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## RESEARCH

# Effects of multidisciplinary team working on breast cancer survival: retrospective, comparative, interventional cohort study of 13 722 women

 OPEN ACCESS

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## Abstract

**Objectives** To describe the effect of multidisciplinary care on survival in women treated for breast cancer.

**Design** Retrospective, comparative, non-randomised, interventional cohort study.

**Setting** NHS hospitals, health boards in the west of Scotland, UK.

**Participants** 14 358 patients diagnosed with symptomatic invasive breast cancer between 1990 and 2000, residing in health board areas in the west of Scotland. 13 722 (95.6%) patients were eligible (excluding 16 diagnoses of inflammatory cancers and 620 diagnoses of breast cancer at death).

**Intervention** In 1995, multidisciplinary team working was introduced in hospitals throughout one health board area (Greater Glasgow; intervention area), but not in other health board areas in the west of Scotland (non-intervention area).

**Main outcome measures** Breast cancer specific mortality and all cause mortality.

**Results** Before the introduction of multidisciplinary care (analysed time period January 1990 to September 1995), breast cancer mortality was 11% higher in the intervention area than in the non-intervention area (hazard ratio adjusted for year of incidence, age at diagnosis, and deprivation, 1.11; 95% confidence interval 1.00 to 1.20). After multidisciplinary care was introduced (time period October 1995 to December 2000), breast cancer mortality was 18% lower in the intervention area than in the non-intervention area (0.82, 0.74 to 0.91). All cause mortality did not differ significantly between populations in the earlier period, but was 11% lower in the intervention area than in the non-intervention area in the later period (0.89, 0.82 to 0.97). Interrupted time series analyses showed a significant improvement in breast cancer survival in the intervention area in 1996, compared with the expected survival in the same year had the pre-intervention trend continued

( $P=0.004$ ). This improvement was maintained after the intervention was introduced.

**Conclusion** Introduction of multidisciplinary care was associated with improved survival and reduced variation in survival among hospitals. Further analysis of clinical audit data for multidisciplinary care could identify which aspects of care are most associated with survival benefits.

## Introduction

Breast cancer is the commonest cancer in women worldwide.<sup>1</sup> Its incidence has increased over several decades, while the death rate has fallen because of improved survival.<sup>2-3</sup> Survival has probably improved because of a mixture of earlier detection of the disease (both through screening and earlier symptomatic presentation),<sup>4</sup> biological changes that have made the disease more susceptible to hormonal therapy,<sup>5,6</sup> and improved treatment.<sup>7</sup>

Treatment of cancer has increasingly been provided within centralised, specialist multidisciplinary teams in Europe, the United States, and Australia.<sup>8-12</sup> These teams were established after observational evidence identified better outcomes among patients treated by specialists for various common cancers<sup>13</sup>, such as an 11-17% reduction in risk of death among women treated for breast cancer by specialist surgeons.<sup>14</sup> However, it remains unclear whether multidisciplinary care improves cancer survival and whether the costs justify clinical benefits.<sup>15-18</sup> Although attempts have been made to estimate the costs of multidisciplinary teams,<sup>15</sup> we are not aware of comparisons with costs for conventional care.

Although some evidence has shown improved outcomes in cancer associated with the introduction of multidisciplinary care,<sup>19-21</sup> a recent systematic review of 21 studies (including five on breast cancer) could not determine a causal relation between

such care and cancer survival for three main reasons.<sup>18</sup> Firstly, the definition of multidisciplinary care was imprecise and heterogeneous. Secondly, the outcomes of multidisciplinary care could have indicated selection biases towards patients with more favourable prognostic features rather than true treatment effects. Thirdly, no adjustment was made for the confounding effects of temporal improvements in survival that might have occurred without the introduction of multidisciplinary care. For example, none of the identified studies included a contemporaneous comparison group.<sup>18</sup>

