ELSEVIER

Health Policy 54 (2000) 125–141

HEALTH policy

www.elsevier.com/locate/healthpol

Cost implications of routine mammography screening of women 50–69 years in the County of Funen, Denmark

Mickael Bech *, Dorte Gyrd-Hansen

Institute of Public Health, Health Economics, SDU-Odense University, Winsløwparken 19, 3., DK-5000 Odense C, Denmark

Received 8 April 2000; accepted 16 June 2000

Abstract

In order to estimate the net costs of introducing mammography screening to women 50–69 years of age, unit costs of all relevant activities related to detection and treatment of breast cancer were estimated using activity based costing methods. In order to determine the overall impact of mammography screening, activity data collected from the second screening round (1996–1997) were compared with expected activity levels in the case no screening had taken place in this time period. The direct health care costs associated with the screening activity, excluding effects on treatment and diagnostics but including women's transport and time costs, were estimated at DKK 305 per attendee. The cost of clinical mammography decreases with the introduction of screening due to a decrease in the total number of women undergoing this introductory diagnostic activity, while surgery costs increases, whereas cost incurred by adjuvant treatment and treatment of recurrences will be significantly reduced. Overall, inclusion of effects on course of treatment decreases the net cost of screening by 30–40% to DKK 208 and DKK 128 including and excluding the women's time and transport costs, respectively. © 2000 Elsevier Science Ireland Ltd. All rights reserved.

Keywords: Breast cancer; Mammography screening; Cost analysis

* Corresponding author. Tel.: +45-6550-3081; fax: +45-6591-8296.
E-mail address: mbe@sam.sdu.dk (M. Bech).

PII: S0168-8510(00)00104-4

1. Introduction

The Danish National Board of Health has recently recommended that all women 50–69 years of age should be offered mammography screening [1]. In 1999 only one-fifth of Danish women are offered regular mammography, with systematic screening activities taking place in the County of Funen and in the municipalities of Copenhagen and Frederiksberg. The present evaluation is based on the experiences of the Funen screening programme which was initiated in November 1993 and has since screened about 23 000 women a year.

The background for this project is a request from the Danish National Board of Health to evaluate systematic mammography screening with special focus on the economic and psychological consequences. This cost analysis is part of such a health technology assessment financed by the Danish Institute for Health Technology Assessment.

The purpose of the study is to evaluate the cost consequences of introducing mammography screening by comparing costs associated with detection and treatment of breast cancer amongst 50–69 year olds in a setting with and without systematic screening. The null-option is the traditional diagnostic system, as it was observed in the pre-screening period 1991–1992. Beyond the costs incurred by the screening activity per se, a potential effect of introducing systematic screening is a change in the level of diagnostic activities. Such activities are likely to increase because a number of healthy women are referred to further examination as a consequence of abnormal screening images (false positives). This effect may, however, be partly counterbalanced if a systematic screening programme can reduce the number of healthy women who are referred to clinical mammography via their GP on the grounds of symptoms or other reasons for anxiety. Additional resource implications of screening are potential alterations in the course of treatment. Results from earlier studies indicate that screening costs will be counterbalanced in part by savings on treatment [2–4].

In addition to estimating the direct costs of screening, this study will estimate these derived effects in turn, with the aim of estimating the overall net cost of introducing systematic screening in the County of Funen, Denmark.

2. Methods

Using activity based costing methods, unit costs were estimated for all relevant activities related to breast cancer detection and treatment. Unit costs include salary, materials and capital outlay. Generally, unit costs are calculated as incremental costs, which do not include overheads and therefore cannot be considered as full-cost estimates. Overheads are defined as costs which cannot directly, or indirectly, be associated with activity levels. This analysis made an effort at determining relevant cost drivers, thus reducing the extent of cost elements which cannot be associated with activities. In the present paper, the difference between full-cost estimates and incremental cost estimates is judged as being relatively insignificant, and the unit costs presented here may hence be seen as good approximations of long terms costs.

Unit costs not only include the use of resources associated with the department performing the activity in question, but also include derived activities in other departments such as pathology and other service departments. All costs estimates are presented in 1997 Danish Kroner (DKK) (7.50 DKK $\approx$ 1 EUR).

The perspective of this cost analysis is societal, implying that all costs associated with diagnosing and treating breast cancer should be included irrespective of whether the costs are incurred by the health care sector, other public sectors or the participating women. When evaluating the costs of introducing a population screening programme important cost elements are time and travel costs associated with participation. In the present analysis the women's transport and time costs were disclosed on the basis of data collected via questionnaires given to a sample of 320 women, of which 52% visited the stationary screening unit and 48% were serviced by the mobile unit. This distribution corresponds well to the overall allocation of women between the two units which is, respectively 55 and 45%. The questionnaire contained questions regarding travel distance to the screening centre, transport mode, as well as an estimated use of time on travel and screening activity. Transport costs are estimated by multiplying travel distance with a cost per kilometre calculated specifically for alternative travel modes. Cost of time was estimated by applying hourly wages based on occupational specific salaries. Time costs were assumed to be zero for women who for some reason are unemployed (retired, housewives and involuntarily unemployed) thereby the estimated time costs may be seen as being an underestimate of the true opportunity costs incurred. A sensitivity analysis demonstrates the implications of setting the opportunity cost equal to half of the wage rate net of tax.

