**National trends and regional variation in immediate breast reconstruction rates**

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**ABSTRACT**

**Background:** Previous studies have identified variation in immediate reconstruction (IR) rates following mastectomy for breast cancer across English regions during a period of service reorganization, a national audit and changing guidelines. This study analyses current variations in regional rates of IR in England.

**Methods:** Patient-level data from Hospital Episode Statistics was used to define a cohort of female patients who underwent primary mastectomy for invasive or *in situ* breast carcinoma in English National Health Service (NHS) hospitals between April 2000 and March 2014.A time series of IR rates was calculated nationally and within regions in 28 cancer networks. Regional IR rates before and after the national audit were compared, using logistic regression to adjust for patient demographics, tumour type, co-morbidity and year of mastectomy.

**Results:** Between 2000 and 2014, a total of 167 343 women had a mastectomy. The national IR rate was stable at around 10 per cent until 2005; it then increased to 23.3 per cent by 2013–2014. Preaudit (before January 2008), adjusted cancer network-level IR rates ranged from 4.3 to 22.6 per cent. Postaudit (after April 2009) adjusted IR rates ranged from 13.1 to 36.7 per cent, with 20 networks having IR rates between 15 and 24 per cent. The degree of change was not greatest amongst those that started with the lowest IR rates, with four networks with the largest absolute increase also starting with relatively high IR rates.

**Conclusion:** The national IR rate increased throughout the study period. Substantial regional variation remains, although considerable time has elapsed since a period of service reorganization, guideline revision and a national audit.

**Introduction**

Immediate breast reconstruction (IR) after mastectomy is oncologically safe1, and has been linked to higher levels of patient-reported satisfaction and quality of life compared with mastectomy alone following a diagnosis of breast cancer2. Previous research has indicated that, although some countries appear to have relatively high and increasing rates of IR3–5, others have persistently low rates6–9. A review of the literature undertaken in 201310 highlighted the large degree of variation internationally, finding population-based IR rates that ranged from 3.8 to 29.2 per cent in different countries or large geographical regions.

In the English National Health Service (NHS), the 2000 National Cancer Plan created cancer networks to integrate regional services and develop referral pathways for patients with cancer11. When cancer networks were established in 2001, less than two-thirds of the 178 NHS acute trusts (hospital organizations) undertaking mastectomy also provided IR, and merely 40 provided a plastic surgery service12. This major reorganization was one of several factors that affected breast cancer services in England at the time. In August 2002, the National Institute for Health and Care Excellence (NICE) published breast cancer guidelines which stated that surgeons should discuss reconstruction with all patients and that it should be available at the first surgical operation13.Revised NICE guidelines in February 2009 clarified that all women undergoing mastectomy should be provided with information about reconstruction, and that IR should be offered to all patients if not precluded by their fitness for surgery or an urgent need for adjuvant therapy14.

Concurrent with these developments, a national prospective audit was undertaken in England to evaluate the offer and uptake of IR, and the outcomes of mastectomy surgery2. It collected data prospectively between January 2008 and March 2009, and reported an IR rate of 21 per cent, which compared favourably with a rate of 11 per cent observed between April 2005 and March 2006. The audit found substantial regional variation in reconstructive uptake across the English cancer networks, findings broadly consistent with a population-based study that examined the period between 2006 and 200915. This regional variation is undesirable and may have reflected different rates at which cancer networks’ referral pathways were being implemented16, and it could also be related to breast cancer services being audited17–19.

The present study undertook an analysis of the change in patterns of IR in the English NHS from April 2000 to March 2014. This time period includes the service reconfiguration that resulted from the NHS Cancer Plan, the publication of both sets of NICE guidelines, the national audit, and the publication and dissemination of its findings. A particular aim was to analyse whether the regional variation in IR rates was a transient phenomenon or remains apparent across England.

**Methods**

*Patient population and data set*

This study used data extracted from the Hospital Episode Statistics (HES) database of the English NHS20. The database captures information on all patients’ hospital admissions, including both sociodemographic and clinical data (such as diagnoses and operative procedures). Patients are allocated a unique pseudonymized identifier (HESID) that allows their admission history to be tracked over time.