In the early 1990s, variations in survival among hospitals managed by the Greater Glasgow health board were reported to the director of public health (HJGB). The hospital with highest survival had delivered care in a multidisciplinary manner. As a result, multidisciplinary teams were formally established in October 1995 throughout the Greater Glasgow health board area, with the aim of improving survival and minimising variations among hospitals. No substantial reorganisation of breast cancer care took place in areas managed by other health boards in the west of Scotland until 2000, when national guidance was introduced.<sup>22</sup>

We aimed to determine whether the introduction of multidisciplinary care affected the survival of women with breast cancer. Multidisciplinary teams were introduced to Greater Glasgow health board as an NHS Scotland area-wide policy to improve the quality of care. Therefore, an experimental study design, such as the randomisation of patients to hospitals providing or not providing multidisciplinary care, would not be possible. We compared an intervention area that had introduced multidisciplinary care with neighbouring areas (without such care), before and after the organisational change. We addressed the limitations of previous studies,<sup>18</sup> by defining the composition of a multidisciplinary team at the outset, observing the effect of care where no other model was available, and including a contemporaneous comparison population to adjust for temporal improvements in survival.

## Methods

### Design and patients

We did a retrospective, comparative, non-randomised, interventional cohort study. From the Scottish Cancer Registry, we selected data for all incident, symptomatic invasive breast cancers (ICD-10, international classification of diseases (ICD), 10th revision, codes C50.1 to C50.9) diagnosed between 1 January 1990 and 31 December 2000 for residents of health board areas in the west of Scotland. We obtained data from the Scottish Cancer Registry, which is a comprehensive account of all incident cancers gathered from pathology, hospital, and death records, among other sources. The registry is linked, by probability matching, to death records from the General Register Office for Scotland and has a high level of accuracy.<sup>23 24</sup> Patients were grouped according to the health board of diagnosis. The Greater Glasgow health board area (population 900 000) was the intervention area, and areas managed by the remaining health boards in the west of Scotland (1 600 000) comprised the non-intervention area.

Data for tumour size was only available in the Scottish Cancer Registry from 1997 onwards. If data were available, we grouped tumour size.<sup>14</sup> We calculated age at diagnosis for all patients, and used four age groups: younger than 50 years, which is considered to be a proxy for premenopausal status<sup>25</sup>; 50-64 years, the age band at which patients would be invited for breast screening; 65-79 years, elderly and post screening age; and 80 years and older. The oldest age group has been shown to have

survival equal to that of younger women after treatment of breast cancer<sup>26</sup>; the most appropriate management in this age group also remains unclear.<sup>27</sup>

We included patients if they were diagnosed with breast cancer but had no other primary cancers, were resident in and attending an NHS hospital managed by one of the health boards in the west of Scotland, and were not diagnosed by the National Breast Screening Programme. Tumours detected by screening programmes are usually at earlier stages with better prognoses. Although screen detected patients might have been diagnosed by the programme throughout the west of Scotland, they were treated mainly in two hospitals managed by the Greater Glasgow health board.

### Multidisciplinary team intervention

In 1995, multidisciplinary team care for all patients with breast cancer was introduced in the Greater Glasgow health board area (intervention area), but not in the areas managed by other health boards in the west of Scotland (non-intervention area). Five multidisciplinary teams were formed in the intervention area, each led by a specialist surgeon performing in excess of 50 operations for invasive breast cancer each year. In 1995, a multidisciplinary team was defined as a group with the following characteristics:

- Comprised specialist breast cancer surgeons, pathologists, oncologists, radiologists, and specialist nurses
- Worked to evidence based guidelines, written by the specialist breast surgeon whose patients had the highest survival rates before reorganisation of care delivery (WDG)
- Held weekly formal meetings to discuss results and agree on adjuvant treatment for individual patients
- Audited clinical activity and reported results at regular intervals
- Lead clinicians from each team met regularly with the director of public health (HJGB) to discuss audit results throughout the area, with the aim to minimise deviations from guidelines and variations in practice and improve quality of care.