The costs included in this analysis are restricted to those cost implications that are related directly to the introduction of a mammography screening programme. Indirect effects incurred as a consequence of postponement or avoidance of breast cancer death, such as unrelated health care costs, consumption and production gains, are not included. Since the target groups for this health care intervention involves elderly people, meaning that the majority of life-years will be gained amongst the 60+ year olds, the gain in production capacity as a result of introducing mammography screening is likely to be negligible. In contrast, unrelated health care costs as well as costs associated with general consumption will amount to a cost per life-year in the range of DKK 80 000 [5]. The ethical implications of including indirect effects associated with gained life-years are apparent when the health care intervention being evaluated is targeted at an elderly population who in future years is likely to consume rather than produce resources. These authors have chosen not to include these cost elements due to the controversy that surrounds the inclusion of unrelated costs and benefits [6–10]. An additional reason has been the uncertainty surrounding the life-expectancy of breast cancer patients, as well as the effect of screening on breast cancer mortality rates. This discussion is beyond the scope of the present analysis.

Diagnostic activities including screening activities were registered from the period 1 January 1996–31 December 1997 which is the second round of screening in the County of Funen. Diagnostic activities were likewise collected for the period 1 January 1991–31 December 1992, which is the latest period without mammography screening in the County of Funen. From registers at the Centre for Mammography Screening, County of Funen, data on the number of women screened and the proportion of these women undergoing clinical mammographies due to abnormal screening images, were collected. Data on the number of women referred directly to clinical mammography in the two time periods were collected from the Department of Radiology, Odense University Hospital (OUH). In addition, number of surgical biopsies resulting in a benign diagnosis were collected for the two time periods from the central registry at OUH.

Number of breast cancers observed in the two aforementioned time periods in the County of Funen were 277 and 365[1], respectively. For these numbers to be comparable, such that the 1991–92 scenario reflects a 1996–97 scenario in the case no screening had taken place, adjustments were necessary. The 1991–92 figure is adjusted for changes in population size, age-distribution and an increasing trend in breast incidence over time[2]. Annual Danish breast cancer incidence rates rose by 1.48% per year from 1963 to 1995 [1], which is similar to experiences from Sweden with an increasing incidence of 1.4% per year [11]. Number of cancers observed in 1996–97 may reflect detection of cancers which have entered the screen-detectable phase in periods prior to 1996–97, but which have remained undetected to date. The proportion of such cancers being detected in a screening round is determined by the sensitivity of the screening test, and is likely to stabilise after the third screening round. As the present data is collected from the second screening round, the number of screen-detected cancers has not yet stabilised and will not reflect the effect of screening in the long term. Experiences from the mammography screening programme in Copenhagen show that the number of operated women will decrease by 7.9% from the second to the third screening round [12]. The 1996–97 figure was adjusted by this amount, in order to reflect the long term effects of screening.

After all the above adjustments are made, the number of cancers detected in the screenings-scenario and the non-screening scenario is estimated to 347 and 327, respectively. The difference of 20 cancers may be explained by the higher number of Ductual Carcinoma In Situ (DCIS) detected in the screening-scenario.

The course of treatment of women with breast cancer is reconstructed on the basis of data collected from databases and patient's records. The Danish Breast Cancer Cooperative Group (DBCG) who register all breast cancers in Denmark and coordinate the adjuvant treatment, provided data on stage distributions of

[1] Two hundred and twenty-eight cancers found at screening, 87 indterval cancers detected amongst women participating in screening and 50 cancers detected amongst women who did not participate.

[2] A further problem involved in making comparisons across two time periods could be that changed attitudes and earlier diagnosis are not taken into consideration. However, analysis of DBCG figures based on unscreened populations in the relevant time period indicates no significant shift in tumour size.

breast cancers detected in the two time periods. This register also provided information on the standardised course of adjuvant treatment per breast cancer stage, as well as the frequency and timing of recurrence for each stage. The administrative system at OUH registers codes for the various diagnostic activities and types of operations performed on the individual cancer patient, in addition to information on cancer stage at time of detection. This information, collected from the period 1996–97 was used to establish stage-specific courses of diagnosis and treatment. Treatment patterns as observed in 1991–92 were not included in the analysis, since the aim of the analysis is to determine the implications of screening and no screening in a 1996–97 context. For example, the surgical treatment of breast cancer has changed in the last decade implying an increase in the frequency of tumourectomies [13]. If 1991–92 treatment data were included in the analysis it would not be possible to distinguish the effect of screening from the effect of a change in treatment practices over time.

