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Assessing the resource implications of extending routine invitation to breast screening to women aged 65–67 years

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Abstract

UK breast screening policy currently restricts routine 3-yearly invitation to screening to 50–64 year olds. However, it is likely that routine invitation will be extended to 65–67 year olds in 2001. This paper first predicts the additional demand for breast screening as a result of this new policy by modelling the response to the 1998 invitation of women eligible for screening in 2001. The independent variables include (i) the woman's characteristics: her screening history; the deprivation score of the area she lives in; and (ii) the characteristics of the screening: whether the screening took place in a mobile van or at a static site; and time of the year. The modelling of attendance is quite successful in that most hypothesised variables have the expected sign. It is estimated that an additional 10 829 women will be screened per annum. The additional invitation, screening and assessment costs are expected to be approximately £350 000 in 2001.

Keywords: Mammography; Patient compliance; Statistical models; Costs and cost analysis

1. Introduction

The UK breast screening policy currently restricts routine 3-yearly invitations to screening to 50–64 year olds. Older women can self-refer, but are not routinely invited. When the breast screening programme was introduced in the UK, it was restricted to women aged 50–64 years, in part, because of a belief that uptake from this group would be low. Since then a number of studies have compared the attendance rate of women aged 65–69 years with that of women aged 50–64 years [1–5]. Although the uptake by the older age group varies in these studies between 37 and 76%, attendance in the older group is roughly 90% of that in the younger group.

Recognising that the uptake is likely to be higher than originally thought and that age is the most important risk factor for breast cancer, the UK Breast Screening Programmes have decided to introduce two additional screening rounds from 2001 onwards. This means that the age range for routine invitation will be extended to women aged up to 70 years.

Routine invitation to older women is likely to be implemented by initially inviting those women aged 65–67 in the year 2001, who were last invited in 1998. The aim of this paper is to predict the *additional* demand for breast screening in Scotland in the year 2001 as a result of this policy. This information is then used to estimate the resource implications of this change to current screening policy. To predict additional demand, data were obtained for women eligible for screening in 2001 if, and only if, the new policy is introduced. Their attendance response to their most recent invitation to breast screening is modelled. In order to estimate the increase in demand it is necessary to make allowances for those women aged 65–67 years who would self-refer in 2001 if invitation policy does not change.

2. Patients and methods

To predict demand for breast screening, a model is developed to explain attendance or non-attendance following the invitation to screening. The model is estimated for women living in Scotland who are eligible for

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routine invitation to breast screening in 2001 if, and only if, the new policy is introduced. These are women born between 1934 and 1936 who were last invited in 1998. (Because there is a 3-year screening cycle, only women who were last invited in 1998 are eligible.) The model is estimated by regressing their attendance response to the 1998 invitation on several potentially determining factors. The coefficients of the regression equation are then used to predict their attendance in 2001.

A number of studies have shown that a wide range of factors including age, socio-economic status, housing and educational level are involved in the decision whether or not to attend for breast screening [6]. Emotional and psychological factors also play an important part in inhibiting women from participating in the screening programme, especially the fear and anxiety associated with coming to terms with potential ill-health. Since the aim of the model is to predict the increase in demand, only variables for which data are available for all eligible women can be included. These are: (i) the woman's characteristics: her screening history; and the deprivation score of the area she lives in; and (ii) the characteristics of the screening session: whether the screening was scheduled to take place in a mobile van or at a static site and the time of the year.

2.1. Woman's characteristics

The woman's characteristics included are: her screening history; and the deprivation score of the area she lives in. Age was not included because of the narrow range considered in the study. The previous screening record can vary substantially across women. The Scottish Breast Screening Programme started in a limited area in 1988 and a first screening round was completed countrywide in 1994. The total number of routine attendances per woman can in principle not exceed four for those invited in 1989 and three for those first invited after 1989 because there is a 3-year screening cycle. However, the number of invitations can exceed this number because if a woman does not take up the invitation she may be invited again the year after. This results in many potentially different screening histories. Seven distinct screening histories are distinguished:

1. Those women invited more than once previously and who attended each time.
2. Those women invited once previously and who attended the session.
3. Those women invited more than once previously and who attended the most recent, but not all of the sessions.
4. Those women invited more than once previously and who attended at least one session, but not the most recent one.
5. Those women never invited previously.
6. Those women invited once previously and who did not attend.
7. Those women invited more than once and who never attended any of the sessions.

