancer mortality is therefore the key outcome variable in an evaluation. With screening mammography as the exposure variable, an evaluation ideally requires the presence also of

breast cancer mortality data from an unexposed control group. This was straightforward in the randomized controlled trials, which provided the evidence for the initiation of screening [2], but it is not straightforward to identify an unexposed control group in evaluation of service screening programs offered to all women in the target population. The best proxy seems to be a study design with “three control groups” composed of women in the screening region prior to screening, and women in the non-screening regions both during and prior to screening [3]. This design has proved useful in Denmark [4] and Finland [5]. A somewhat similar design was used in a recent Norwegian study concluding that the introduction of the organized screening mammography program decreased breast cancer mortality by 10% only [6]. The results from this study have been disseminated widely and have contributed to the

ongoing debate on the pros and cons of screening mammography [7]. However, the widespread use of opportunistic screening in Norway complicates the evaluation of the NBCSP, the potential control groups may not be unexposed to screening mammography, and an evaluation of the organized program will in this case be affected by a considerable misclassification.

To assess the possibilities for a valid evaluation of the NBCSP, we therefore made a comprehensive investigation of all mammography activity in Norway during the period 1983 to 2008, and estimated the impact of this activity on the measurable effect of the NBCSP.

## Material and methods

### *Mammography*

Mammography can be undertaken both as a clinical examination of symptomatic women, and as a screening examination of asymptomatic women. At clinical mammography the number of projections depends on the localization and visibility of the suspected lesion. At screening mammography two projections, a craniocaudal and an oblique, are made of each breast. In Norway, mammography examinations have been performed in three settings, within the organized screening program, elsewhere in the public health sector, and in the private sector. The opportunistic screening mammography has been performed primarily in the private sector. To get a comprehensive picture, the activity in all three sectors needs to be included. As examinations, we aimed at counting the annual number of women undergoing mammography.

### *Data*

We searched all potential data sources on mammography activity in Norway. We found three data sources reporting on number of performed mammography examinations [8–10,12–14], and two data sources reporting on women's experiences with mammography examinations [16,17].

The Norwegian Radiation Protection Authority investigated the number of performed mammography examinations in 1983, 1988, 1993 [8], 2002 [9], and 2008 [10]. In the counting of examinations, the Authority follows a European Union definition saying that “a radiological examination ... is defined as imaging ... of an anatomical region ...” [10]. Concerning mammography, this definition leaves room for interpretation. For the 1993 data, Olerud and Saxebøl stated that “mammography examinations in Norway refer to one single breast” [11].

For the 2008 data, Almén et al. [10] stated that “mammography ... involving double sided organs can be registered as one or two examinations”. Widmark and Olsen [8] and Olerud and Saxebøl [11] reported somewhat different numbers for 1993. We used the numbers reported by Widmark and Olsen, as these could be converted to number of examined women.

For 2008 we did not use Authority data, as numbers on examined women were available from other sources. Hofvind and co-authors investigated the number of performed mammography examinations in the private sector in 2003 [12], and the number of mammography examinations in all three sectors in 2005 and 2008 [13]. They counted number of examined women, with the reservations that in the latter investigation they counted a given woman in a given institution in the respective year only once, and they included only women aged 28–75 years.

The Cancer Register of Norway published annual number of women invited to the NBCSP from 1996 to 2007 [14]. Assuming an average participation rate of 78% [1,13], the number of examinations in the organized screening mammography program can be estimated based on these data. Due to a current embargo on use of data from women with normal screening mammograms [15], the number of participating women could not be tabulated directly.

The Norwegian Women and Cancer Study, NOWAC, in 1996, 1997–1998 and 2002 issued questionnaires to random samples of Norwegian women in screening relevant ages. In total 121 683 women were invited, and 70% of them provided information on previous mammography examinations. NOWAC participants had been found to have the same breast cancer incidence rate as Norwegian women [16]. Concerning mammography, women were in 1996 to 1997–1998 asked the following question: “Do you regularly undergo mammography examination? With the answering categories: no; yes with an interval of two years or less; yes with an interval of more than two years. In 2002 the question was: Have you had your breasts examined with mammography? With the answering categories: yes or no. If yes: How old were you the first time? And how many times have you been examined?”