Treatment of patients with recurrent breast cancer is diverse and complex, making detailed cost analysis of all patients very time consuming. A general picture of the activities related to treating recurrent cases of breast cancer was reconstructed on the basis of patients' records using a sample of 78 women who died from breast cancer in 1998. From the records were collected data on the number of outpatient visits and inpatient bed days. Tariffs from OUH were used when estimating the resource implications.

All incidents of diagnosis and treatment were linked to the stage of the disease at time of detection. Changes in these activity levels were calculated on the basis of the difference in stage distribution between the two time periods 1991–92 and 1996–97. Resource implications were calculated by applying estimated unit costs.

3. Results

Mammography screening in the County of Funen is organised with one stationary screening unit located at OUH and one mobile screening unit covering the rural areas. In both units approx. 14 women can be screened per hour. The two units screen approx. 23 000 women a year. The startup cost for the screening programme, investments in machines, mobile screening unit, setting up facilities, etc. was 10.3 million DKK. The startup costs are incorporated in the calculation of the unit cost of screening as a value of depreciation, assuming a lifespan of 5–15 years depending on the type of equipment and the intensity of use. Hence, costs of equipment are handled not as a fixed cost but as costs which vary with number of mammograms performed over time. Members of staff in the Department of Mammography screening who are involved full-time in the screening programme include two doctors, seven nurses and three secretaries. Cost of staff is assumed to vary with the number of mammograms performed, assuming that all labour costs are variable in the long run. Cost of postage mainly includes invitation costs. The invitation system is such that each woman receives one invitation and up to two reminders. If a woman declines to participate, she is not invited in the subsequent screening round. Table 1 shows the running costs in 1997 of the two units including the yearly depreciation of the startup cost.

In the second round of screening in the County of Funen 48 178 women were invited and 45 806 participated. With an average of 22 903 women invited over a year and a participation rate of 95%, the cost per woman screened is estimated at 225 DKK, including only costs incurred by the health care sector.

Out of the 320 women who were questioned on the time and travel costs involved in participating, 134 were employed and 186 were either housewives or unemployed (62 women) or retired (124 women). Of those in employment only 40 women took time off work in order to participate, while the remaining women used their leisure time. The opportunity cost of time is estimated using gross wages for women foregoing working time, wage rates net of tax for women visiting the clinic in their leisure time and assuming zero opportunity cost for women unemployed or retired. In addition 30 women were accompanied to the screening unit by another person. In these cases, an opportunity cost for the accompanying person was included in the estimations. Assuming full production loss as working time is reduced, lost production amounts to an average DKK 28 per attending woman, while the value of lost leisure time amounts to DKK 30 per screened woman.

Out of the 320 women travelling, 221 women came by private car, four by taxi, 22 used public transport, while 73 walked or cycled. The societal cost of travel was set at DKK 1.21 per km when using a private car, DKK 1.18 per km when using public transport and DKK 10.33 per km in a taxi[3]. There was assumed to be no cost involved when women walked or cycled. The average transport cost per attending woman amounted to DKK 22. Overall, inclusion of time and travel costs increases cost of screening by 35% (DKK 80) to DKK 305 per attendee.

The proportion of screened women recalled for further assessment because of abnormalities observed on the mammogram, was 1.6% or 716 in absolute numbers. A clinical mammography constitutes a number of repeated or detailed mammograms, ultrasound, and, if necessary, fine-needle aspiration biopsies. Clinical mammographies are likewise performed on women, who are referred directly to

Table 1
Running cost of screening in 1997

Costs	Amount (DKK)
Staff	3 298 395
Consumables	1 066 865
Postage	200 000
Rent of buildings	120 000
Depreciation	473 055
Total	5 158 315

[3] Direct costs of car, train and bus usage is based on information received from car renting companies, public transport authorities and taxi companies. In addition, externalities of transport are included [26].

Table 2
Clinical mammographies, activity levels and unit costs

	Non-screening-scenario	Screening-scenario	Unit cost (DKK)
Number of assessments after positive screening test		716	824
Number of assessments referred with symptoms	2335	924	1000

Table 3
Number of surgical biopsies on women *without* cancer

	Non-screening-scenario	Screening-scenario	Unit cost (DKK)
Surgical biopsy with needle marking	11	37	4290
Surgical biopsy	48	44	3052
Total number of surgical biopsies	59	81	

further assessment by their GP. When comparing the total number of assessments in the time periods 1991–92 and 1996–97, adjusting for population size and age-distribution, the total number of assessments has decreased after introduction of mammography screening, as can be verified in Table 2. Although introduction of screening entails that a number of false positives will be referred to further examination, this increase in further assessment is more than cancelled out by a reduction in the level of "opportunistic screening", i.e. ungrounded referrals. A decrease in such referrals not only reduces costs of further assessment, but also decreases number of GP visits significantly. Every direct referral involves two GP visits, whereas the responses to our questionnaire demonstrated that only a very small fraction (two out of 320) of the women consulted their GP prior to participation in the screening programme. Hence, number of GP visits induced by screening may be seen as negligible.