The seven groups are ordered according to how likely they are to take up the invitation. Group 1 is used as the base case. Therefore, all the signs of the coefficients on the six dummy variables for screening histories 2–7 are expected to be negative.

The previous screening history dummy variables are clearly problematic if the interest was in testing hypotheses about the determinants of breast screening attendance. The coefficients of previous screening history have to be interpreted with caution. They do not indicate the impact of the attendance record itself, but rather of the underlying factors that determined previous attendance record. This will include, amongst other things, deprivation.

In some cases, women are invited in subsequent years because the mammogram indicated that something might be wrong (early recalls). A dummy variable is included in the model which indicates whether women have been recalled early in the past. Competing hypotheses can be generated for this variable. Because women might think they are more likely to have breast cancer detected, they are more likely to attend. However, they have attended more sessions in the past than average and may therefore perceive the marginal benefit of the current session to be lower.

The impact on attendance of the socio-economic characteristics of the area in which the woman resides is estimated by using the Carstairs deprivation index [7] which is derived from data collected in the 1991 Census. The Carstairs index is a composite score based on four variables: (i) unemployment; (ii) overcrowding; (iii) non-car ownership; and (iv) low social class. There are seven different categories ranging from 1 (least deprived) to 7 (most deprived) (see Ref. [7] for details).

Dummy variables for each deprivation category are included and deprivation category 1 is used as the base case. It is hypothesised that women in more deprived areas are less likely to attend breast screening. It should be noted that deprivation is likely to be one of the determinants of previous screening history. Because previous screening history is also included in the model, the deprivation dummies are unlikely to reflect the full impact of deprivation on attendance.

2.2. Characteristics of the screening session

The characteristics of the screening session include when the screening took place and whether the invitation is for screening in a mobile van or at a static site. Dummy variables for the different months of the year

are included to test for an impact of time of year on attendance. It is hypothesised that a relatively low proportion of the women invited in December and January attend the session. To examine whether the location (static site or mobile van) to which the women are invited influences attendance, a dummy variable for mobile van is included. No prior hypothesis is generated.

2.3. Statistical analysis

Table 1 gives the definitions of all independent variables included in the model. Given a binary dependent variable (did or did not attend) logistic regression is used. The software package Limdep [8] is used to analyse the data. The Goodman and Kruskal λ is used to assess the predictive ability of the model. This is the proportion of correct predictions adjusted for the largest row marginal (i.e. the number of cases in the outcome with the most observations). The λ values indicate the reduction in prediction error as a result of using the model.

The seven screening programmes areas differ quite substantially from one another, as illustrated by the proportion of women assigned to different deprivation categories. To allow for the differences, interaction terms of the seven areas with the independent variables could be included. However, this would result in a complex model, which would be more difficult to interpret. The model is therefore estimated separately for each of seven programmes.

The regression equation is used to estimate the expected probability of attending the 2001 invitation for each woman given the values for the independent variables. The individual probabilities are added to give the total number expected to attend.

3. Data

The Scottish Breast Screening Programme routinely collects data on each screening episode. Data were abstracted from the database for women born between 1934 and 1936 who were last invited in 1998. The original sample included 25 719 women. This was reduced to 24 833 because the postcode was either not entered ($n = 730$) or entered incorrectly ($n = 156$).

The Appendix shows some descriptive statistics for the sample by breast screening programme. There are some notable differences in the deprivation categories across the seven breast screening programmes with the Glasgow programmes covering more deprived areas than other programmes. The proportion of women invited to a mobile van ranges from 0.594 to 0.785.