HES records for female patients aged 16 years or over with a diagnosis of invasive or *in situ* carcinoma of the breast (ICD-10: C50 and D05) between 1 April 2000 and 31 March 2014 were identified21. Patients undergoing prophylactic surgery were excluded. Patients were then grouped based on whether their index procedure was breast-conserving surgery (BCS) (OPCS4: B28 excluding B28.4) or mastectomy (OPCS4: B27)22. Procedure laterality was used to distinguish separate episodes of cancer. For example, patients with breast cancer who underwent a right-sided BCS procedure and then, at a later date, a left mastectomy, were included twice in the study. Patients who underwent multiple operations on the same side were included only once, for their first therapeutic procedure.

Patients undergoing mastectomy were categorized as having IR if a reconstructive procedure was undertaken on the same date and side as their index procedure. All types of reconstruction (expanders, implants, pedicled flaps and free flaps, or any combination of these) were included, as defined in an earlier study15.

Finally, a cohort of women who had delayed breast reconstruction (DR) were identified. This included women whose previous mastectomy could be identified, and women whose previous mastectomy could not be found but who had a diagnosis of breast cancer at the time of their first reconstructive episode (this situation was most common in the early years of the study period). The DR date was based on the first reconstructive procedure identified.

*Study variables*

Variables for age at admission, tumour type (invasive, invasive with ductal carcinoma *in situ* (DCIS), DCIS alone), co-morbidity, ethnicity and socioeconomic deprivation were derived. The number of relevant co-morbidities was calculated using the Royal College of Surgeons of England modified Charlson score23. The 16 ethnic categories in HES were grouped as white (including mixed ethnic categories), Asian, black or other (including unknown). The area-based Index of Multiple Deprivation (IMD) 2004 score was used to determine socioeconomic deprivation24, and patients were categorized into quintiles from 1 (least deprived) to 5 (most deprived) based on their IMD ranking. Finally, each patient was assigned to one of the 28 English cancer networks that existed on 31 March 2014, based on the NHS trust that carried out their mastectomy. Women were excluded from the study if their cancer network could not be identified.

*Statistical analysis*

The number of female patients with breast cancer who underwent BCS, mastectomy alone, and IR over the study period, grouped by HES year (April to March), was calculated. Annual IR rates on a quarterly basis were then derived using a 4-point moving average. The quarterly numbers of immediate and delayed reconstructive procedures were plotted to describe national trends in reconstructive activity.

The remaining analyses included only those patients who underwent mastectomy (with or without IR). A multivariable logistic regression model was developed to estimate the likelihood of a patient undergoing IR based on demographic and clinical characteristics (age, tumour type, co-morbidities, ethnicity, deprivation and mastectomy year). Robust standard errors were calculated for the model coefficients to allow for any correlation among patients within hospitals (clustering).

To examine changes to regional patterns over time, unadjusted cancer network-level IR rates were calculated for nine discrete time periods, and the spread in actual rates was summarized using a sequence of box plots based on median, interquartile range (i.q.r.), and minimum and maximum (range) values. The first time period was defined to include patients undergoing mastectomy who were treated from April 2000 to December 2005, as the logistic regression model revealed that mastectomy year did not affect the likelihood of IR in the first 5 years. Thereafter, 12-month time periods were used, apart from the fourth interval, which covered the 15 months of the national audit. Adjusted cancer network-level IR rates were also derived using the regression model to present comparable standardized values, and the data were grouped into three time periods to show the change for each cancer network. All statistical tests were two-sided, with *P*< 0.050 indicating a significant result. The analyses were performed using STATA® version 11 (StataCorp, College Station, Texas, USA) and Microsoft Excel® 2010 (Microsoft, Redmond, Washington, USA).