Doctors operating on small numbers outside the five main centres were no longer allowed to manage patients needing care for breast cancer. As a result, there was a degree of centralisation of services. However, the geographical location of the hospitals in the intervention area was such that patients did not have to travel long distances to receive care.

No formal change in delivery of care was introduced in the non-intervention area; patients continued to receive care along more traditional approaches, with surgeons making unilateral decisions regarding surgery and adjuvant treatment. In 1999, Scottish guidance was issued on the reorganisation of cancer care.<sup>22</sup> In 2001-02, services throughout the country began to form managed clinical networks, of which multidisciplinary care was a component. Thus, there was unlikely to be a clear difference in the use of multidisciplinary care within the west of Scotland NHS area after 2000.

### Socioeconomic circumstances

Socioeconomic status was inferred for all patients on the basis of their area of residence at the time of diagnosis, using a deprivation category score, which is a validated seven category ordinal score that ranks all postcode sectors from 1 (most affluent) to 7 (most deprived), using four census variables that have been shown to best correlate with health outcomes: car

ownership, male unemployment, occupational social classes IV and V (semi-skilled and unskilled occupations, respectively), and overcrowding.<sup>28</sup> We grouped scores further into three conventional categories: affluent (scores 1 and 2), intermediate (3 to 5), and deprived (6 and 7).<sup>14</sup> Data from the 1991 census showed that 51% of people in the intervention area lived in areas classified as most deprived (scores 6 and 7), compared with 18% of residents in the non-intervention area.<sup>29</sup>

## Statistical methods

We used univariate analyses to examine differences in survival trends between the intervention and non-intervention areas for two time periods, from January 1990 to September 1995 and from October 1995 to December 2000. Where appropriate, we used  $\chi^2$  and *t* tests to calculate any significant differences in age, deprivation, and tumour size. If needed, we transformed data to a log scale to satisfy the assumption for the *t* test.

We defined survival as time from incidence of breast cancer to the earlier of date of death or date of censoring. Patients diagnosed in the earlier period were censored at 30 September 2002 and those diagnosed in the later period were censored at 31 December 2007, to remove any effects of differential follow-up times between the two periods. Deaths due to breast cancer were classified as patients with a main cause of death coded by the Scottish Cancer Registry as ICD-9 codes 174.1 to 174.9 or ICD-10 codes C50.1 to C50.9.

We did an analysis of an interrupted time series to investigate the effect of the intervention while adjusting for trends in survival before the intervention.<sup>30</sup> Our analysis did not include patients with a date of incidence in 1995, the year the intervention was introduced. We used survival at five year follow-up (after diagnosis) as the outcome measure.

We did multivariable analyses using Cox's proportional hazards models<sup>31</sup> to examine differences in survival (adjusted for age, deprivation, and year of incidence) between the intervention and non-intervention areas for each time period. The analysis also calculated outcomes in relation to breast cancer mortality and all cause mortality.

We used funnel plots to compare five year survival between hospitals. Funnel plots are control charts in which the event of interest is plotted against a measure of its precision.<sup>32</sup> Limits for the funnel plots were based on Wilson's formula for binomial confidence intervals.<sup>33</sup> We plotted breast cancer survival at five years for each hospital against the number of patients diagnosed with breast cancer in that hospital. To compare survival between hospitals, only one investigator (DSM) knew the code indicating which hospitals comprised the intervention and non-intervention areas. Hospitals with fewer than 25 patients diagnosed in each five year time period were excluded from the funnel plots. This exclusion avoided the range of the y axis scale being too large to distinguish differences between hospitals with larger volumes. We did all analyses using Stata, version 11 software.

