EXPLAINING BREAST CANCER MORTALITY IN ENGLAND:

THE EFFECT OF SOCIO-ECONOMIC FACTORS

AND HEALTH CARE SERVICES

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March 1996

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SUMMARY

England has the worst mortality rate for breast cancer in the developed world. Using area-level data for 145 health districts in England, this study seeks to explain variations in breast cancer mortality among women aged 50-64 in the period before the National Breast Screening Program became operational. It is found that socio-economic and behavioural factors had a larger effect on mortality than health care inputs. This might be explained both by inadequacies in the data, and by the fact that, in the absence of screening, cancers tend to be detected at a later stage, by which time the chances of a successful outcome are reduced. It is suggested that the impact of health care services in reducing mortality will increase in the future as screening becomes widespread and results in earlier detection and treatment. The prioritisation of screening is central to achieving the reductions in mortality from breast cancer specifed in the "Health of the Nation" targets.

Key words:

breast cancer mortality, socio-economic factors, health care inputs.

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INTRODUCTION

England has one of the highest death rates from breast cancer in the industrialised world, and various initiatives have recently been introduced by the Department of Health to try and improve upon this situation. Although, according to Rutstein's classification, breast cancer is not traditionally considered to be an "avoidable death" (1,2), there is a belief that health care services can have a positive impact on survival. Reflecting that expectation, the "Health of the Nation" target seeks to reduce the death rate from breast cancer in women aged 50-64 from 96.3 per 100,000 of the population in 1990 to no more than 72.2 per 100,000 of the population in the year 2000[1]. (3)

Despite significant research advances, the causes of the disease are not yet fully understood, there is no known cure and there is some debate within the medical profession about the most appropriate methods of treatment. Although breast cancer cannot be prevented, its natural progress may be interrupted by early detection and treatment. The results of trials indicate that the risks of death in the female population can be reduced by up to 50% through mass screening by mammography which can detect unpalpable and asymptomatic tumours and thereby enables the problem to be treated earlier than would otherwise have been the case, and hopefully before the cancer had metastasised. (4, 5, 6, 7) Until it is known how breast cancer can be prevented or cured, a major emphasis of the health care services must be in secondary prevention through screening, in order to improve the prognosis of those women who contract the disease.

Mortality rates reflect natural incidence rates and health care services, such as screening, diagnosis procedures and treatment. Individual survival chances are

related to tumour type, age of onset, stage at diagnosis and co-morbidity. In the US, both access to health care and survival are associated with socio-economic status. (8, 9). In England, where health care is provided free to all at the point of delivery by the National Health Service (NHS), socio-economic characteristics are not expected to affect access to treatment, although they may influence the use made of the available services. Patients with health insurance can be treated privately, but only after a general practitioner referral.

Using area-level data for 145 health districts in England, this study seeks to examine the contribution of area-level socio-economic, behavioural and health care service measures to the observed variations in health district breast cancer mortality rates. Such analyses can be useful to evaluate and formulate public health policy.

DATA

The mortality data used in the study cover certified deaths from breast cancer among women aged 50-64 in the period 1988-92, and are drawn from Department of Health, 'Population Health Outcome Indicators for the NHS, 1993, England'. There were almost 25,000 such deaths in England over this period, and breast cancer deaths in this age group represent about 36% of all breast cancer deaths.

The data are presented in the form of absolute numbers and Standardised Mortality Ratios (SMRs) for the 14 Regional Health Authorities (RHAs) and the 145 District Health Authorities (DHAs) of England. The deaths are aggregated over 5 years to avoid problems associated with low numbers of events. Figure 1 shows that there is marked variation in breast cancer death rates between districts, ranging

Figure 1

from an SMR of 123 in Hartlepool, to one of 62 in Darlington. Higher mortality rates are observed in the central and south eastern regions than in the north-east and west of the country. The current regional pattern is very similar to that recorded in 1971. (10)

To explain district variation in standardised mortality ratios, two groups of explanatory variables were identified; the socio-economic and behavioural characteristics of district populations and district-level health care inputs. (A full list of the variables included in the analysis is given in Appendix 1) A large amount of socio-economic information is available at the district level in the NHS Management Executive "Indicators" package for 1992. Much of this was drawn originally from the 100% national 1981 Census of Population. It covers the demographic structure of the area, household size and type, housing tenure and quality, unemployment, car ownership, degree of urbanisation and ethnicity. More recent district-level socio-economic information, that would better match the mortality data, was not available.