At first attendance in the NBCSP, women were asked to fill in a short questionnaire including the following questions: 1) Have you ever had a mammogram? and if yes 2) How many years ago was it? Data from the questionnaires for the period 1996 to 2002 have been tabulated by Weedon-Fekjær and co-authors, where 94% of screening participants are reported to have answered the questionnaire [17]. Due to the current embargo, it was not possible to analyze these data further.

*Analysis*

Firstly, we tabulated the annual number of mammography examinations aiming for data where each examination represented an examined woman. We divided the numbers into mammography within the organized program and mammography elsewhere. To translate the Authority data into number of women undergoing mammography, we relied on personal communication from the investigators. For 1983, 1988 and 1993 we divided the Authority numbers of mammography examinations by two, and for 2002 we used an algorithm based on local registration practice (Hofvind, personal communication, 2010, e-mail). It should be noted that one woman could be counted twice if she attended a private clinic and had further examination at a hospital, although this is not expected to have had a major influence on the estimates. Secondly, we tabulated the available data on women's prior mammography examinations by calendar year, age, and time since last mammogram. Thirdly, we compared the two types of data to check for consistency in the annual number of reported mammography examinations.

The Regional Committee for Medical Research Ethics and the Norwegian Data Inspectorate approved use of NOWAC data. The remaining data were retrieved from already published data sources.

**Results**

Before the implementation of NBCSP in 1996, only diagnostic/opportunistic screening mammograms were undertaken. Converted into number of examined women 5000 in 1983; 40 000 in 1988; 110 000 in 1993; and in 2002 131 758 women were examined outside the program (Table I). According to Hofvind et al., 90 000 examinations were undertaken in the private sector in 2003, but Hofvind et al., did not count examinations in the public sector for this year. In 2005, Hofvind and Sanderud counted 100 907 women examined outside the NBCSP, and in 2008 this number was 99 613. The actual number might have been slightly higher, as Hofvind and Sanderud did not include women above the age of 75. The estimated number of women examined outside the NBCSP thus increased dramatically from 1983 to 1993, where after the number increased slightly to its maximum of 131 000 in 2002. In 2005 and 2008 the number was close to 100 000 (Figure 1).

From 1996 onwards, the annual number of women examined in the NBCSP increased until it reached a steady state around 2004 with an annual number of close to 190 000.

According to the NOWAC data from 1996 (Table II), 47% of women aged 50–69 years in the four pilot counties reported to have had mammography regularly, and the percentage was 40% in the

Table I. Number of mammography examination in Norway 1983 to 2008.

| Year | Norwegian Radiation Protection Authority |   | Hofvind et al. [12,13]                      | Norwegian Breast Cancer Screening Program NBCSP |
|------|--|---|---|---|
|      | Total number of mammograms               | Total number of examined women, excl. NBCSP | Total number of examined women, excl. NBCSP | Total estimated number of examined women        |
| 1983 | 10 000                                   | 5 000                                       | NR  | 0   |
| 1988 | 80 000                                   | 40 000                                      | NR  | 0   |
| 1993 | 221 210                                  | 110 605                                     | NR  | 0   |
| 1996 | NR                                       | NR  | NR  | 49 505  |
| 1997 | NR                                       | NR  | NR  | 67 106  |
| 1998 | NR                                       | NR  | NR  | 66 535  |
| 1999 | NR                                       | NR  | NR  | 74 940  |
| 2000 | NR                                       | NR  | NR  | 103 900   |
| 2001 | NR                                       | NR  | NR  | 128 688   |
| 2002 | 349 057 <sup>1</sup>                     | 131 758 <sup>1</sup>                        | NR  | 164 025   |
| 2003 | NR                                       | NR  | [86 570] <sup>2</sup>                       | 174 516   |
| 2004 | NR                                       | NR  | NR  | 189 501   |
| 2005 | NR                                       | NR  | 100 907                                     | 186 052 <sup>3</sup>                            |
| 2006 | NR                                       | NR  | NR  | 194 603   |
| 2007 | NR                                       | NR  | NR  | 194 778   |
| 2008 | 340 701                                  | No conversion                               | 99 613                                      | 196 073 <sup>2</sup>                            |

NBCSP, Norwegian Breast Cancer Screening Program.