## Results

Of 14 358 patients reviewed, we excluded 636; 16 patients were diagnosed with inflammatory cancer (ICD for Oncology, 2nd edition, code M8530/3; seven patients in the intervention area, nine in the non-intervention area), and 620 were diagnosed only at death (death certificate only; 182, 438). Of 13 722 women in the study population, 6050 (44.1%) were in the intervention area and 7672 (55.9%) in the non-intervention area. Table 1⇓ describes patient characteristics.

Age ranged from 18 to 100 years (mean 62.9 years, standard deviation 14.9); *t* tests of transformed data showed that ages were similar between the intervention and non-intervention areas, both before and after introduction of the intervention. We found a significant difference in deprivation ( $P<0.001$ ) between the intervention and non-intervention areas, both before and after the intervention. However, deprivation had not changed significantly in either area over time. In both time periods, more patients in the intervention area than in the non-intervention area lived in the most deprived areas. Data for tumour size was available from 1997 onwards only; available data showed a mean tumour size of 23.9 mm (standard deviation 14.4); *t* tests of transformed data showed that tumour size was similar in both the intervention and non-intervention areas.

## Survival

By the end of the follow-up period (seven years from the end of each time period), 4844 (35.3%) study patients had died of breast cancer and 8301 (60.5%) had died overall. Breast cancer survival at five years in the time period before introduction of multidisciplinary care was 71.3% ( $n=2201$ ) in the intervention area and 73.6% ( $n=2881$ ) in the non-intervention area. These proportions rose to 79.2% ( $n=2346$ ) and 75.9% ( $n=2853$ ), respectively, in the time period after the intervention was introduced. Overall survival at five years in the earlier time period was 59.9% ( $n=1849$ ) in the intervention area and 61.5% ( $n=2408$ ) in the non-intervention area. These proportions rose to 65.6% ( $n=1942$ ) and 63.8% ( $n=2400$ ), respectively, in the later time period.

Our analysis using an interrupted time series was based on breast cancer survival at five years and omitted patients with an incident cancer in 1995 (fig 1⇓). The analysis showed a significant improvement ( $P=0.004$ ) in survival in the intervention area in 1996, compared with the expected survival in that year had the pre-intervention trend continued—that is, had the intervention not been introduced. We saw no corresponding improvement in survival among patients in the non-intervention area ( $P=0.64$ ). Overall survival also did not improve in 1996, in either the intervention or non-intervention area. The introduction of the multidisciplinary approach initially had a significant positive impact on breast cancer survival at five years, on incident cancers in 1996, and this impact was maintained (fig 1). We saw a similar pattern in overall survival at five years, but the changes were not significant.

Table 2⇓ shows the multivariable survival analyses, using a Cox's proportional hazards model, that was adjusted for age, deprivation, and year of incidence.

## Breast cancer mortality

Before multidisciplinary care was introduced in 1995, breast cancer mortality was higher in the intervention area than in the non-intervention area (hazard ratio 1.11, 95% confidence interval 1.00 to 1.20; table 2). After the intervention was introduced, mortality was significantly lower in the intervention area than in the non-intervention area (0.82, 0.74 to 0.91). Another Cox model showed a significant interaction between time period and intervention area ( $P<0.001$ ), indicating that mortality differed significantly between the intervention and non-intervention areas over time. Subgroup analyses by age group showed that the effect of the intervention was strongest in patients aged 80 years and older ( $P=0.001$ ), and significant also in patients aged 65-79 years ( $P=0.01$ ). We saw no significant effects in either of the younger age groups.

## All cause mortality

We saw no significant difference in all cause mortality between intervention and non-intervention areas in the earlier time period before multidisciplinary care was introduced (hazard ratio 1.06, 95% confidence interval 0.98 to 1.14; table 2). However, in the later time period, mortality was 11% lower in the intervention area than in the non-intervention area (0.89, 0.82 to 0.97). As with breast cancer mortality, the effect of the intervention on all cause mortality differed significantly in both the intervention and non-intervention areas ( $P=0.003$ ). Subgroup analyses by age group showed a less clear pattern for all cause mortality than that seen for breast cancer mortality. However, the effect of the intervention was most significant in patients aged 80 years or older ( $P=0.002$ ); this effect was not seen in any other age group.