**Results**

Between April 2000 and March 2014, 448 633 female patients diagnosed with breast cancer had primary surgery. Of these, 281 290 (62.7 per cent) had primary BCS. The annual number of BCS procedures increased steadily, from 16 193 in 2000–2001 to 24 863 in 2013–2014 (*Fig. 1*). Over the same interval, 167 343 patients had a primary mastectomy, rising from 11 075 to 12 655 per annum. The national mastectomy rate, as a proportion of primary breast cancer surgery procedures, fell from 40.6 to 33.7 per cent over the study period. Of the patients who underwent mastectomy, 23 792 (14.2 per cent) had IR. The number of mastectomy procedures without IR increased annually until 2005–2006, but then decreased.

*Fig. 2* shows the quarterly trend in the IR rate, as well as the total number of delayed reconstructive procedures. In 2000, there were approximately 250 immediate (IR) and 100 delayed (DR) reconstructions per quarter. The number of DR procedures increased steadily from 2001, but plateaued after 2008 at around 350 per quarter. The number of IR procedures began to increase during 2005 and continued to do so over the remainder of the study period, reaching around 750 per quarter in 2013. Thus, overall reconstructive activity increased over the period from roughly 350 to 1050 procedures per quarter. The national IR rate followed a similar pattern to that for IR procedure numbers, remaining stable at approximately 10 per cent before 2005 and increasing steadily to 23 per cent by the first quarter of 2013.

*Factors associated with an increased likelihood of immediate reconstruction*

*Table 1* shows the association between patient characteristics and the likelihood of IR, adjusted for year of mastectomy. IR was more common among patients with DCIS than in those with invasive disease. It became less common with increasing age, co-morbidity and deprivation. Women of Asian ethnicity were less likely and women of black ethnicity more likely to undergo IR than those of white ethnicity.

The odds of IR within each year of the study followed the pattern observed in the unadjusted time series. The 3.5-fold relative increase in odds compared with the 2-fold increase in national IR rates arose because the odds were calculated in relation to a baseline patient rather than to the average for all women. Relative differences in IR rate across the categories for each patient characteristic remained broadly similar throughout the study period (results not shown).

*Immediate reconstruction rates across the cancer networks over time*

The distribution of unadjusted IR rates across the 28 cancer networks is shown in *Fig. 3*. The network-level variation in IR rates became wider during the national audit and in the years immediately before and after, with an average i.q.r. of 9.5 per cent. Regional variation then decreased slightly, with an i.q.r. of 6.7 per cent between April 2012 and March 2013. However, in the last year of the study, network-level variation increased again (i.q.r. 8.4 per cent).

In *Fig. 4* the adjusted network-level IR rates for the preaudit, audit and postaudit time periods are presented, with networks ordered from high to low based on their preaudit rates. Before the audit, adjusted network-level IR rates ranged from 4.3 to 22.6 per cent. Following the audit, adjusted rates increased across all networks. This was not related to network-level mastectomy volume, which changed by less than 1 per cent between the first and third time periods. Postaudit adjusted IR rates ranged from 13.1 to 36.7 per cent, although most networks had rates between 15 and 20 per cent. The degree of change was not greatest amongst those that started with the lowest IR rates. Four cancer networks (Essex, Humber and Yorkshire Coast, South East London, South West London) that started with relatively high IR rates also demonstrated the largest absolute changes.

**Discussion**

This 14-year study period spanned a time of considerable investment in NHS breast cancer services in England, within a relatively homogeneous healthcare system. Its strengths are the use of a complete national administrative database that includes data on all patients treated within NHS hospitals, and the use of relatively stable diagnostic and procedural classification systems. The HES database does not cover private hospitals, but these comprise only a small proportion of breast cancer cases in England. The study period encompassed funding increases, service reorganization and the publication of national clinical guidance. Improved access to immediate reconstruction was a key element of this transformation, and the proportion of women who underwent IR increased from about 10 to 23.3 per cent.