Previous research at the individual level has found that the risks of contracting breast cancer are influenced by a combination of genetic and behavioural factors (4, 11, 12, 13). Elevated risks are associated with women having had no pregnancies or with their first pregnancy above the age of 30, early menarche, late menopause, benign breast disease, and a close family member (mother, sister) with breast cancer. There is some debate about the effect of smoking (14), alcohol (15), the contraceptive pill and dietary fat. (16, 17) Lower risks are associated with women having more than three pregnancies.

Area level indicators of socio-economic status are likely to be imperfect proxies for individual risk factors. Furthermore, known risk factors have been shown to explain only 55% of disease incidence (18), and many women with breast cancer have no known risk factors. Despite this, household size and the percentage of large families in a district might proxy the number of women having more than three pregnancies. Similarly, the number of births to women under 19 and over 35 years of age could reflect the breast cancer risks associated with different child bearing patterns.

Area-level information on two additional behavioural factors that might influence breast cancer incidence, namely smoking habits and alcohol consumption, was available from the Department of Health, 'Public Health Common Data Set, 1992', and was included in the analyses. Important risk factors not adequately represented by the available data were hormonal factors that affect the timing of the menarche and the menopause, genetic influences that result in inherited cases of breast cancer, and the incidence of benign breast disease in a district.

To examine the effect of health care services on mortality, data on health care inputs relevant to the treatment of breast cancer were obtained from the NHS Management Executive "Indicators" package for 1992, and incorporated as explanatory variables. Since no specific information on breast cancer treatment was available, and most breast cancer cases in England are treated in general surgery units, the health care variables used included expenditure on general surgery nurses and doctors, the number and type of general surgery nurses and doctors, and the physical condition of hospital buildings. The amount of health education activity for each district in 1991 was also included. Furthermore, health care activity rates were

available from the Department of Health "Hospital Episode Statistics, 1990-1991". This provided information on the number of admissions and average waiting times for breast cancer patients. Waiting times are an important influence on the quality of care, and, in the case of breast cancer, might affect the outcome from treatment.

Health care services can also affect outcomes by screening, through its role in early detection of the disease. No data was available on screening activity for inclusion in this study, and mass screening has only become available in England for women aged 50-64 since 1990.

Some data manipulation was required before certain variables could be incorporated into the analysis. Data taken from the NHS Management Executive Indicators package was presented for the 191 DHAs in existence prior to April 1993. This had to be amalgamated to conform to the 145 DHAs to which the mortality data applied. Since actual boundary line changes were minimal, this process should not have introduced error into the analysis. Hospital episode data was only available at the regional level, and it had to be assumed that activity rates were even across all districts in a region. All variables that were presented in absolute terms were transformed to proportions by dividing through by the total district population.

METHODOLOGY

In order to explain the effect of socio-economic and behavioural factors, and of health care inputs, on breast cancer mortality, it was first necessary to select a short list of potential explanatory variables from the total of 48 available. It was then possible to run multiple regressions using the selected variables. The

regressions provided estimates of the effects of the independent variables on breast cancer mortality.

Standard correlation matrices were used to assist in the selection of potential explanatory variables. Correlation coefficients provided an indication of the explanatory power of individual variables on mortality, and they also gave a measure of collinearity between all pairs of independent variables. Multicollinearity can generate misleading results, with high overall goodness of fit statistics but poor individual t-statistics. Variables correlated with mortality were identified. Where high correlations were observed between selected variables, the ones most closely related to the dependent variable and most appropriate for proxying a known risk factor were selected. All the variables that had been selected by this process were fitted into equations which were intended to mathematically represent the relationship between the dependent and independent variables.

The mathematical representation chosen was a multiplicatively separable function which states that mortality (M) is the product of power functions of the explanatory variables (Xi); ie

$$M = X_1^{\beta 1} . X_2^{\beta 2} . . . X_n^{\beta n} \quad \text{(i)}$$

This function was chosen because it is sufficiently flexible to estimate both positive and negative health care impacts on mortality rates. Furthermore, parameter flexibility enables tests to be carried out to show the changing impact of different levels of health care. (19)

Transformed into logarithmic form this function becomes linear, and multiple regression techniques can be used to provide estimates of the percentage change in mortality for a corresponding one percent change in one of the explanatory variables; ie

$$\ln M = \beta_1.\ln X_1 + \beta_2.\ln X_2 + \ldots + \beta.\ln X_n \qquad \text{(ii)}$$

Data for the selected explanatory variables were introduced into equation (ii) and ordinary least squares estimates of the β_is were generated.

