Regional variation in intervention rates: what are the implications for patient selection?

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Abstract

Background Whereas geographical variations in intervention rates are well recognized, little is known about their implications for patient selection. This study looks at how the relative probability of being treated in different regions within England vary with a person's need for treatment, and whether higher intervention rates are associated with a greater probability of treatment at all levels of need or confined to only certain levels.

Methods The method was modelling of retrospective data from population surveys, patient cohort studies and population intervention rates. Two southern regions (SW Thames and Wessex) and two northern regions (Northern and Mersey) were compared. Subjects were men aged 55 years and above in the population with urinary symptoms suggestive of benign prostatic hyperplasia and men undergoing surgical treatment. The ratio of probability of surgery in the southern regions to that in the northern regions by level of symptom severity was determined.

Results The rate of surgery in the southern regions was 26.5 per cent higher than in the north. A higher proportion of patients in the north had severe symptoms before surgery (58 per cent vs 52 per cent; p = 0.002). The probabilities of being operated on in a given year varied by symptom severity in both the north and the south. The probability was higher in the south at all levels of symptom severity: none/mild (ratio = 1.44; p > 0.01), low-moderate (ratio = 1.35; p = 0.003), high-moderate (ratio = 1.53; p < 0.001), and severe (ratio = 1.15; p > 0.01). On testing the sensitivity of the key assumptions by assuming a more severe distribution of symptoms in the south, the differences at none/mild and low-moderate symptom levels were enhanced but differences at high-moderate and severe symptom levels were reversed.

Conclusions As few men with mild symptoms qualify for surgery and most men with severe symptoms are operated on, any difference in patient selection between high and low rate regions is inevitably confined to the intermediate group of men with moderate symptoms. Surgeons appear to be rationing their resources in a sensible way, though perhaps not as stringently as could be achieved.

Keywords: Prostatectomy, rationing, regional variations, patient selection

Introduction

Geographical differences in the rates of health care interventions have been well documented, particularly for surgical procedures.1-4 Although one potential explanation would be that higher rates reflect greater need in the population, the bulk of the evidence suggests that this hypothesis is false.5,6 Instead, higher rates appear to reflect greater availability of health care resources.

The ensuing debate about which rate is right revolves around a fundamental question: are the populations of regions with higher rates of use better off as a result of treating more people? Conversely, do lower-rate regions utilize a more rational selection process so that those people most likely to benefit receive treatment whereas those with little to gain do not?

To answer these questions, comparative studies of specific interventions are needed. One of the reasons such studies have never been undertaken is the lack of comparable data from each region. Meaningful comparative studies require accurate measures of the population distribution of surgical indications for the intervention derived from prevalence surveys, information on the distribution of such indications among people receiving treatment from representative surgical cohorts, and data on the intervention rate in the population. Ideally, all these data should use the same definitions, be collected in the same way and refer to the same time period.

Previous work comparing an area of the United States with an area in the United Kingdom found that the high intervention rate area (United States) was associated with higher levels of surgery in men with low levels of need who are unlikely to gain much benefit.7 That study focused on an international difference and used retrospective data from a variety of sources. The observed differences in patient selection may have arisen from differences between the two countries in methods of funding health care rather than from differences in the prevailing rates of surgery. To overcome this, the present study considered two regions within the same country and used a prospective design.
It aimed to answer the questions: how does the relative probability of being treated in different regions vary with a person’s need for treatment; and are higher intervention rates associated with a greater probability of treatment at all levels of need or confined to only certain levels?

We again selected a common, largely discretionary procedure which had been the subject of several relevant studies – prostatectomy for benign prostatic hyperplasia (BPH). Two assumptions were made: the principal determinant of surgery was the severity of urinary symptoms; and that whereas decision-making criteria varied within both regions, a collective pattern existed that characterized each. To examine the pattern of patient selection in each region, three types of information were needed: the prevalence of symptoms among men receiving surgery; the prevalence of symptoms in the population at risk; and the overall rate of surgery in the population.