The average cost of further assessment is estimated for those referred from the screening unit (DKK 824), and those referred from their GP (DKK 1000). The unit cost of assessment is based on registrations of time and materials in the Department of Radiology and depreciation of equipment. For those women referred with symptoms the assessment cost includes cost of two visits to the GP, which partly explains the discrepancy between the two cost estimates. However, some of the difference is counterbalanced by a higher frequency of fine-needle aspiration biopsies amongst those referred from the screening unit.

If a clinical mammography is inadequate for setting a diagnosis, the woman is referred to a surgical biopsy. In the case that the tumour is non-palpable it is marked with a needle by a radiologist. Table 3 lists the number of women undergoing surgical biopsy who do not have breast cancer. It is noticeable that the total number of surgical biopsies amongst healthy women has increased after the introduction of screening.

It is important to distinguish between surgical biopsies with and without a needle marking because the unit cost of the two activities are significantly different due to the involvement of a radiologist in the latter case. The unit costs are listed in Table 3 and include costs of surgery and pathology.

Frequency of operation types in a non-screening and a screening scenario were simulated on the basis of the stage distributions observed in the two scenarios, combined with stage-specific probabilities of operation type as observed in 1996–97. Table 4 lists the number of mastectomies and tumorectomies performed in 1996–97, and the expected number of operations performed in the same time period had no screening taken place. The number of operations do not add up to the number of cancers detected on two grounds. Firstly, one breast cancer case may initiate several operations and, secondly, some of the women with DCIS may not be referred to a tumourectomy/mastectomy.

The unit cost for the surgical operations contain the cost of theatre time, nursing, hotel costs as well as the cost to other departments, such as pathology, blood tests and physiotherapy. The proportion of the unit cost carried by the department of surgery is about 2/3. Mastectomy patients stay in hospital for an average of 6 days, and the average length of stay for tumourectomy patients is 5 days. This difference in length of stay accounts for the discrepancy in unit costs. It should be noted, however, that the unit costs do not differ significantly.

Subsequent to surgical treatment patients are placed in adjuvant treatment protocols according to the stage their disease is in. Patients with DCIS do not receive adjuvant treatment, but are merely observed for a period of 10 years[4]. Amongst those patients categorised as low risk 52% are treated with radiotherapy, while the remaining 48% receive no adjuvant treatment. Of patients categorised as high-risk 43% are treated with CMF (nine treatments with 3 weeks intervals), 3% with CEF (nine treatments with 3 weeks intervals), 52% are treated with Tamoxifen over a period of 5 years and 1% are treated with ovarial radiotherapy (five times

Table 4
Number of surgical biopsies, tumourectomies and mastectomies performed on women *with* cancer

	Non-screening-scenario (expected)	Screening-scenario (actual)	Unit cost (DKK)
Total number of cancers	327	347	
Surgical biopsy with needle marking	42	59	4290
Surgical biopsy	38	44	3052
Tumourectomy	111	137	18 399
Mastectomy	201	202	20 325

[4] Patients with breast cancer are always kept under observation for a period of 10 years irrespective of cancer stage. The cost follow-up is included in Table 7.

Table 5
Low and high risk cancers. Average cost of adjuvant treatment in the two risk groups

	Non-screening-scenario	Screening-scenario	Unit cost (DKK)
DCIS	24	37	0
Low risk cancers[a]	100	182	8131
High risk cancers[b]	203	128	22 463
Total number of cancers	327	347	

[a] Low-risk is defined by node-negative and tumour size ≤5 cm.
[b] High-risk is defined by either node-positive or tumour size >5 cm.

Table 6
Recurrences: number of inpatient bed days and ambulant treatments

	Sample	Mean	SD	95% CI for mean	95% CI for mean
Inpatient bed days	76	29.66	31.08	22.62	36.70
Ambulant treatments	77	26.47	23.45	21.10	31.84

within one week). In addition, 41% of the high-risk patients receive radiotherapy to the remains of the operated breast.

Unit cost per adjuvant treatment of DCIS, low and high risk cancers were estimated based on the cost of radiotherapy and chemotherapy/hormone treatment. A substantial proportion of the cost of radiotherapy is depreciation of equipment (approx. 40%), whereas cost of pharmaceuticals account for 28–65% of the costs of chemotherapy or hormone treatment. The cost of the procedures are: radiotherapy DKK 14 496, ovarial radiotherapy DKK 3485, CMF treatment DKK 16 395, CEF treatment DKK 31 362, treatment with Tamoxifen DKK 14 889.