Notes:

<sup>1</sup>349 057 included NBCSP examinations all counted as 1, and non-NBCSP examinations locally counted as 1 or 2. We used an algorithm based on local registration practice to calculate the 131 758 non-NBCSP examinations.

<sup>2</sup>Private sector only.

<sup>3</sup>As reported by Hofvind and Sanderud<sup>13</sup>.

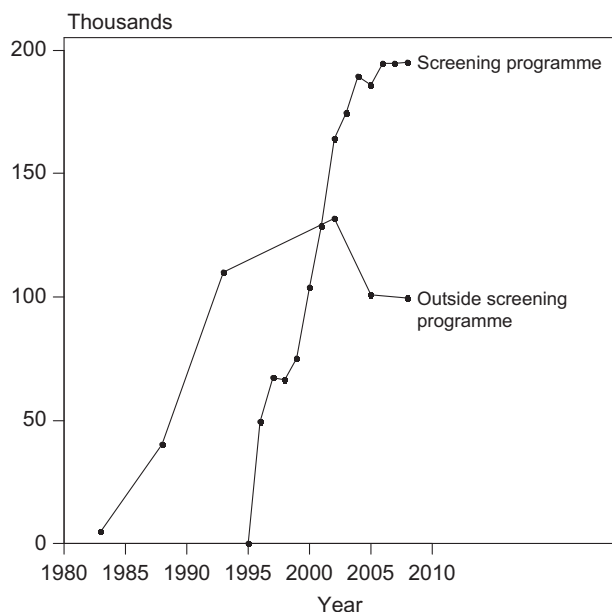


Figure 1. Number of women examined with mammography in Norway 1983 to 2008.

rest of Norway, a difference of 7%. The difference might be due to regional differences as the most urban parts of Norway were included in the pilot counties, but it might also reflect the start of the screening program in 1996. By 1997–1998 the difference had grown to 26%, with 73% in the four pilot counties and 47% in the rest of Norway. In 2002, 92% of women in the screening counties reported to have had their breast examined with mammography, while this percentage was – based on small numbers – 79% (1159/1462) in the few counties, where the screening program had not yet been implemented, giving a difference of 18%. In the screening program, 64% of first attendees in 1996–2002 reported to have had mammography before; a difference of 28% compared with the 92% reporting to have had mammography in the 2002 NOWAC data. The participation rate in the program was 78%, and if we assume that women with prior regular mammography would also attend the organized screening when invited, we can calculate that 50% ( $= (0.64 \times 0.78 \times 100)$ ) of women targeted by the program had prior mammography. The 50% is pretty close to the 47% cross-sectional coverage reported for non-program counties in the NOWAC data in 1997–1998, which is approximately in the middle of the period.

According to the NOWAC from 1996, 25% of Norwegian women aged 40–69 had regular mammography less than two years ago, and 18% of Norwegian women had regular mammography more than two years ago. In 1996, there were 712 000 Norwegian women aged 40–69 [18]. With 25% using mammography less than two years ago, we get an

annual number of 87 000 mammography examinations, and with 18% using mammography say every fourth year, we get an additional 32 000 annual mammography examinations. This gives in total, 119 000 examinations, which with this crude estimation is fairly good in line with the number of 111 000 mammography examinations reported for the private sector by the Norwegian Radiation Protection Authority for 1993.

## Discussion

The five independent data sources all documented a considerable mammography activity in Norway prior to the introduction of the NBCSP in 1996. Given the use of different methodologies in these data sources some divergence between the reported numbers was to be expected. The data sources nevertheless showed a fairly consistent pattern. The most important observation was that at least 40% of Norwegian women regularly underwent mammography prior to their first invitation to the NBCSP.