4. Results

Table 2 shows the percentage attending by deprivation category and by previous screening history. The percentage attending tends to be lower for women who

Table 1
Definition of independent variables

Variable name	Definition
Invited once—did attend	1 if invited once and did attend; 0 otherwise
Attended last, but not all	1 if invited more than once and attended last, but not all; 0 otherwise
Attended some, but not last	1 if invited more than once and attended some, but not last; 0 otherwise
Never invited	1 if never invited before; 0 otherwise
Invited once—did not attend	1 if invited once and did not attend; 0 otherwise
Invited >1—did not attend	1 if invited more than once and did not attend any; 0 otherwise
Early recall	1 if ever recalled early; 0 otherwise
Deprivation category 2	1 if deprivation category equals two; 0 otherwise
Deprivation category 3	1 if deprivation category equals three; 0 otherwise
Deprivation category 4	1 if deprivation category equals four; 0 otherwise
Deprivation category 5	1 if deprivation category equals five; 0 otherwise
Deprivation category 6	1 if deprivation category equals six; 0 otherwise
Deprivation category 7	1 if deprivation category equals seven; 0 otherwise
Mobile	1 if invited to mobile unit; 0 if invited to static site
December	1 if invited to session in December; 0 otherwise
January	1 if invited to session in January; 0 otherwise
February	1 if invited to session in February; 0 otherwise
March	1 if invited to session in March; 0 otherwise
April	1 if invited to session in April; 0 otherwise
May	1 if invited to session in May; 0 otherwise
June	1 if invited to session in June; 0 otherwise
July	1 if invited to session in July; 0 otherwise
August	1 if invited to session in August; 0 otherwise
September	1 if invited to session in September; 0 otherwise
October	1 if invited to session in October; 0 otherwise

Table 2
Percentage attending by deprivation category and by screening history

Deprivation category	Screening history							Total
	1	2	3	4	5	6	7	
Invited > 1—attended all	90.7	88.2	77.5	55.1	70.2	43.6	21.5	89.1
Invited once—did attend	90.4	81.1	71.2	60.4	67.7	37.7	13.3	81.1
Invited > 1—attended last, but not all	89.6	84.2	72.4	53.4	66.1	37.8	16.4	70.3
Invited > 1—attended some, but not last	89.3	81.9	72.6	49.4	58.3	24.5	12.5	50.5
Never invited	87.7	83.2	69.5	45.9	49.4	18.0	11.4	59.3
Invited once—did not attend	86.0	80.3	60.1	43.7	49.2	28.4	14.0	28.4
Invited > 1—did not attend any	86.9	73.9	62.2	52.7	31.7	24.7	20.5	14.1
Total	80.3	77.6	76.1	71.0	66.2	62.2	56.6	70.6

live in more deprived areas, although there are some exceptions to this pattern. The relative percentages for the screening histories are as expected.

Table 3 shows the regression results. Since the aim of the model is to predict attendance, predictive ability is of most importance. The Goodman and Kruskal λ indicates that the models reduce errors in prediction by 31.3–44.4% depending on the breast screening programme. This indicates that all seven models are successful in that they reduce prediction errors considerably.

Although the actual coefficients and their statistical significance are of less interest, they are also important