Changes in the stage-distribution when screening is introduced entail relatively big changes in the cost of adjuvant treatment, since the cost of treating high-risk patients is significantly higher than the cost of treating low-risk patients. The shift in the stage-distribution also affects the frequency and timing of recurrences among patients. Table A1 in Appendix A lists the probability of recurrence over time for high and low risk breast cancer patients in the County of Funen in the period 1991–98. Number of recurrences over time in a non-screening and a screening scenario were estimated by combining stage-specific probabilities of recurrence with the stage distributions that are listed in Table 5. The result was 99 expected recurrences in a no screening scenario, and only 72 cases of recurrence if screening takes place. The predictions were performed assuming that DCIS patients have no risk of recurrence.

Average cost per adjuvant treatment was based on data collected from a sample of patients who died in 1998. Data on ambulant treatment and inpatient days collected from patients' records are presented in Table 6.

The charge per in-patient bed days when the patients are receiving oncological treatment is DKK 3589 per day, while the charge for an ambulant treatment is

DKK 1485 (charges from OUH, 1998). Combining these cost figures with the statistics in Table 6 entails that the average incidence of recurrence costs DKK 145 757 (95% CI: DKK 112 517; DKK 178 998).

Introducing mammography screening in the County of Funen implies both increases and decreases in resource use. Table 7 lists all direct resource implications as they have been listed above. Cost of surgery increases while the cost of adjuvant treatment and treatment of recurrence is expected to decrease. It is also noticeable that the net cost of diagnostic assessment decreases.

The total net increase in the cost of screening, taking account of the derived changes in the cost of surgical and oncological treatment of breast cancer patients, amount to DKK 9.5 million over a 2 year period, implying a net cost per screened women of DKK 208.

4. Validation

Most of the interim results of this paper, such as the estimated unit costs, do not differ significantly from estimates published in the literature. Although comparisons are complicated by country specific differences in cost levels as well as the complexities involved in comparing analysis which have not been performed in the same year, similarities validate the results presented here. The cost of screening per attendee was calculated at DKK 225 excluding time and travel costs. Similar, estimates, which also exclude time and travel costs were found by others: DKK 202 [14], DKK 294 [15] and DKK 343 [16]. Discrepancies between this study's estimate and estimates from other studies are most likely explained by differences in price levels, and not by variations in the relative combination of input factors. This could be demonstrated by a comparison of this study with a study done in Finland which have the same relative costs of input, but not the same absolute cost [15].

Table 7
Total resource effects of introducing mammography screening (in DKK)[a]

	Non-screening-scenario	Screening-scenario	Costs per screened woman
Screening (hospital costs)		10 306 350	225
Screening (women's costs)		3 664 480	80
Assessment	2 335 602	1 514 243	−18
Surgical biopsies on women without cancer	238 592	360 040	3
Surgical treatment of women with cancer	6 696 182	7 213 809	11
Adjuvant treatment	5 383 899	4 388 247	−22
Ambulant control (10 years follow-up)	1 396 971	1 540 757	3
Treatment of recurrence	12 464 948	9 057 677	−74
Total	28 516 194	38 045 603	208

[a] Note: the discount rate is fixed to 5%. Some of the costs (ambulant control, treatment of recurrence and part of the adjuvant treatment) occur beyond 1 year.

The cost of a clinical mammography was estimated to cost on average DKK 824 if women were referred from the screening unit and DKK 1000 if they were not. These unit costs lie within the range of cost estimates found in other studies, e.g. DKK 686 [16], DKK 874 [17] and DKK 1996 [4]. A surgical biopsy was costed at DKK 4290 if needle marking was performed and DKK 3052 if needle marking was unnecessary. Compared to some estimates from the literature these estimates are low, e.g. DKK 10 500 [4] and DKK 20 000 [18]. However, results from Norway and New Zealand indicate that the these results are reasonable, e.g. DKK 3700 [17] and DKK 4700 [16].

An alternative Danish estimate of the cost of mastectomy/tumourectomy is based on tariffs and reports an estimate of DKK 32 109 [19], which is significantly higher than the estimates from this study (DKK 20 325 and DKK 18 399, respectively). The difference between the results of this study and the earlier estimates may be explained by a reduction in the average number of in-patient bed days for breast cancer patients. Danish DRG weights imply that a mastectomy costs DKK 26 562 while a tumourectomy costs as little as DKK13 950. This difference in cost across operation type was not confirmed in this study. Other studies have estimated mastectomy and tumourectomy to be respectively: DKK 31 455 and DKK 27 960 [4], DKK 30 511 and DKK 24 903 [20], DKK 29 120 and DKK 24 542 [21], DKK 18 705 and DKK 15 212 [17], DKK 14 805 and DKK 11 995 [16].

In this analysis cost of recurrence was estimated to lie in the range of DKK 112 500 and DKK 179 000. Compared with estimates from the literature e.g. DKK 100 760 [20], DKK 101 355 [4] and DKK 146 790 [22], the result from this study are of a similar magnitude. It should be noted that these studies, including the present study, have excluded costs incurred by the social sector which according to Koopmanschap et al. [23] is likely to increase the cost of recurrence by up to 25%[5].