## Funnel plot analysis

We used funnel plots to compare breast cancer survival at five years among hospitals before and after the introduction of the intervention in 1995 (fig 2). A separate funnel plot was created for each time period. In the earlier time period, we plotted breast cancer survival for eight hospitals in the intervention area, and 15 hospitals in the non-intervention area. The number of patients diagnosed per hospital ranged from 30 to 881 in the intervention area and from 26 to 682 in the non-intervention area. Overall mean survival at five year follow-up was 70.3% (range 36.7-76.8% in the intervention area, 65.4-86.4% in the non-intervention area). Three of eight hospitals in the intervention area were below the 95% confidence limit and two were above. None of the non-intervention hospitals was below the 95% confidence limit but two were above.

In the later time period, we plotted breast cancer survival for five hospitals in the intervention area, and 10 hospitals in the non-intervention area. The number of patients diagnosed per hospital ranged from 293 to 1025 in the intervention area and from 155 to 775 in the non-intervention area. Overall mean survival at five years during this period (77.0%) was higher than that during the earlier time period, with less variation among hospitals (range 78.5-80.2% in the intervention area, 69.6-80.6% in the non-intervention area). All hospitals in the intervention area lay within the 95% confidence limit. One hospital in the non-intervention area was above the 95% confidence limit and three were below the limit.

## Discussion

### Main findings

We found that the introduction of teams providing multidisciplinary care for the treatment of breast cancer was associated with 18% lower breast cancer mortality at five years and 11% lower all cause mortality at five years, compared with similar patients treated in neighbouring areas over the same time period. The introduction of this intervention was also associated with a reduction in the number of hospitals treating breast cancer, reduced variation in survival rates among hospitals, and the reorganisation of breast cancer care away from hospitals with the poorest survival outcomes. Our use of a contemporaneous comparison group suggests that the benefits of multidisciplinary care exceeded those that would otherwise have occurred owing to ongoing improvements in treatment of breast cancer.

The effect size was of a similar magnitude to that found by Gillis and Hole between specialist and non-specialist breast cancer surgeons.<sup>34</sup> Before the introduction of multidisciplinary

teams in the present study, patients with breast cancer in the intervention area were treated by a mixture of specialist and non-specialist surgeons, so it might be expected that only modest improvements in survival would have been achieved by introducing surgery by specialists alone. Although evidence suggests that better local and regional treatment of disease by specialist surgeons explains some of their survival advantage,<sup>35</sup> the survival advantage of treatment within a multidisciplinary team is unlikely to be explained by surgical specialisation alone. Our results suggest an “empirical induction period” in the intervention area, during which survival continued to increase sharply between 1996 and 1997.

### Strengths and weaknesses of the study

This non-randomised intervention study compared an experimental intervention with no intervention. Although it did not have the strength of a randomised controlled trial, that study design was no longer possible because of the prolific introduction of the multidisciplinary approach of care. The principal limitation of our study was that the observed differences in survival after the introduction of multidisciplinary care in the intervention area might have been due to selection biases or confounding factors.

Although a few patients in our study might have died outside the UK and had been assumed to be alive, we have no reason to believe that this was more likely to occur in the intervention area than the non-intervention area. Selection criteria were applied in the same way to all health board areas—therefore, differential selection of patients with less advanced disease in the intervention area after September 1995 seems unlikely. Indeed, where data for tumour size were available, patients in the intervention area had similar sizes of tumours to those in the non-intervention area.

We excluded all patients with screen detected cancers because they were treated almost exclusively within the intervention area, and such cancers tend to be less advanced and less aggressive.<sup>36</sup> It is possible that patients treated in the intervention area presented with less advanced disease after September 1995. However, we have no reason to suspect this and available data do not support this explanation.