Table 3
Regression results

	Edinburgh		Dundee		Glasgow A		Aberdeen		Irvine		Glasgow B		Inverness	
	b	*t* value	*b*	*t* value	*b*	*t* value	*b*	*t* value	*b*	*t* value	*b*	*t* value	*b*	*t* value
Constant	2.041	12.92	2.352	8.00	2.995	13.07	2.832	9.00	2.853	8.44	2.137	8.66	2.293	1.84
Invited once—did attend	−0.537	−3.12	−1.000	−3.53	−0.530	−2.93	−0.570	−1.61	−0.176	−0.59	−0.953	−5.74	0.620	1.00
Attended last, but not all	−1.248	−11.95	−1.250	−6.92	−1.235	−9.60	−1.135	−4.79	−1.138	−6.48	−1.070	−6.30	−1.550	−5.57
Attended some, but not last	−1.967	−21.25	−2.020	−11.87	−1.983	−18.37	−2.569	−13.90	−2.276	−16.39	−1.821	−13.59	−2.689	−9.84
Never invited	−1.788	−10.63	−1.331	−5.12	−2.037	−11.15	−1.869	−6.38	−1.290	−5.47	−2.181	−8.91	−1.677	−4.37
Invited once—did not attend	−3.409	−17.12	−2.591	−7.83	−2.965	−16.35	−3.732	−9.03	−2.896	−8.42	−2.983	−15.74	−2.228	−5.02
Invited > 1—did not attend	−3.977	−35.65	−3.936	−21.25	−3.648	−30.80	−4.620	−20.64	−4.137	−23.32	−3.306	−23.00	−4.932	−13.08
Early recall	0.253	1.88	−0.169	−0.94	−0.074	−0.58	−0.096	−0.50	0.158	1.08	0.154	1.09	0.443	1.45
Deprivation category 2	0.275	1.59	0.086	0.32	−0.670	−3.33	0.064	0.23	−0.520	−1.86	0.239	0.89	−0.089	−0.07
Deprivation category 3	0.041	0.26	−0.075	−0.29	−0.863	−4.65	−0.004	−0.01	−0.423	−1.47	0.450	1.79	−0.485	−0.41
Deprivation category 4	0.143	0.94	−0.360	−1.33	−0.909	−5.11	−0.212	−0.82	−0.369	−1.39	0.074	0.32	−0.624	−0.52
Deprivation category 5	0.025	0.16	−0.305	−1.15	−1.090	−5.52	−0.179	−0.66	−0.624	−2.41	−0.075	−0.28	−0.820	−0.48
Deprivation category 6	−0.382	−1.35	−0.978	−3.60	−1.112	−6.31	NA	NA	−0.692	−2.41	−0.053	−0.21	NA	NA
Deprivation category 7	−0.501	−1.34	NA	NA	−1.275	−6.42	NA	NA	NA	NA	−0.237	−0.97	NA	NA
Mobile van	−0.175	−2.10	−0.143	−0.83	−0.501	−4.84	0.019	0.12	−0.227	−1.70	−0.271	−2.47	0.525	1.78
December	−0.209	−1.19	0.558	1.90	−0.126	−0.60	−0.797	−2.23	−0.577	−2.38	−0.556	−2.80	−1.245	−3.62
January	0.003	0.02	0.080	0.30	0.257	1.27	−0.240	−0.67	0.052	0.20	0.280	1.29	0.175	0.31
February	−0.072	−0.43	0.042	0.17	0.683	3.15	−0.452	−1.37	−0.179	−0.74	0.431	2.00	0.398	0.78
March	0.062	0.39	0.008	0.03	0.367	1.70	−0.196	−0.58	0.002	0.01	0.588	2.66	0.413	0.88
April	0.072	0.42	0.269	0.47	0.185	0.93	−0.369	−1.13	−0.185	−0.73	1.004	3.09	1.585	3.08
May	−0.168	−0.95	0.223	0.79	0.476	2.35	−0.192	−0.61	0.134	0.52	0.910	3.16	0.383	0.98
June	−0.044	−0.26	0.166	0.66	0.430	2.13	−0.065	−0.20	−0.281	−1.07	0.388	1.78	0.517	1.32
July	−0.088	−0.55	−0.042	−0.15	0.577	2.76	−0.734	−2.16	−0.117	−0.44	−0.078	−0.38	0.239	0.55
August	−0.029	−0.18	0.043	0.17	0.520	2.53	−0.324	−0.96	−0.304	−1.11	−0.170	−0.87	−0.040	−0.11
September	0.003	0.02	0.408	1.65	0.210	1.03	−0.160	−0.45	−0.666	−2.66	−0.359	−1.87	0.106	0.28
October	−0.068	−0.43	0.442	1.80	0.346	1.69	−0.484	−1.42	0.114	0.43	−0.118	−0.64	0.203	0.48
Goodman and Kruskal λ	0.432		0.384		0.409		0.418		0.444		0.313		0.352	
n	6340		2451		4967		2676		3151		3901		1347	

NA, not applicable.