No matter how detailed a cost analysis is, there is always some uncertainty involved in such estimates, making it necessary to determine the implications on final results of potential errors. Below, unit costs will be altered and the resulting change in final cost estimates determined. In addition, the effect of using a discount rate different from the base case rate (5%) will be investigated. As indicated by the results in Table 7 the major cost components are the costs of screening and the cost savings incurred by a reduction in number of recurrences. Hence, we choose to look at the extent to which cost per attendee alters as unit cost of screening and treatment of recurrences are varied. Table 8 lists the results, which demonstrates that the final cost estimate is highly sensitive to changes in the screening costs, but less so when discount rates are altered or changes made to the cost of recurrence. It is especially interesting to look at the effect of increasing the opportunity cost of employing additional radiologists. In the base case evaluation, it is assumed that the market for radiologists remains unaffected by an increase in demand, such that wage levels remain constant. Introducing nation wide screening in Denmark will, however, increase the demand for radiologists significantly which is likely to

[5] No serious bias is introduced by excluding cost to social sector when focus is on *primary* treatment, since most women are able to take care of themselves right after discharge.

Table 8
Sensitivity analysis on some crucial components

Component	Changes in the component	Net cost per screened woman (DKK)	Change in the cost per screened woman (%)
Reference model	–	208	–
Discount rate	Standard 5% varied to 0%	196	−5.8
	Standard 5% varied to 10%	218	4.8
Unit cost per screening (base case: DKK 305)	Women's time and transport cost are excluded (DKK 305 → 225)	128	−38.5
	Women's opportunity cost of leisure is excluded (DKK 305 → 275)	178	−14.4
	Opportunity cost of leisure for unemployed women is set equal to half of the wage rate net of tax (DKK 305 → 337)	240	15.4
	The opportunity cost of a radiologist is assumed equivalent to the salary of a radiologist in a private hospital. (DKK 305 → 349)	252	21.2
Unit cost for treatment of recurrence (base case: DKK 147 757)	Cost of recurrence equivalent to minimum value of 95% CI: DKK 112 517	225	8.2
	Cost of recurrence equivalent to maximum value of 95% CI: DKK 178 998	191	−8.2

increase the opportunity costs involved. In the sensitivity analysis the salary was assumed to increase to the current wage levels in private hospitals in Denmark. This would increase overall costs by as much as 21.2%.

Analysing the validity of the results presented here suggests that the unit costs are in line with cost calculations performed by other investigators. The final cost estimate per attendee is, however, sensitive to the calculation of the screening cost with results indicating that an increase in screening costs of 1% will increase net cost per attendee by 1.4%. The results show that costs will be significantly reduced if the perspective of the analysis is limited to that of the health care sector.

5. Discussion

In the evaluation presented here, cost calculations are based on a comparison of two scenarios: a screening scenario which involves biennial screening of the 50–69 year olds and a non-screening scenario based on the experiences in the County of Funen in the period 1991–92. It is important to emphasise that these two scenarios are not exhaustive of all alternatives, since screening programmes may be designed with alternative target groups and screening intervals in mind. However, costs of screening per attendee will only be affected significantly if the number of screenees rise significantly and a major proportion of total costs are fixed costs. Amongst the costs of screening only rent of building and a small proportion of postage costs are treated as fixed costs, implying that fixed costs represent a small proportion of overall screening costs. In addition, net cost per attendee could be affected if the target group is extended to including women with markedly different self-referral patterns. In this case the resource savings made through changes in diagnostic activities may be altered. Also, savings on treatment costs per woman screened will be affected by choice of target group, if the target group is extended to including women with a lower or higher risk of breast cancer. The same effect will arise if the screening interval is altered markedly. A change towards a more intensive screening programme, i.e. a shorter screening interval and/or extension of the target group to the younger age-groups, will increase cost per attendee since the detection rate and hence savings on adjuvant treatment and treatment of recurrence will not rise proportionately. However, since screening costs represent the major cost component, and a large proportion of screening costs vary with number of screening tests performed, the estimated cost per attendee presented in this analysis can be used more generally as a good approximation of the net cost per attendee for alternative screening programmes, if such programmes do not differ significantly from the programme presented here.

Alternatively, if health effects had been included and a cost-effectiveness analysis performed, the choice of comparators would generally have been more critical, since incremental cost effectiveness ratios will increase as programmes are intensified, and average cost effectiveness ratios will not adequately reflect the cost of the most expensive life-year gained. For an illustration see Gyrd-Hansen et al. [24].