RESULTS

The correlation coefficients between mortality and all independent variables were examined. All variables with correlation coefficients above 0.1 were identified and considered for inclusion in the subsequent analysis, since it was suspected that they might have an influence on mortality[2]. The possible explanatory variables that had been selected in this manner were then correlated amongst themselves, and pairs of variables with coefficients above 0.5 were identified. In order to avoid multicollinearity, one of each pair was then excluded, depending upon their respective correlations with mortality and appropriateness for proxying risk factors. A decision was made to exclude two indices of social deprivation. Being weighted averages of a range of social and economic indicators, these indices have been widely used in other studies, but they were highly correlated with other independent variables, and their use would not enable the influence of individual factors to be identified.

Fourteen independent variables were selected for closer analysis. Socio-economic factors were represented by the proportion of households without a car and the proportion of households living in public rented accommodation in a district. Also included were the population density of the area and the percentage of families from ethnic minorities. Household size, and the proportion of mothers under 19 and over 35 were selected to represent child bearing behavioural factors. Health care inputs were covered by the inclusion of the number of health education officers, general surgery consultants and the proportion of medical and nursing staff employed in a part-time capacity. In addition, health care activity rates in a district were represented by the number of ordinary and day case admissions related to breast cancer, and by the average waiting time for breast cancer-related operations.

Two regression models were run. In the first, standardised breast cancer mortality ratios were regressed on socio-economic and behavioural variables and health care inputs. In the second, standardised breast cancer mortality ratios were regressed on the same socio-economic and behavioural variables and on health care activity rates in the area of breast cancer care and treatment. Health care inputs and activity rates were not included in the same equations to avoid overlap in the assessment of the impact of health care. The results of the analysis are shown in Table 1 . Although in both regressions the overall explained variation is relatively low, they represent the best fit equations obtained.

Child bearing behavioural variables are found to be significant influences on mortality, with the expected signs. The household size variable was significant at the 95% level in both models and had estimates of - 0.545 and - 0.548. Coefficients for early and late pregnancies were significant in the second model only, the

coefficients being -0.059 and + 0.058 respectively. This means, for example, that an increase of 1% in the number of births to mothers under the age of 19 would lead to a reduction in the breast cancer SMR of 0.059%. In districts where women tend to have fewer children, or have their children later in life, the mortality rates from breast cancer are higher.

Ethnic minorities, population density and renting from a local authority are positively correlated with the breast cancer mortality rate. On the other hand, the number of households not owning a car appears to be negatively related to mortality. The car ownership and housing tenure variables were significant at the 95% level in both equations. The ethnic minority and population density variables were only significant at this level in the second equation.

The only health care input to appear as significant was the number of general surgery consultants. This variable had an estimate of -0.02 suggesting that mortality is reduced in areas where more general surgery consultants are available per 10,000 general surgery cases treated. The size of the coefficient suggests that a 1% rise in the number of general surgery consultants will reduce a district's breast cancer SMR by 0.02.

Of the health care activity variables, the average waiting time for operations was just significant at the 95% level, the negative sign suggesting that higher mortality in a district is associated with shorter average waiting time. There is a positive correlation between mortality and the number of breast cancer related ordinary admissions in a district which is 94% significant.

DISCUSSION

This paper uses area-level data to explain the variation in breast cancer mortality between DHAs in England. From regressions of SMRs on socio-economic and behavioural factors, health care inputs and health care activity rates, estimates of their impact on the mortality rates were generated. The overall explained variation (around 0.2) was relatively low, possibly partly as a result of various data-related problems.

In common with other area-level studies, cross boundary flows could not be accounted for, and it had to be assumed that these were evenly distributed. Inaccuracies in the mortality data may arise from the well documented problems associated with identifying and coding the underlying cause of death, which is particularly relevant in the case of cancers, where fatal secondary problems can develop (20, 21, 22). Results are only likely to be biased, however, if misclassifications are non-systematic. Although evidence of consistent bias in certifying death from cardio-vascular disease exists (23), to our knowledge there is no evidence of similar bias with respect to breast cancer.

Inherent in this ecological approach is the problem that group level associations may not hold at the individual level. Furthermore, the use of 1981 socio-economic and behavioural data to explain breast cancer mortality amongst women aged 50-64 between 1988 and 1992 is problematical given the long course of tumour induction and promotion, and involves assumptions about medium term stability in the characteristics of district populations. Bearing these limitations in mind, this aggregate data analysis confirms the significance of child bearing behaviour on the risks of death from breast cancer that has been observed in

individual level studies. The negative coefficient of the household size variable is consistent with the higher risk of contracting breast cancer associated with women having had no pregnancies, and the lower risk for women with many children. The results also suggest that young age pregnancies are related to a reduced risk of breast cancer, and, as other studies have also shown (24), that pregnancies above the age of 35 increase the susceptibility to it.