The collected data on mammography examinations prior to the introduction of the NBCSP can be used to estimate the impact of the exposure misclassification on the measured effect of the organized program on breast cancer mortality. Based on the national cancer register data the pre-program, 1990–1995, breast cancer mortality rate was 71 per 100 000 for women aged 50–79 [19]. For simplicity, we assume that there was no pre-program difference between screening and non-screening counties. Again based on the national cancer register data, the mortality rate would in the absence of screening have been expected to decline to 67 per 100 000 in the screening period. In line with the literature [20], the screening program would with the participation rate of 78% be expected to reduce the population-based breast cancer mortality rate by 25%. Prior to the start of the program, 40% of women had been screened (Table II). During the implementation of the program, the screening coverage increased to 92% in counties with an organized program and to 64% in counties without (Table II). Under these conditions, an expected 25% reduction in breast cancer mortality will be estimated to be an 11% reduction (Table III).

This calculation was made under the assumption that opportunistic screening is as efficient as organized screening. Few studies have compared the outcome of the two screening modes. Austria has widespread opportunistic screening, while Sweden and Finland have organized programs. A comparative study found Austria to have a larger annual decrease in breast cancer mortality than Sweden and Finland [21]. It should though be taken into account

Table II. Proportion of Norwegian women reporting at least one previous mammography examination in the NOWAC study, and at least one previous mammography examination at first attendance in the organized screening mammography program, NBCSP.

|   | 40–49 years |        |       | 50–59 years |         |       | 60–69 years |        |       | 50–69 years |
|---|-------------|--------|-------|-------------|---------|-------|-------------|--------|-------|-------------|
|   | N           | N, yes | %     | N           | N, yes  | %     | N           | N, yes | %     | %           |
| NOWAC, 1996                               |             |        |       |             |         |       |             |        |       |             |
| – 4 pilot NBCSP counties <sup>1</sup>     | 957         | 358    | 37.5% | 2167        | 1064    | 49.1% | 1524        | 655    | 43.0% | 46.6%       |
| – Non screening counties                  | 1488        | 514    | 34.5% | 3411        | 1446    | 42.4% | 2272        | 830    | 36.5% | 40.0%       |
| – Difference                              |             |        | 3.0%  |             |         | 6.7%  |             |        | 6.5%  | 6.6%        |
| NOWAC, 1997–1998                          |             |        |       |             |         |       |             |        |       |             |
| – 4 pilot NBCSP counties                  | 12 344      | 3981   | 32.3% | 8536        | 6275    | 73.5% | 1197        | 819    | 68.4% | 72.9%       |
| – Non screening counties                  | 19 331      | 5771   | 29.9% | 14 118      | 6709    | 47.5% | 1870        | 764    | 40.9% | 46.7%       |
| – Difference                              |             |        | 2.4%  |             |         | 26.0% |             |        | 27.5% | 26.2%       |
| NOWAC, 2002                               |             |        |       |             |         |       |             |        |       |             |
| – 4 pilot NBCSP counties (A)              | 148         | 103    | 69.6% | 2841        | 2730    | 96.1% | 2111        | 2097   | 99.3% | 97.5%       |
| – New NBCSP counties <sup>2</sup> (B)     | 194         | 125    | 64.4% | 3761        | 3311    | 88.0% | 2688        | 2323   | 86.4% | 87.4%       |
| – Non screening counties <sup>3</sup> (C) | 48          | 28     | 58.3% | 840         | 675     | 80.4% | 622         | 484    | 77.8% | 79.3%       |
| – Difference (A) – (C)                    |             |        | 11.3% |             |         | 15.7% |             |        | 21.5% | 18.2%       |
| NOWAC, 2002                               |             |        |       |             |         |       |             |        |       |             |
| – 4 pilot and new NBCSP counties          | 342         | 228    | 66.7% | 6602        | 6041    | 91.5% | 4799        | 4420   | 92.1% | 91.8%       |
| SCREENING PROGRAMME 1996–2002             |             |        |       |             |         |       |             |        |       |             |
| – 4 pilot (A) and new NBCSP counties (B)  | NR          | NR     | NR    | 202 307     | 133 871 | 66.2% | 112 558     | 67 756 | 60.2% | 64.0%       |
| – Difference                              |             |        | NR    |             |         | 25.3% |             |        | 31.9% | 27.8%       |