At the same time, increasing numbers of BCS and mastectomy procedures were also performed within the NHS owing to a 38.6 per cent increase in the annual number of women diagnosed with breast cancer in England, from 36 704 in 2000 to 50 864 in 201325,26. Although the number of mastectomies increased, there was an even greater increase in BCS, most likely due to the 2002 publication of high-quality evidence that BCS, when combined with radiotherapy, can be as effective as mastectomy in treating breast cancer29. Radiotherapy access improved over the study period as its delivery became coordinated at cancer network level11. The indications for BCS also widened following the dissemination of therapeutic mammoplasty techniques involving breast volume displacement or replacement30,31. These newer BCS techniques enable surgeons to remove larger tumours, while maintaining an acceptable aesthetic appearance. Nonetheless, mastectomy remains common, with the importance of reconstruction undiminished. Consequently, increased IR rates are evidence of improved service provision within the English NHS.

The growth in IR rates was not uniform across English cancer networks. Regions differed both with respect to the timing of the IR rate increase and its magnitude. Cancer network-level IR rate variation increased before, during and after the national audit. However, in 2013–2014 there was still a threefold difference between the networks with the lowest and highest IR rates, which could not be accounted for by differences in their respective patient populations. Surgeon or multidisciplinary team preferences and opinions, particularly with respect to radiotherapy, may partly explain the variation. Some clinicians argue that adjuvant radiotherapy following immediate reconstruction may impair its outcomes, and that reconstruction should be delayed if radiotherapy is anticipated38. The national oncoplastic guidelines39 highlight this point with respect to implant-based procedures, but are more equivocal with regard to flap-based reconstruction. Cancer networks with high IR rates may have clinical oncologists who offer postmastectomy radiotherapy less often, or who do not perceive it to be a contraindication to IR, particularly if their surgical colleagues use flap-based techniques preferentially.

A general increase in the use of IR after mastectomy, as observed here, has been reported in various countries including Spain, Australia and the USA4,8,10. Various studies have also noted organizational factors that are associated with regional variation. A study of practice in Catalonia, Spain, reported hospital-level variation in IR rates within the region that was associated with hospitals’ specialization level4. Another study7 found intercounty variation in IR rates within Ontario, Canada, that was partly explained by whether or not a plastic surgeon worked within the county. A third study9 undertaken in Western Australia reported higher IR rates for patients from urban areas or treated in urban hospitals, along with patients treated privately or with private health insurance. However, other population-based studies analysing variation in rates across geographical regions over time have not been published, and so it is unclear how the increase in IR rates within other countries is related to levels of regional variation.

Although NICE guidelines probably contributed to the increased IR rate, the present study did not identify an obvious link between their introduction and changes to reconstructive activity. That there was diffuse change in practice is perhaps unsurprising, as the uptake of clinical guidelines is influenced by many variables2,32. Guideline implementation requires clear recommendations, a strong evidence base, and adequate funding and support from clinicians. A number of these did arise during the study period. First, the 2000 Cancer Plan11 resulted in a nationwide shift towards multidisciplinary team working, and the creation of the cancer networks helped to integrate reconstructive and adjuvant therapy services by improving referral pathways. This reorganization was accompanied by increased funding for cancer services in England11. Second, oncoplastic and reconstructive training was improved and expanded through national and local fellowship schemes33. Third, the NICE guidelines were supported by equivalent publications from the relevant surgical specialty associations34,35. Finally, patients became more likely to receive information on reconstructive techniques from surgeons, dedicated breast care nurses and breast cancer charities2,11.

Another potential contributor to changing IR rates was the National Mastectomy and Breast Reconstruction Audit2. This audit of practice and outcomes was undertaken by the specialist associations, and its findings were widely reported and disseminated. Moreover, the audit asked clinicians to document whether or not they made an offer of IR to their patients undergoing mastectomy, and details of their decision-making, which may have altered their approach. Other studies have reported that this type of scrutiny results in changes in practice. A prospective study of antibiotic prescribing36 found that completion of decision-making forms following each patient encounter substantially reduced inappropriate prescribing by clinicians. Another study37 reported that clinicians based at high- and low-performing hospitals demonstrated significantly different responses to being monitored.