Method

The work was based on a comparison of the north of England (Mersey and Northern regions) and the south of England (SW Thames and Wessex regions) in 1992. These areas were selected because they had participated in a multi-centre study in which the pre-operative symptoms of men undergoing prostatectomy for BPH had been measured. Data were also required on the prevalence of symptoms in the population. The only data available were for NW Thames region for 1992. Finally, data were needed on the rates of surgery for BPH in the two areas for 1992. These were obtained from existing data sources. Details of all datasets are described below.

All analyses were based on men aged 55 years and above because surgery for BPH is rare in younger men – less than 4 per cent of such operations. Men in whom prostatic cancer was discovered incidentally to the decision to operate were included whereas men in whom surgery was performed to palliate symptoms caused by cancer recognized before surgery were excluded. No attempt was made to exclude any other cases from the analyses (such as men with a history of acute retention) given the largely discretionary basis for intervening surgically and the lack of a consensus regarding what constitute mandatory indications.

Symptom severity in the surgical cohorts

The pre-operative symptom severities of men treated surgically had been measured using an index based on seven symptoms, endorsed by the American Urological Association and known as the AUA-7 (incomplete emptying, frequency, intermittency, urgency, weak stream, straining, nocturia). Each symptom scored from zero (not at all) to five (almost always), except for nocturia, which scored from zero (never) to five (five or more) times the patient typically got up each night. This gave a total range of 0–35. Data were available on 1016 men in the north and on 1911 in the south.

Symptom severity in the population

Data on the prevalence and severity of urinary symptoms reported by a representative sample of men aged 55 years and over living in NW Thames region in 1992 were obtained from a population survey. The study provided a Symptom Index based on six symptoms (incomplete emptying, frequency, intermittency, urgency, weak stream, straining). Each symptom scored from zero (never) to five (almost always), giving an index range of 0–30. For comparison with data on the surgical cohorts, the data were multiplied by 1.17 to rescale to a range of 0–35. This assumed that the distribution of nocturia was similar to that of other symptoms, an assumption based on the findings of previous studies.

Surgical rates

The number of prostatectomies (OPCS4 codes M61, M65 and M67) performed for benign disease in the two study areas in 1992 were obtained for NHS hospitals from Hospital Episode Statistics. Coding shortfall was almost non-existent so no correction had to be made. Data on the number of operations performed in independent (private) hospitals were obtained from a survey conducted by the Medical Care Research Unit, University of Sheffield. These data potentially included operations for malignant disease. Anecdotal reports, however, suggest very few such cases are treated in private hospitals so this is not thought to have led to any significant overestimation of the rate for benign disease. The numbers of male residents aged 55 years and over in 1992 were obtained from the Office of Population Censuses and Surveys.

Data analysis

Symptom severity was categorized in the way suggested by Barry et al., but with the moderate category subdivided: none (0); mild (1–7); low-moderate (8–13); high-moderate (14–19); and severe (20–35). Probability distributions of symptom severity scores for the surgical cohorts and for the population were smoothed using an extended running-median smoother. The statistical significance of the differences in the distributions of symptom severity for patients in the north and in the south was assessed using a χ² test of the numbers in each severity category (calculated by multiplying the smoothed proportion by the total number) and Z tests (particularly severity ranges). Although the latter do not produce exactly independent inferences, the large sample sizes make the method appropriate.

Treatment probability conditional on severity score was calculated for the two cohorts separately. Assuming the distributions of symptom severity scores in the population are the same in the north and south, the probability of treatment conditional on severity score can be calculated using Bayes theorem (see Appendix).

The sensitivity of the results to the assumption that the prevalence of BPH was the same in both areas was tested by assuming the prevalence of moderate and severe symptoms in
the southern population was twice that in the north. Details of
the methods used are described in the Appendix.