Women from more affluent areas have consistently been shown to have better survival from breast cancer than those from less affluent areas,<sup>37 38</sup> but the improvement was observed even after adjusting for deprivation. Other concurrent changes in healthcare services, not attributable to the intervention, could have occurred after 1995. However, we are not aware of differences in availability of diagnostic or treatment services between health board areas in the west of Scotland in 1996-2000. No other major interventions, either local or national, were introduced during that time. We are not aware of any formal arrangements to introduce multidisciplinary care in the non-intervention area after 1995, but we do know that trainee surgeons in the intervention area in the early 1990s took up consultant posts in other parts of Scotland. Therefore, improvements in surgical practice could have occurred in the non-intervention area as a result of multidisciplinary working. Such an effect would attenuate rather than increase the true effects of multidisciplinary care, by introducing some misclassification of intervention and non-intervention areas.

### Strengths and weaknesses in relation to other studies

Comparisons have been made between contemporaneous groups of patients given multidisciplinary or conventional treatment,

within the same geographical area.<sup>39</sup> However, the multidisciplinary approach probably selects patients with different prognostic factors from the entire patient population, introducing potential selection biases. Patients treated by a multidisciplinary team are also likely to undergo more investigations and be subject to additional clinical audits, so that information about their health and outcomes might differ systematically from those of patients not in multidisciplinary care. These selection and information biases complicate investigations into the true effects of multidisciplinary working. Our study probably did not have these biases, because the intervention was provided for all patients within a geographical area and we obtained the same data from the Scottish Cancer Registry for patients in both intervention and non-intervention areas. We defined the composition and functions of multidisciplinary teams and used the same selection criteria for both areas, thus directly avoiding weaknesses of previous attempts to determine the effects of multidisciplinary care.<sup>18</sup> Owing to the lack of a precise definition of multidisciplinary care, and the variation in provision of health services in countries outside the UK our results could be difficult to generalise.

### Implications for doctors and policy makers

Multidisciplinary care probably improves patient outcomes by influencing various aspects of care. These factors include adherence to guidelines and nurse education,<sup>40</sup> increased surgical volume and experience,<sup>41</sup> and improved interdisciplinary working.<sup>42-43</sup> Kingsmore and colleagues reported that the survival benefits of treatment by a specialist surgeon in breast cancer could be explained by better local and regional treatment, as defined by the King's Fund consensus statement.<sup>35-44</sup> Although multidisciplinary care is considered standard practice in many countries, access to such care still varies.<sup>8-10-11-45</sup> Our results support the universal provision of cancer care by specialist, multidisciplinary teams. Furthermore, significantly improved survival was achieved among patients aged 80 years and older, which could be an important explanatory element to support the introduction of multidisciplinary care for cancer.

### Unanswered questions and future research

Further work is needed to understand how the multidisciplinary approach affects specific elements of breast cancer care, to further improve the effective management of patients. We found that the benefits of multidisciplinary working were greatest in older patients. Since the intervention guidelines were not age specific, they could have given surgeons and other team members more confidence to actively treat older patients rather than managing them conservatively.

We found that multidisciplinary team care for breast cancer was associated with substantial improvements in survival compared with those we might have expected to occur. The introduction of multidisciplinary care led by specialist breast surgeons performing more than 50 operations per year, resulted in a degree of centralisation of care. Therefore, multidisciplinary teams could increase efficiency by fostering more centralised hospital care. Owing to a lack of data, we were unable to explore the financial cost of multidisciplinary working in our analysis. There is clearly scope for research in this topic; doctors and policy makers alike would benefit from cost effectiveness studies of multidisciplinary working, which could help inform implementation of future programmes. Although multidisciplinary care for cancer has become standard practice in many countries, persisting variations in access to specialist care need to be minimised.