One may also discuss the choice of null-option, and its appropriateness. In this study it is assumed that the level of diagnostic activities as observed in 1991–92 in the County of Funen, is the relevant alternative to screening. However, it is possible that diagnostic activities performed on healthy women could have been reduced through a stricter referral system and/or a campaign focussing on reassuring and informing the women who "misuse" the system. Hence, the present analysis may to some extent underestimate the cost of screening by using a non-optimal comparator. Alternatively, the introduction of screening in some Danish counties could potentially increase the level of opportunistic screening in counties that have not yet introduced screening. This would entail that for these specific counties the null-option may constitute higher levels of diagnostic activity on healthy women. Hence, the appropriate net cost of screening may be lower than the estimate presented in this analysis.

A potential cost of offering systematic screening to a limited group of the population, could also be an increase in opportunistic screening amongst borderline groups. In the case of breast cancer screening one could hypothesise that opportunistic screening amongst women under 50 year of age will increase as a consequence of introducing a screening programme targeted at the 50–69 year olds. Although the existence of such an effect cannot definitely be rejected, the level of diagnostic activity before and after the introduction of screening amongst age-groups other than 50–69 year olds undermines this hypothesis [1].

Potential cost savings on terminal care were not included due to lack of information on the timing of death of breast cancer patients in a screening and a non-screening scenario. A further reason is the lack of information on the relative cost of terminal care of breast cancer patients, and other patients in general. If cost of terminal care for breast cancer patients is more resource consuming vis-à-vis terminal care for other patients and the timing of terminal care is postponed due to the health effects of screening, the derived savings are likely to be higher than those estimated here. If, however, terminal care is less resource consuming, it is unclear whether the net cost implications of postponing death are positive or negative. Evidence suggest that the cost of terminal care for breast cancer patients is more resource consuming than terminal care provided to patients who die of other causes [25]. Hence, the derived cost savings on treatment estimated in this paper may be underestimated. Exclusion of terminal care costs affecting the social sector will increase this bias [24].

Finally, the reader should be aware that the results from this analysis should not be generalised to other settings without reservation. The results presented here are based on Danish price levels, and patterns of diagnosis and treatment specific to one Danish county. Hence, any extrapolation to screening programmes introduced in other counties or countries should accommodate these considerations. These authors have made an effort at presenting detailed information on unit costs and activity levels which serve as the basis for the cost estimation. Hence, any region specific discrepancies in single values is made obvious to the reader, and appropriate re-calculations can be made at the readers discretion.

6. Conclusion

Screening cost per attendee was estimated at DKK 305 if time and travel costs are included, and DKK 225 if the perspective is that of the health care sector. The analysis demonstrates that introduction of screening incurs major cost savings elsewhere in the hospital sector amounting to an average of DKK 97 per attending woman.

The results of this analysis cannot contribute to a debate on priority setting within the health care sector, since health effects are not discussed. A cost analysis can however contribute to planning within the health care sector once it has been decided that a screening programme is to be introduced. The results of this analysis illustrate that there are no savings to be made on surgery of women with breast cancer, and even suggests that costs may rise by a smaller amount. On the other hand, significant savings can be gained on adjuvant treatment. The results further show that screening is likely to reduce recurrent events, thereby saving major resources in addition to the health care effects obtained. This effect may be even more significant in the likely event that new and more expensive drugs are introduced in terminal palliative care in the future. Yet another interesting result is the reduction in cost of clinical mammographies. The experience in the County of Funen has demonstrated that the number of women undergoing clinical mammographies unnecessarily can be reduced by introducing systematic screening, thereby incurring cost savings. Costs incurred by the health care sector when introducing screening can be reduced by 40% through derived cost savings.

In this analysis we have chosen to estimate the travel and time costs incurred by women in order to present a societal perspective. The results illustrate that every time the health care sector invests DKK 10 in screening activities other sectors of society will contribute DKK 3. These additional costs should not be ignored when the costliness of a screening programme is evaluated, and is highly relevant in the context of priority setting. Hopefully, the cost estimations of this paper can be incorporated into a cost effectiveness analysis when the health care effects of mammography screening have been determined.

Acknowledgements

This work was done in close collaboration with clinicians at the Odense University Hospital. We are greatly indebted for the input made by Christen Axelsson (Department of Surgery), Martin Bak (Department of Pathology), Uffe Dyreborg (Department of Radiology), Dorthe Grabau and Carsten Rose (Oncological Research Centre), Walter Schwartz and Torben Bellstrøm (Centre for Mammography Screening, County of Funen). However, the authors alone are responsible for any errors made in the analysis. This study is financed by the Danish Institute for Health Technology Assessment.

Appendix A. Probability of recurrence

Year after operation	Low risk cancers (%)	High risk cancers (%)
0–1 year	2.245	4.304
1–2 year	3.172	8.876
2–3 year	3.472	5.815
3–4 year	2.135	8.518
4–5 year	2.825	5.526
6–7 year	0.000	5.319
7–8 year	0.000	3.438
Total	13.849	41.796

Source: Data from DBCG from the county of Funen in the period 1991–98 $N^{\text{low-risk}} = 579$, $N^{\text{high-risk}} = 313$.