Results

Surgical rates

The number of prostatectomies carried out in the two areas in
1992 are shown in Table 1. The surgical rate in the south was
26.5 per cent higher than in the north. Using a standard error of
5 per cent for the estimates, the range of ratios was from 1.14 to
1.40.

Symptom severity of surgical cases

The distributions of the symptom severity of patients treated
surgically in each area differed significantly (χ², p = 0.04)
(Fig. 1). A larger proportion of men in the north had severe
symptoms [difference 5.4 per cent, 95 per cent confidence
interval (CI) 2–10 per cent, p = 0.002] whereas a smaller
proportion had moderate symptoms (difference 5.4 per cent, 95
per cent CI 1–7 per cent, p = 0.006). There was no significant
difference for men with no (95 per cent CI -1 to 3 per cent) or
mild (95 per cent CI -3 to 2 per cent) symptoms.

Symptom severity in the population

The symptom severity distribution in the general population in
NW Thames region (based on 1416 men) is shown in Fig. 2.

Probability of surgery by symptom severity

The probabilities of being operated on in a given year (annual
number of operations per 1000 men in the population) varied by
symptom severity in both areas (Fig. 3). The probability
increased from zero for men with no symptoms to about 11 per
1000 for men with symptom scores of around 30. The
probability subsequently decreased at higher severity levels.
This finding may have been due to an association between
symptom severity and the occurrence of comorbid conditions
which raised the operative risk and hence reduced the
likelihood of surgery being attempted. In addition, the highest
levels of severity may also have been associated with older
patients in whom the benefits of surgery were perceived by the
men themselves, or by their doctors, as being of less value.

Ratio of treatment probabilities

The difference in probability of treatment between the two
study areas was judged by considering the south:north ratio
(Fig. 4). The probability of treatment was higher in the south for
men with none–mild symptoms. Table 2 shows the results of
comparing the surgical probabilities for different ranges of
severity scores. The ratios suggest that for men with none/mild
(≤7), low-moderate (>7 to ≤13) and high-moderate (14 to
≤19) symptoms, the probability of surgery in the south was
greater than in the north. The difference was not statistically
significant for men with none/mild symptoms but was
significant, at the 1 per cent level, for men with moderate
symptoms. For men with severe symptoms the probability of
surgery was slightly higher in the south but the difference was
not significant at the 1 per cent level.

Sensitivity analysis

The potential impact of the assumption that the prevalence and
severity distribution of BPH in the two areas were the same
needs to be considered. To test the potential impact of this, the
probabilities of surgery were calculated assuming the distribu-
tion of symptoms in the southern population was more severe
than in the north. Table 3 shows the results of assuming the
proportion of the population in the south with moderate and
with severe symptoms was twice that of the north. This
assumption made little difference to the relative probabilities of
surgery for mildly affected men (though the ratio approached
statistical significance), increased the previously observed
difference for low-moderate men, and reversed the findings
for high-moderate and severe men (i.e. men were more likely to
be treated in the north than in the south).

Discussion

This study has demonstrated one way in which the impact of
inter-regional differences in levels of health care provision can
be explored. In the example studied, in which the rate of surgery
in the south was 26.5 per cent higher than in the north, we found
that the probability of treatment at all levels of need was higher
in the area with a higher intervention rate, though the difference
reached statistical significance at the 1 per cent level only for
men with low-moderate (35 per cent higher) and high-moderate

<table>
<thead>
<tr>
<th>Number of operations</th>
<th>Population estimate</th>
<th>Operation rate per 100000</th>
<th>South : north rate ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NHS*</td>
<td>Private</td>
<td>Total</td>
</tr>
<tr>
<td>South</td>
<td>6075</td>
<td>1660</td>
<td>7735</td>
</tr>
<tr>
<td>North</td>
<td>4612</td>
<td>910</td>
<td>5522</td>
</tr>
</tbody>
</table>

*Includes private (pay) beds in NHS hospitals.
(53 per cent higher) severity and not for men with mild or severe symptoms. In other words, the difference for men living in a high intervention rate area from those living in a low intervention rate area was that men with moderate symptoms were more likely to be operated on. In contrast, men living in a low intervention rate area were just as likely to be operated on as men in a high rate area if they suffered from mild or severe symptoms.