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Ethical approval: The West of Scotland Cancer Surveillance Unit obtained permission to obtain cancer registry data both from Caldicott Guardians of all five health boards in the west of Scotland and from the information services division of the NHS in Scotland privacy advisory committee.

Data sharing: No additional data available.

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**What is already known on this topic**

Care by a specialist clinician is associated with improved cancer survival

Treatment of cancer has increasingly been provided within centralised, specialist multidisciplinary teams, but it remains unclear whether such care has contributed to improvements in cancer survival

**What this study adds**

Introduction of multidisciplinary care was associated with substantially greater improvements in breast cancer survival over and above those that were expected to occur had the approach not been introduced

Benefits of receiving multidisciplinary care for breast cancer versus conventional care are similar to those of receiving specialist care versus non-specialist care

Introduction of multidisciplinary care was associated with the removal of poorly performing hospitals and reduced variations in outcomes among hospitals.

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## Tables

**Table 1 | Age and socioeconomic characteristics of 13<sup>th</sup>-722 female patients with breast cancer in the west of Scotland, 1990-2000. Data are no (%)**

	January 1990 to September 1995		October 1995 to December 2000	
	Non-intervention group (n=3913)	Intervention group (n=3088)	Non-intervention group (n=3759)	Intervention group (n=2962)
<b>Age (years)</b>				
≤49	853 (21.8)	735 (23.8)	823 (21.9)	739 (24.9)
50-64	1299 (33.2)	996 (32.3)	1131 (30.1)	751 (25.4)
65-79	1236 (31.6)	948 (30.7)	1220 (32.5)	1032 (34.8)
≥80	525 (13.4)	409 (13.2)	585 (15.6)	440 (14.9)
<b>Deprivation category</b>				
Most affluent	448 (11.4)	548 (17.7)	449 (11.9)	533 (18.0)
Intermediate	2745 (70.2)	1298 (42.0)	2684 (71.4)	1255 (42.4)
Most deprived	720 (18.4)	1242 (40.2)	626 (16.7)	1174 (39.6)
<b>Tumour size (mm)</b>				
≤19	—	—	1090 (54.2)*	764 (52.3)*
20-39	—	—	760 (37.8)*	543 (37.2)*
≥40	—	—	161 (8.0)*	153 (10.5)*
Not recorded	3913 (100)	3088 (100)	1748 (46.5)	1502 (50.7)

\*Percentages calculated using number of patients with available data as the denominator.

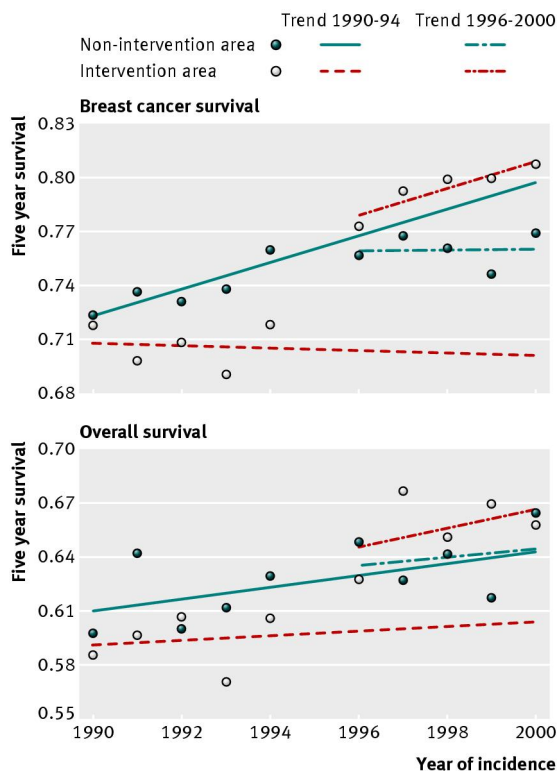


Table 2 | Adjusted hazard ratios of mortality in the intervention area compared with the non-intervention area