References

[1] Sundhedsstyrelsen, Tidlig opsporing og behandling af brystkræft, Sundhedsstyrelsen, København, 1997 (report from the Danish National Board of Health).

[2] Hall J, Gerard K. Will early detection of breast cancer reduce the cost of treatment? Australian Journal of Public Health 1994;18:388–93.

[3] Hall J, Gerard K, Salkeld G, Richardson J. A cost utility analysis of mammography screening in Australia. Social Science and Medicine 1992;34:993–1004.

[4] van der Maas PJ, de Koning HJ, van Inveld BM, Oortmarssen GJ, Habbema DF, Lubbe KThN, Geerts AT, Colette HJA, Verbeek ALM, Hendriks JHCL, Rombach JJ. The cost-effectiveness of breast cancer screening. International Journal of Cancer 1989;43:1055–60.

[5] Gyrd-Hansen, D., Consequences of including unrelated future costs and earnings in economic evaluation. Modelling the cost-effectiveness of cancer in Denmark Ph.D. thesis, Odense University, Odense, 1998.

[6] Garber AM, Phelps CE. Economic foundations of cost effective analysis. Journal of Health Economics 1997;16:1–31.

[7] Gold MR, Siegel JE, Russell LB, Weinstein MC, editors. Cost–effectiveness in health and medicine. Oxford: Oxford; Oxford University Press, 1996.

[8] Meltzer D. Accounting for future costs in medical cost-effectiveness analysis. Journal of Health Economics 1997;16:33–64.

[9] Russel LB. Is prevention better than cure? Washington, DC: Brooking Institution, 1986.

[10] Weinstein MC, Stason WB. Foundations of cost-effectiveness analysis for health and medical practices. New England Journal of Medicine 1977;296:716–21.

[11] Socialstyrelsen, Hälsoundersökning med mammografi, SoS-rapport (17), (report from the Swedish National Board of Health and Welfare), 1998.

[12] Lynge, E., Mammography screening for breast cancer in Copenhagen April 1991–March 1997, APMIS supplementum, vol. 106, Munksgaard, Copenhagen, 1998.

[13] Hirsch FR, Mouridsen HT, Hansen OP, Hansen OP, Jørgensen T, Blichert-Toft M, Rank FE, Jensen MB. Behandling af primær cancer mammae-konsekvenser af mammografiscreening i Københavns Kommune (In Danish). Ugeskrift for Læger 1996;9:1218–21.

[14] Garuz R, Forcén T, Cabasés J, Antoñanzas F, Trinxet C, Rovira J, Antón F. Economic evaluation of a mammography-based breast cancer screening programme in Spain. European Journal of Public Health 1997;7:68–76.

[15] Leivo T, Sintonen H, Tuominen R, Hakama M, Pukkala E, Heinonen OP. The cost–effectiveness of nationwide breast carcinoma screening in Finland, 1987–1992. Cancer 1999;86:638–46.
[16] Szeto KL, Devlin NJ. The cost–effectiveness of mammography screening: evidence from a microsimulation model for New Zealand. Health Policy 1996;38:101–15.
[17] Ekerhovd, K.M., Mammografiscreening i Norge-betydelig kostnar, liten effekt?, Paper presented at Nordic Health Economist Study Group Meeting, Stockholm, August 1996.
[18] Rosenquist JC, Lindfors KK. Screening mammography beginning at age 40 years — a reappraisal of cost–effectiveness. American Cancer Society 1998;82:2235–40.
[19] Sundhedsstyrelsen, Brystkræft — tidlig opsporing og undersøgelse, Sundhedsstyrelsen, København, 1994 (report from the Danish National Board of Health).
[20] Salkeld G, Gerard K. Will early detection of breast cancer reduce the costs of treatment? Australian Journal of Public Health 1994;18:388–93.
[21] Kattlove K, Liberati A, Keeler E, Brook RH. Benefits and costs of screening and treatment for early breast cancer. The Journal of the American Medical Association 1995;273:142–8.
[22] de Koning HJ, van Ineveld BM, van Oortmarssen GJ, de Haes JCJM, Collette HJA, Hendriks JHCL, van der Maas PJ. Breast cancer screening and cost- effectiveness; policy alternatives, quality of life considerations and the possible impact of uncertain factors. International Journal of Cancer 1991;49:531–7.
[23] Koopmanschap MA, van Ineveld BM, Miltenburg TEM. Costs of home care for advanced breast and cervical cancer in relation to cost-effectiveness of screening. Social Science and Medicine 1992;35:979–85.
[24] Gyrd-Hansen D, Hølund B, Andersen P. A cost effectiveness analysis of screening against cervical cancer — health policy implications. Health Policy 1995;34:35–51.
[25] Comis, J., To, T. An overview of major breast screening studies and their findings. Report from Canadian Coordinating Office for Health Technology Assessment, Ottawa, 1992.
[26] Danish Economic Council. Danish Economy, Danish Economic Council, Copenhagen, 1996.