The study has limitations. Studies based on administrative data sets such as HES are subject to coding inaccuracies. IR rate estimates can be affected by the omission or miscoding of procedures and laterality. There is evidence that the coding of breast cancer surgery in HES is accurate overall, with studies finding 90–93 per cent concordance between HES and contemporaneous data from two separate national clinical audits2,27. The evolution of OPCS codes for breast reconstruction procedures over the study period may also have introduced errors, although these coding changes mostly allowed for a more precise description of the reconstructive techniques, which would not have affected the present analyses. A wide range of procedure codes were used to avoid omitting an IR operation, and consequently the effect of potential coding errors would be small.

Another limitation is that HES does not record tumour size and grade, adjuvant therapy, and lifestyle factors such as smoking and obesity. These factors might explain some degree of the regional variation and changes observed over time. However, the patient and tumour characteristics included in the risk adjustment produced a logistic regression model with good discrimination (c-statistic 0.819). Furthermore, a risk adjustment model developed in another study2 of regional patterns of breast surgery that included information on tumour, treatment and patient lifestyle factors failed to reduce the level of regional variation observed. Thus, adding this information would most likely not substantially reduce the level of variation in adjusted cancer network-level IR rates.

Finally, the number of IR operations reported here is less than the total number performed and should not be compared with IR rates based on all mastectomies. Mastectomy procedures (with or without IR) that were undertaken after a failed BCS were excluded because these do not relate to the initial treatment decision-making process. Moreover, women who have a mastectomy after a failed BCS procedure are more likely to undergo IR for a number of reasons, and cancer networks are likely to differ in both surgical practice and local thresholds for BCS reoperation and subsequent mastectomy28. It can be expected that including these procedures would have increased the observed regional variation.

This study highlights increasing surgical activity for breast cancer. The optimal IR rate is unknown, but the increasing number of IR procedures undertaken indicates greater access. Nonetheless, substantial and persistent regional variation in rates suggests that women still have unequal access to breast reconstruction. Moreover, the greatest absolute change was seen within cancer networks already providing IR to high proportions of their patients at the start of the study. This may be because cancer networks with high IR rates tend to have more appropriately trained surgeons with the ability to meet a further increase in demand. Although the study was not able to investigate how patient preferences may have impacted on the variation observed across cancer networks, it is unlikely that regional differences in these could account for an i.q.r. of 8.4 per cent in the postaudit period examined. This study also demonstrated that female patients from deprived areas were less likely to have IR. Whether this is related to patient preference or service provision is unclear, but it warrants further investigation to determine whether it is evidence of inequitable access. The present study demonstrates that patients diagnosed with breast cancer in England still have unequal access to immediate breast reconstruction. Evidence of this persistent variation should motivate hospital clinicians and the commissioners of breast cancer services to identify and remove barriers to the provision of reconstructive surgery, so that women have more equitable access in future.

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**Fig.1** Number of mastectomy, mastectomy with immediate reconstruction (IR) and breast-conserving surgery (BCS) procedures undertaken annually within the English National Health Service between April 2000 and March 2014



**Fig.2** Number of mastectomy with immediate (IR) and delayed (DR) reconstruction procedures undertaken in the English National Health Service each quarter, together with the IR rate calculated as a four-quarter moving average. Time periods associated with the publication of National Institute for Health and Care Excellence (NICE) guidelines and the National Mastectomy and Breast Reconstruction Audit are also shown. Quarters run from 1 April each year

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**Fig.3** Distribution of immediate reconstruction rates across English cancer networks over the 14-year study period. Box denote interquartile range values and whiskers show the range for network-level rates in each time period

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**Fig.4** Adjusted network-level rates of immediate reconstruction in England during preaudit, audit and postaudit time periods. Cancer networks are ordered by their preaudit rate of immediate reconstruction

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**Table 1** Likelihood of immediate reconstruction, stratified by patient characteristics (age, tumour type, co-morbidity score, ethnicity, deprivation and year of mastectomy) following adjustment in a multivariable logistic regression model