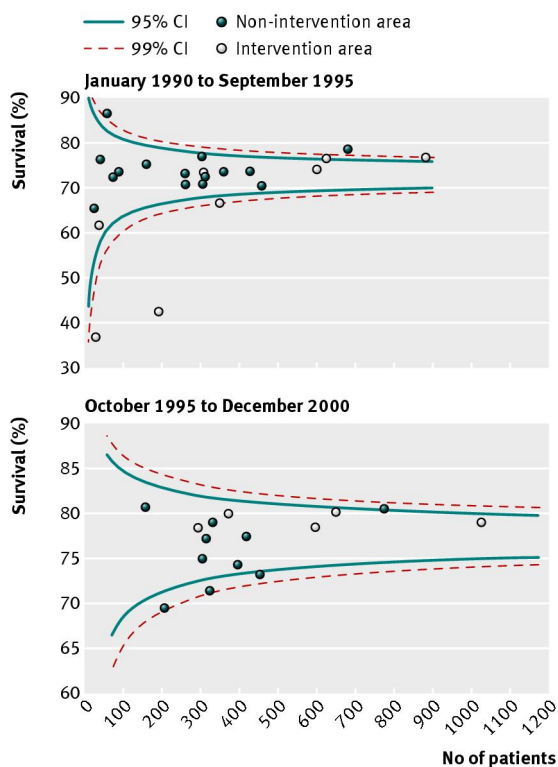
Patient age group and time period of analysis	N	Breast cancer specific mortality		All cause mortality	
		Hazard ratio (95% CI)*	P	Hazard ratio (95% CI)*	P
<b>All cases</b>					
January 1990 to September 1995	7001	1.11 (1.00 to 1.20)	0.04	1.06 (0.98 to 1.14)	0.13
October 1995 to December 2000	6721	0.82 (0.74 to 0.91)	<0.001	0.89 (0.82 to 0.97)	0.005
Interaction between time period and area	13 722	—	<0.001	—	0.003
<b>Age ≤49 years</b>					
January 1990 to September 1995	1588	1.05 (0.86 to 1.29)	0.63	1.03 (0.85 to 1.25)	0.77
October 1995 to December 2000	1562	1.04 (0.81 to 1.32)	0.78	1.13 (0.90 to 1.42)	0.31
Interaction between time period and area	3150	—	0.95	—	0.52
<b>Age 50-64 years</b>					
January 1990 to September 1995	2295	1.14 (0.96 to 1.34)	0.13	1.18 (1.01 to 1.37)	0.03
October 1995 to December 2000	1882	0.92 (0.74 to 1.13)	0.42	0.94 (0.78 to 1.14)	0.55
Interaction between time period and area	4177	—	0.11	—	0.07
<b>Age 65-79 years</b>					
January 1990 to September 1995	2184	1 (0.85 to 1.18)	0.97	0.95 (0.83 to 1.08)	0.44
October 1995 to December 2000	2252	0.72 (0.60 to 0.85)	<0.001	0.87 (0.77 to 1.00)	0.05
Interaction between time period and area	4436	—	0.01	—	0.47
<b>Age ≥80 years</b>					
January 1990 to September 1995	934	1.24 (1.00 to 1.56)	0.05	1.08 (0.93 to 1.26)	0.33
October 1995 to December 2000	1025	0.75 (0.59 to 0.94)	0.01	0.78 (0.67 to 0.91)	0.002
Interaction between time period and area*	1959	—	0.001	—	0.002

\*Adjusted for year of incidence, deprivation, and (where appropriate) age.

# Figures



**Fig 1** Five year survival by year of incidence with trends before and after year 1995, by intervention area



**Fig 2** Funnel plot of breast cancer survival at five years in study hospitals, by time period. Hospitals diagnosing fewer than 25 patients in each time period were excluded (of which more than 75% diagnosed fewer than three cases of breast cancer)