Notes:

<sup>1</sup>Rogaland; Oslo; Hordaland; Akershus.<sup>2</sup>Telemark; Agder; Troms and Finnmark; Østfold; Nordland; Buskerud; Trøndelag; Oppland.<sup>3</sup>Møre and Romsdal; Sogn and Fjordane; Hedmark; Vestfold.

that Austria started out from a higher level and therefore had a larger potential for improvement [22]. A small comparative study from Denmark, showed mammograms taken opportunistically to have a considerably lower sensitivity than mammograms taken in organized programs [23]. Our calculation is sensitive to the effect of opportunistic screening. If we

assume that opportunistic screening had 2/3 of the effect of organized screening, an expected 25% reduction in breast cancer mortality would be estimated to a 17% reduction.

Kalager et al. [6] evaluated the impact of the NBCSP on breast cancer mortality, using a “three control groups” study design. For the target age

Table III. Expected bias in the estimation of the effect of the organized screening mammography program in Norway, NBCSP, on breast cancer mortality.

|   | Breast cancer death rate per 100 000 before screening      | Breast cancer death rate per 100 000 during screening        | Relative risk |
|---|--|--|---------------|
| Expected numbers in the absence of opportunistic screening  |  |  |               |
| – NBCSP counties  | 71   | $((0.22 \times 67) + (0.78^1 \times 67 \times 0.68))^2 = 50$ | 0.75          |
| – Non-NBCSP counties  | 71   | 67   |               |
| Expected numbers given the observed opportunistic screening |  |  |               |
| – NBCSP counties  | $((0.60 \times 71) + (0.40^3 \times 71 \times 0.68)) = 62$ | $((0.08 \times 67) + (0.92^4 \times 67 \times 0.68)) = 47$   | 0.89          |
| – Non-NBCSP counties  | $((0.60 \times 71) + (0.40^3 \times 71 \times 0.68)) = 62$ | $((0.36 \times 67) + (0.64^5 \times 67 \times 0.68)) = 53$   |               |

Note:

<sup>1</sup>Participation rate in NBCSP: 78%.<sup>2</sup> $((0.22 \times 67) + (0.78 \times 67 \times Y)) / 71 / (67/71) = 0.75$ , gives  $Y = 0.68$ , which is the estimated effect of screening in screened women. This  $Y$  is used for the other calculations.<sup>3</sup>Proportion of women aged 50–69 with at least one previous mammography examination in NOWAC 1996 data, non-NBCSP counties: 40%.<sup>4</sup>Proportion of women aged 50–69 with at least one previous mammography examination in NOWAC 2002 data, four pilot and new NBCSP counties: 92%.<sup>5</sup>Proportion of women reporting at least one prior mammography examination at first NBCSP attendance, 1996–2002: 64%.

group of women aged 50–69, the study showed a rate ratio in the breast cancer mortality of 0.72, when women in the screening counties were compared with women in the same counties prior to the introduction of the program. For women in the non-screening counties, the rate ratio was 0.82 when compared with the historical rate for women in the same counties. Based on this, the authors attributed 10% of the breast cancer mortality decrease in the screening regions to screening and the remaining 18% to a time effect reflecting better treatment and other temporary changes. Our calculation illustrated that the limited impact of the NBCSP estimated by Kalager et al. might be explained by the widespread use of mammography prior to the start of the program.

In conclusion, Norway had a considerable opportunistic screening activity prior to the introduction of the organized screening mammography program, the NBCSP, in 1996. This activity will seriously jeopardize the ability to estimate the potential effect of the NBCSP on breast cancer mortality in Norway.

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