Hormonal factors underlie these differing risks, and will also be responsible for other biological influences on breast cancer that are not incorporated in this study. Whilst it is accepted that early menarche and late menopause also raise the risks of contracting breast cancer, it has been assumed, for the purpose of this study, that the distribution of these factors is evenly spread through the population. On the other hand, it should not be assumed that child bearing behaviour is constant between groups in society. Indeed variations in this factor may be related to social class and therefore be instrumental in explaining the previously observed area - level association between breast cancer incidence (and hence mortality) and higher social class (25, 10). The negative significant relationship between breast cancer mortality and no car ownership observed in the present study would appear to accord with these earlier findings.

In a similar way, the other socio-economic variables included in analysis are likely to be reflecting other behavioural traits that influence breast cancer mortality. The apparently higher mortality rates in districts with a higher population density, with more local authority tenants and with a larger proportion of ethnic minorities might be explained by less appropriate use of the available health care services in these areas and by these groups of women. Whilst well-off and better educated

women might have enhanced chances of surviving breast cancer because they are alert to its dangers and seek early treatment, the opposite is perhaps true for less advantaged women (26). Evidence of better survival rates amongst higher social classes already exists in both England (27) and the USA (8, 28, 29).

The timing of the health care data used in the study coincides well with that of the mortality series. The effect of hospital activity rates on mortality shown by this study is largely as expected. Both the positive relationship between ordinary admissions and mortality and the negative influence of average waiting time on mortality confirm results that have been recorded elsewhere, and might be explained by case severity (30). Since day admissions account for (on average) only 15% of all hospital admissions for treatment of malignant neoplasms of the female breast, the insignificance of this variable is not surprising

The influence of health care inputs on breast cancer mortality appears small by comparison with that of the broader socio-economic variables that were incorporated in the study. The number of general surgery consultants is inversely related to mortality, and though significant at the 95% level, the coefficient size is small. Neither the number of health education officers in a district, nor the proportion of part-time staff employed were significant influences on mortality rates.

There are a number of possible reasons why health care variables were not significant. One is that data inadequacies precluded the real effect of health care from being observed, particularly in the case of activity rates, which were averaged across regions. Furthermore, the input data were highly aggregated. District expenditure figures could not easily be broken down into budgets for different departments (e.g. pathology, radiology), and resources for treating breast cancer

could not be separately identified from those allocated to general surgery, even though breast cancer treatment only represented some 5.8% of the general surgery workload in 1991. This last factor may have contributed to the low size of the coefficient for the number of general surgery consultants.

An alternative explanation is that health care inputs of the type measured in this study genuinely did not have much effect on mortality. No measures of the quality of treatment were available for inclusion, although recent evidence confirms this to be important in improving survival and reducing mortality. (31) One way in which the health care delivered to breast cancer patients can be improved is through the establishment of specialist breast cancer units. Whilst the evidence is fragmentary, there is concern that general surgery facilities do not provide the best possible means of treating women with breast cancer. (32, 33) Another deficiency of the health services related to breast cancer was the lack of widespread screening prior to 1990. (34) Consideration of screening activity was, therefore, excluded from the present study. The importance of mass screening for breast cancer in women over 50 has, however, been recognised in a number of trials in the USA, Sweden and The Netherlands (4, 5, 6, 7). A National Breast Screening Program for women aged 50-64 in England was announced by the Department of Health shortly after the publication of the Forrest Report on Breast Cancer in 1986 (35). Although it has taken several years for the necessary facilities to be established in all areas of the country, most recent reports indicate that the program is well underway with acceptance rates of 71.3% nationally in 1991-1992. (36) This major extension to health care activity in the field of breast cancer treatment is expected to have a

favourable effect on mortality rates in the future, a fact that is reflected in the Health of the Nation target that refers specifically to the screened population.

Mass screening for breast cancer, however, is not without drawbacks (37); it can cause anxiety to some women, and cost effectiveness studies have shown that it has a relatively high cost per life-year gained compared to some other health care activities (4, 33, 34, 38). Furthermore, selective screening is not generally regarded as a viable alternative strategy due to problems in identifying high risk groups and the large number of sporadic cases that occur. Within the National Breast Screening Program, the effects on cost and mortality of alternative screening methods, frequencies and populations are being evaluated in order to establish the best value-for-money arrangements. Research is also underway to identify how high take-up rates can be achieved, although there is some debate about how essential this is to the success of the program (39, 40). Whilst the provision of information through public health programmes raises participation rates (41), universal coverage has not been found to remove socio-economic disparities in preventive care (42), and this factor may need to be monitored in the future.