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | No. of mastectomies | Immediate reconstructionNo. (%) | Adjusted Odds ratio95% CI) | *P* |
| Age (years) |  |  |  | < 0.001 |
| 16-40 | 10 602 | 3600 (34.0) | 1.00  |  |
| 41–45 | 12 103 | 3583 (29.6) | 0.77 (0.73, 0.81) |  |
| 46–50 | 18 108 | 5186 (28.6) | 0.68 (0.65, 0.72) |  |
| 51–55 | 17 487 | 4327 (24.7) | 0.56 (0.52, 0.61) |  |
| 56–60 | 18 104 | 3002 (16.6) | 0.35 (0.32, 0.38) |  |
| 61–70 | 38 314 | 3509 (9.2) | 0.16 (0.15, 0.18) |  |
| 71 +  | 52 625 |  585 (1.1) | 0.02 (0.02, 0.02) |  |
| Disease |  |  |  | < 0.001 |
| Invasive | 143 987 | 17 373 (12.1) | 1.00  |  |
| Invasive and DCIS | 13 457 |  2904 (21.6) | 1.82 (1.60, 2.07) |  |
| DCIS | 9899 |  3515 (35.5) | 3.36 (2.92, 3.86) |  |
| No. of co-morbidities |  |  |  | < 0.001 |
| 0 | 96 850 | 16 930 (17.5) | 1.00  |  |
| 1 | 56 975 |  6132 (10.8) | 0.54 (0.50, 0.59) |  |
| > 1 | 13 518 |  730 (5.4) | 0.34 (0.31, 0.38) |  |
| Ethnicity |  |  |  | < 0.001 |
| White | 152 329 | 21 497 (14.1) | 1.00  |  |
| Asian | 5118 |  673 (13.1) | 0.57 (0.49, 0.67) |  |
| Black | 2252 |  616 (27.4) | 1.51 (1.15, 1.98) |  |
| Unknown | 7644 |  1006 (13.2) | 0.87 (0.77, 0.99) |  |
| Index of Multiple Deprivation |  |  | < 0.001 |
| 1 (least deprived) | 34 948 |  6204 (17.8) | 1.00  |  |
| 2 | 36 876 |  5505 (14.9) | 0.82 (0.74, 0.91) |  |
| 3 | 35 231 |  4729 (13.4) | 0.72 (0.63, 0.83) |  |
| 4 | 31 705 |  4031 (12.7) | 0.65 (0.55, 0.77) |  |
| 5 (most deprived) | 28 583 |  3323 (11.6) | 0.58 (0.46, 0.73) |  |
| Year of mastectomy |  |  |  | < 0.001 |
| 2000–2001 | 11 075 |  1099 (9.9) | 1.00 (0.86, 1.17) |  |
| 2001–2002 | 10 951 |  981 (9.0) | 0.91 (0.80, 1.03) |  |
| 2002–2003 | 11 222 |  1053 (9.4) | 0.96 (0.83, 1.12) |  |
| 2003–2004 | 11 757 |  1076 (9.2) | 0.98 (0.89, 1.07) |  |
| 2004–2005 | 11 674 |  1089 (9.3) | 1.00  |  |
| 2005–2006 | 12 116 |  1287 (10.6) | 1.16 (1.03, 1.29) |  |
| 2006–2007 | 12 031 |  1363 (11.3) | 1.25 (1.09, 1.42) |  |
| 2007–2008 | 12 049 |  1510 (12.5) | 1.43 (1.26, 1.61) |  |
| 2008–2009 | 12 128 |  1828 (15.1) | 1.78 (1.55, 2.04) |  |
| 2009–2010 | 12 146 |  2013 (16.6) | 2.08 (1.76, 2.45) |  |
| 2010–2011 | 12 611 |  2284 (18.1) | 2.43 (2.07, 2.84) |  |
| 2011–2012 | 12 455 |  2559 (20.5) | 3.00 (2.54, 3.55) |  |
| 2012–2013 | 12 473 |  2698 (21.6) | 3.22 (2.71, 3.82) |  |
| 2013–2014 | 12 655 |  2952 (23.3) | 3.67 (3.13, 4.31) |  |