in that more confidence is placed in the models if the coefficients have the expected sign. The coefficients that are statistically significant at a 5% level are shaded. The coefficients on previous screening history are statistically significant for all seven breast screening programmes. For Aberdeen, Irvine and Inverness, the coefficient on the dummy variable for those women who have been invited once and did attend is not significant, indicating that those women are just as likely to attend as those women who have been invited more than once and attended all sessions. As hypothesised, in the case of women who were invited more than once, but did not attend every time, those who attended the last session were more likely to attend than those who did not attend the last session. In summary, most coefficients with respect to screening history have the expected sign and relative size. Deprivation seems to have some influence, especially in Dundee, Glasgow A and Irvine. That the coefficients on deprivation are not consistently significant is expected since previous screening history is to some extent determined by deprivation. Some month dummies are statistically significant, with the month December having a negative impact on attendance. The dummy variable for mobile unit is significant only in the case of Glasgow A.

The regression models are used to predict annual additional demand in 2001 for each of the seven breast screening programmes. There are two issues that need to be taken into account. Firstly, some women who did not attend in 1998 were subsequently invited in 1999 and or in 2000. Women who attended in 1999 or 2000 are excluded ($n = 429$). Second, women over the age of 64 years are able to refer themselves for breast screening and the numbers doing so have been increasing year by year. Women aged 65–67 years who self-refer are of particular relevance in that they are not part of the increase in demand resulting from extending the age of routine invitation since they would have attended anyway. Any estimate of the increase in the demand for breast screening must take these women into account.

While self-referral could be modelled, given its limited extent in the past and its fairly rapid increase, it would be difficult to develop a satisfactory model. An alternative approach is to simply take the number of women aged 65–67 years who self-referred in the last few years and predict how many will self-refer in 2001. The number who would self-refer in 2001, if policy did not change, is essentially not possible to know. The available data (shown in Table 4) suggest that approximately 8.5% of 65–67 year olds might be expected to self-refer in 2001 (if there were no changes in invitation policy). The breakdown across programmes is estimated by considering the changing proportion of women self-referring over time and each programme's share of women aged 65–67 years.

Table 5 shows the predicted annual additional demand for breast screening. The predicted increase in demand ranges from 1039 to 4200 depending on the breast screening programme. The total number of self-referrals if the policy would not be introduced is estimated to be 6856. The net effect is that an additional 10 829 women would be screened in 2001 as a result of changing the routine invitation policy for 65–67 year olds.

Table 4
Number of self-referrals by women aged 65–67 years

	1996	1997	1998	1999
Edinburgh	798	939	1031	1468
Dundee	191	269	488	607
Glasgow A	421	491	751	852
Aberdeen	233	404	641	864
Irvine	246	282	453	645
Glasgow B	414	498	985	642
Inverness	159	173	300	346
Scotland	2462	3056	4649	5424
Total women 65–67 years	76 690	78 000	77 720	77 620
% of 'eligible' women	3.21	3.92	5.98	6.99

5. Resource implications

The most detailed information available on the costs of invitation, screening and assessment in the UK [9] can be used to indicate the broad resource implications of extending routine invitation to screening 65–67 years olds. The additional costs of inviting approximately 25 000 women, and of screening an additional 10 829 women and of any subsequent assessment would be £350 000 per annum based on 1999/2000 prices. However, such an estimate ignores the indivisibilities which are likely to arise in practice. A more accurate figure would require detailed information of how each programme would respond to the increase in activity. For example, the extent to which the supply of screening would be increased by holding more static site or mobile van sessions. It must take account of several factors

Table 5
Predicted additional demand in 2001

	n invited	Predicted attendance[a]	Self-referral	Additional demand
Edinburgh	6354	4200	1689	2511
Dundee	2429	1757	743	1014
Glasgow A	5146	3421	1081	2340
Aberdeen	2624	2046	1081	965
Irvine	3130	2173	811	1362
Glasgow B	4260	3049	878	2171
Inverness	1347	1039	573	466
Total	25 290	17 685	6856	10 829

[a] These numbers do allow for women not included in the modelling because of a missing postcode. Predicted attendance is estimated using data on all other variables.

including the capacity constraints faced by each provider, how the cost of screening older women differs from screening younger women and the efficiency of the different providers.