This suggests either an underprovision of surgery in the north or overprovision in the south, unless the prevalence of BPH in the south is greater than in the north. Sensitivity analysis showed that if the prevalence in the south had been higher than in the north, the observed differences for mild men would have been largely unchanged, for low-moderate men even greater, but for high-moderate and severe categories the difference would have been reversed. In other words, for the scenario tested in the sensitivity analysis to be an accurate reflection of reality, it would be necessary to accept that there were severely affected men in the south who wanted surgery but were being denied it. This seems implausible.

This study was based on the conceptual assumption that, although the decision to operate is rarely made solely on the basis of symptom severity, the latter is a valid indicator of the need for treatment. This could be challenged on three counts. First, we failed to take into account the presence of indications other than symptoms, such as a history of acute retention or a
post-void residue of over 250 ml, or to formally incorporate sociodemographic factors such as age. However, there is no consensus among surgeons as to what constitute mandatory criteria so that intervention on the basis of such factors reflects clinical judgement.13

The second ground for challenging the use of symptom severity as the indicator of need for treatment is that the key aspect for many men is not the presence of symptoms per se but the extent to which they cause bother and decreased quality of life. However, several studies have shown that the extent to

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**Figure 3** Probability of treatment by symptom severity in north and south.

**Figure 4** Ratio of probabilities of treatment by symptom severity (south: north).
Table 2  Comparison of probabilities of surgery (for different ranges of symptom severity) between the south and the north assuming similar distribution of symptom severities in the two populations

<table>
<thead>
<tr>
<th>Symptom severity score range</th>
<th>Ratio of surgery probabilities (south:north) (95% CI)</th>
<th>Significance level for testing ratio 1 vs &lt; 1 or &gt; 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ≤ score ≤ 7</td>
<td>1.44 (1.3, 1.6)</td>
<td>0.11</td>
</tr>
<tr>
<td>7 &lt; score ≤ 13</td>
<td>1.35 (1.1, 1.7)</td>
<td>0.003</td>
</tr>
<tr>
<td>13 &lt; score ≤ 19</td>
<td>1.53 (1.3, 1.8)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>19 &lt; score ≤ 35</td>
<td>1.15 (1.1, 1.3)</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Table 3  Comparison of probabilities of surgery (for different ranges of symptom severity) between the south and the north assuming distribution of symptoms more severe in the south

<table>
<thead>
<tr>
<th>Symptom severity score range</th>
<th>Ratio of surgery probabilities (south: north) (95% CI)</th>
<th>Significance level for testing ratio 1 vs &lt; 1 or &gt; 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ≤ score ≤ 7</td>
<td>1.4 (1.1, 1.9)</td>
<td>0.014</td>
</tr>
<tr>
<td>7 &lt; score ≤ 13</td>
<td>2.3 (1.7, 3.1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>13 &lt; score ≤ 19</td>
<td>0.7 (0.5, 0.9)</td>
<td>&gt;0.1*</td>
</tr>
<tr>
<td>19 &lt; score ≤ 35</td>
<td>0.5 (0.4, 0.6)</td>
<td>&gt;0.1*</td>
</tr>
</tbody>
</table>

*The relationship is reversed, i.e. the probability of treatment in the south is significantly less than in the north.

which men are bothered by their condition is closely related to the severity of their symptoms.\(^\text{16-18}\) Thus, symptom severity appears to be an acceptable proxy indicator of need for treatment in an analysis such as this one.