3700 WORDS

ACKNOWLEDGEMENTS

This work was partly supported by a grant from Department of Health, Economics and Operational Research Division.

The authors would like to thank Dr Victor Kiri, at the Institute of Public Health, University of Surrey , for supplying up-to-date data, and Dr Ann Hendricks and her colleagues at the Institute for Health Policy, Brandeis University for helpful advice in the early stages of the work. All remaining errors are our own.

FOOTNOTES

1 The figures quoted here are taken from Department of Health, Public Health Common Data Set, 1992, and are revised versions of those presented in the original White Paper.

2 A correlation coefficient of 0.13 or more is statistically significant at the 95% level.

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FIGURE 1

Mortality from breast cancer (ages 50-69) by district health authority in England, 1988-1992.

Source: Department of Health, Population Health Outcome Indicators for the NHS, 1993, England. p 59

APPENDIX 1: List of variables used in the study.

Except where otherwise stated, all variables were available at the level of 145 district Health Authorities for England.

A Dependent Variable

Breast cancer deaths (ages 50-64) in England, 1988-1992, Standardised Mortality Ratio

Source: Department of Health: Population Health Outcome Indicators for the N.H.S., 1993, England.

B Independent Variables

i) Socio-economic and behavioural factors

1 Population density: people per hectare

2 Jarman's Underprivileged Area Score, - a weighted average of eight factors:
% elderly living alone,
% children under 5,
% one-parent families,
% unskilled socio-economic groups,
% unemployed,
% overcrowding,
% change of address within one year,
% households headed by a person in the New Commonwealth or Pakistan.

3 Department of Environment, Social Index, which combines six factors to identify socially deprived areas:
% elderly living alone,
% one parent families,
% unemployment,
% poor housing,
% overcrowding,
% ethnic minorities.

4 Household size: average number of residents per household

5 % large families: percentage of households with 3 or more dependent children

6 % ethnic minorities: percentage of people living in private households headed by a person born in the New Commonwealth or Pakistan

7 % one parent families: percentage of families which are one parent families

8 % owner occupiers: percentage of private households which are owner occupied

9 % Local Authority tenants: percentage of private households which are rented from the local authority

10 % unfurnished private letting: percentage of private households which are privately rented and unfurnished

11 % furnished private letting: percentage of private households which are privately rented and furnished

12 % economically active residents unemployed: percentage of economically active people who are unemployed
13 % households overcrowded : percentage of private households with more than one person per room
14 % households with no inside wc: percentage of private households without an inside wc
15 % households using shared amenities: percentage of private households which share a bath or inside wc or both
16 % households with no car: percentage of private households which do not have a car
17 Births in district by maternal age, 0-19: total number of births to mothers in district aged 0-19/district population
18 Births in district by maternal age, 35+: total number of births to mothers in district aged 35+/district population
19 % ethnic headed households: percentage of private households headed by people born in the New Commonwealth or Pakistan
20 Pregnancies in women under 16/1000 of district female population aged 10-15: total number of pregnancies (deliveries and terminations) of women under 16 in district per 1000 of district female resident population aged 10-15.

Source: N.H.S Management Executive Indicators, 1992.

21 Female alcohol consumption above sensible limits
22 Female smoking prevalence

Source: Department of Health, Pubic Health Common Data Set, 1992.

(ii) Health care inputs

23 Total revenue expenditure
24 Total revenue expenditure, hospital services
25 Total revenue expenditure, inpatient services
26 Total revenue expenditure, by staff group-medical and dental
27 Total revenue expenditure, by staff group-nursing and midwifery.
28 % of building area in physical condition A
29 % of building area in physical condition D
30 Total cost health promotion and education /1000 resident population.
31 Health education officers/100,000 resident population
32 Part-time as % total staff-medical and dental
33 Part-time as % total staff-nursing and midwifery
34 Locum/agency staff hours as % total-medical and dental
35 Locum/agency staff hours as % total-nursing and midwifery
36 Available day beds by speciality - general surgery
37 Throughput by speciality-general surgery
38 Average length of consultant episodes-general surgery
39 Consultants per 10,000 consultant episodes-general surgery
40 Total cost of pathology service divided by number of patient days

Source: NHS Management Executive Indicators, 1992

(iii) Health care activity rates

41.42 Ordinary admissions by operation and by diagnosis
43.44 Day care admissions by operation and by diagnosis
45.46 Bed days by operation and by diagnosis
47.48 Average waiting times by operation and by diagnosis

Note: Operations and diagnosis categories were selected that related to malignant neoplasms of the female breast.
Hospital episode data was only available at the level of 14 Regional Health Authorities.

Source: Department of Health, Hospital Episode Statistics, 1990-91