6. Discussion

This paper estimated the additional demand for breast screening in Scotland in the year 2001 if the policy of routinely inviting women aged 65–67 years is introduced. The attendance response to the 1998 invitation of women who would be eligible for screening in 2001 if, and only if, the new policy is introduced was modelled using logistic regression. The modelling of attendance was quite successful in that most hypothesised variables had the expected sign. The overall predicted additional demand is equal to 10 829. The additional invitation, screening and assessment costs are expected to be about £350 000 in 2001. This analysis is for the first year of the new policy. A similar analysis could be performed for later years. It is likely that the results for the second and third years would be broadly similar. However, from the fourth year onwards, the routine invitation would be offered not only to women aged 65–67 years but also to women aged 68–70 years.

This paper did not assess the feasibility of introducing two additional screening rounds. Any problems with recruitment and retention of staff, such as radiographers or radiologists, will be exacerbated by the resultant increased demand for screening. However, the policy of extending routine invitation will not only increase demand, it should also facilitate the planning of the programme by reducing the extent of self-referral.

There are a number of potential limitations to this study which should be considered. First, the deprivation category of the postcode sector in which the woman resides is based on data collected at the 1991 Census. Depending on the rate of socio-economic change, this classification may not be a particularly good measure of socio-economic differences between areas. However, it is probably the best available and is still quite widely used. A more serious shortcoming might be with respect to the extent to which the deprivation category adequately reflects the character of an area. It might, for example, be satisfactory in densely populated urban areas, but less satisfactory in more sparsely populated rural areas. A further limitation concerns the estimate of the likely future extent of self-referral, not just in the first year, but particularly in later years, if the invitation policy were not to be changed.

Finally, only the broad resource implications were identified in this paper. A more accurate figure would take account of several factors such as the capacity constraints faced by each provider. However, the paper does demonstrate how the future planning of a screening programme can be aided by the analysis of routinely available data.

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Appendix. Descriptive statistics

Variable	Edinburgh *n* (%)	Dundee *n* (%)	Glasgow A *n* (%)	Aberdeen *n* (%)	Irvine *n* (%)	Glasgow B *n* (%)	Inverness *n* (%)
Deprivation category							
1	484 (7.6)	209 (8.5)	498 (10.0)	292 (10.9)	192 (6.1)	191 (4.9)	10 (0.7)
2	709 (11.2)	425 (17.3)	530 (10.7)	783 (29.3)	446 (14.2)	370 (9.5)	145 (10.8)
3	1231 (19.4)	728 (29.7)	774 (15.6)	413 (15.4)	454 (14.4)	847 (21.7)	624 (46.3)
4	2375 (37.5)	337 (13.7)	962 (19.4)	731 (27.3)	667 (21.2)	1037 (26.6)	561 (41.6)
5	1377 (21.7)	338 (13.8)	526 (10.6)	457 (17.1)	1065 (33.8)	353 (9.0)	7 (0.5)
6	105 (1.7)	414 (16.9)	1185 (23.9)	0	327 (10.4)	469 (12.0)	0
7	59 (0.9)	0	492 (9.9)	0	0	634 (16.3)	0
Early recall							
No	5815 (91.7)	2171 (88.6)	4448 (89.6)	2335 (87.3)	2658 (84.4)	3384 (86.7)	1195 (88.7)
Yes	525 (8.3)	280 (11.4)	519 (10.4)	341 (12.7)	493 (15.6)	517 (13.3)	152 (11.3)
Screening							
Static site	2209 (34.8)	926 (37.8)	1202 (24.2)	1087 (40.6)	677 (21.5)	1190 (30.5)	387 (28.7)
Mobile van	4131 (65.2)	1525 (62.2)	3765 (75.8)	1589 (59.4)	2474 (78.5)	2711 (69.5)	960 (71.3)
Uptake	4237 (66.8)	1792 (73.1)	3387 (68.2)	2114 (79.0)	2252 (71.5)	2848 (73.0)	1066 (79.1)

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