Third, not all men over the age of 55 years with lower urinary tract symptoms will have bladder outflow obstruction caused by an enlarged prostate. One study has suggested that an enlarged prostate is responsible in about only 70 per cent of cases.\(^\text{11}\) Even if this were true, it can be assumed that similar proportions of symptomatic men in the south and in the north would have an obstruction. This factor would therefore only affect the absolute probabilities of treatment but not the relative levels between the two areas.

Unlike the earlier study which compared areas of the United Kingdom and United States,\(^\text{7}\) the difference in prevailing rates between the north and the south of England was only 26.5 per cent. Despite this modest difference, significant differences in patient selection have been found. Whereas in the international comparison the impact was confined to mild and low-moderate men, in this study it was the low-moderate and high-moderate men whose probability of treatment was affected. It was reassuring to find that a mere 7–8 per cent of men undergoing surgery reported only mild symptoms, as these men can expect to make only small gains in health (unless they also happen to be suffering from chronic retention). It was equally reassuring to find no significant difference in treatment probabilities among severely symptomatic men, who make up over half of all surgical cases. Given the surgeons' lack of opportunity to manipulate intervention rates among mild and severe men, they inevitably have to balance supply and demand among the moderately symptomatic categories. This is indeed what was found. To this extent, the surgeons were rationing their resources in a sensible way, though not as stringently as could be achieved. The finding that high-moderate men were 53 per cent more likely to be operated on in the south than the north was worrying, if it reflects supply rather than demand factors. Such men stand to gain much from surgery and should not be denied that opportunity.

The approach used in this study can contribute to our understanding of the implications of variations in intervention rates. Until more such studies are performed, the relevance and importance of process variations will remain unclear and the subject of speculation by clinicians, managers and politicians.

Acknowledgements

We thank Duncan Hunter (population prevalence), Mark Emberton (surgical cohorts), Jon Nicholl (private data) and Dave Foot (NHS data) for providing data. Data collection on the surgical cohorts was originally funded by the Department of Health.
Appendix

\[ P(\text{Treatment}|X) = \frac{P(X|\text{Treatment}) \times P(\text{Treatment})}{P(X)} \]

where \( X \) is a value of the symptom severity score, \( P(X|\text{Treatment}) \) is the proportion of treated men with severity score \( X \), \( P(\text{Treatment}) \) is the prostatectomy rate and \( P(X) \) is the proportion of the population with score equal to \( X \).

The differences in probability of treatment is formally tested by examining the ratio and testing it against the value of unity. Using the delta method, the mean and standard deviation of the loge ratio can be found and can be approximated to the Normal distribution so that the Z test can be used to test whether the loge of the ratio is significantly different from zero.

\[
\text{Ratio} = \frac{P(\text{treated}|X, \text{south})}{P(\text{treated}|X, \text{north})} = \frac{[P(X|\text{treated}, \text{south}) \times P(\text{treated}|\text{south})]}{[P(X|\text{treated}, \text{north}) \times P(\text{treated}|\text{north})]}
\]

\[
\log_e(\text{ratio}) = \ln\left[\frac{P(X|\text{treated}, \text{south})}{P(X|\text{treated}, \text{north})}\right] + W
\]

where \( W = \ln[P(\text{treated|south})/P(\text{treated|north})] = \ln(\text{ratio of prostatectomy rates}).

The distribution of the quantity on the right side of equation (1) can be shown to be approximately Normal, with mean = \( \ln(p.S) \), variance = \( [1 - p.S]/[n.Sp.S] \), where \( p.S \) is raw proportion of treated cohort in south with score \( X \), \( n.S \) is cohort size and similarly for the proportion in the north treated cohort.

\( W \) is the ratio of prostatectomy rates in the south and north. Hence it is estimated by \( 0.01112/0.00879 \). The mean distribution of \( \ln W \) is estimated by \( \ln(0.01112/0.00879) \). The standard error is the error in the prostatectomy rates and, as explained previously, this will be small and so is estimated to be 5 per cent.