

## REVISION KNEE REPLACEMENT IN ENGLAND AND WALES: AN AUDIT OF HOSPITAL VOLUME

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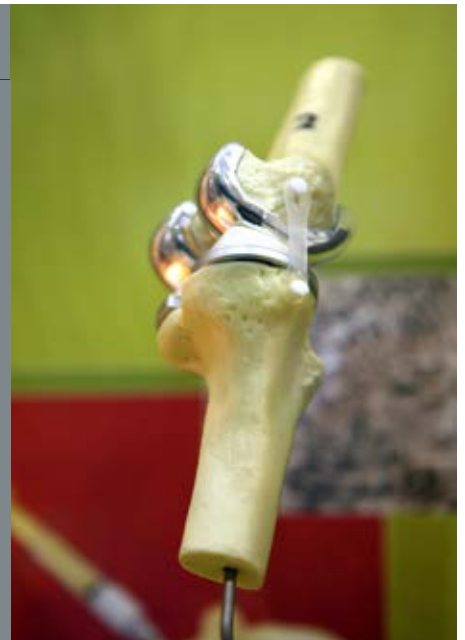
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**Increasing surgeon and hospital volume improves outcome following a range of surgical procedures,<sup>1</sup> including primary and revision knee surgery.<sup>2,3</sup> Increasing operative volume leads intuitively to greater familiarity and experience. This is particularly important for those surgeons and centres undertaking complex procedures that are often performed infrequently.<sup>4-6</sup>**

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This correlation has led the paediatric cardiology services in England and Wales to restructure their services. By centralising surgical expertise in fewer larger centres, they aim to produce better patient outcomes, and ensure vital services are safe and sustainable for the future.<sup>7,8</sup> Benefits of this type of service model include delivery of a trained workforce of experts, producing better training for surgeons in surgical centres at the forefront of modern working practices and technologies.<sup>8</sup> These specialist centres would ultimately form a network facilitating collaboration in research and clinical development and encouraging the

sharing of knowledge across the network. Revision knee arthroplasty is a complex and demanding procedure requiring meticulous planning, a skilled surgical team and familiarity with an adequate inventory of the necessary equipment. It does not produce the same outcome as that seen after primary replacement<sup>9</sup> and the ability to restore or improve quality of life is not as consistent.<sup>10</sup> Restructuring this service into fewer higher volume centres would therefore be theoretically beneficial, especially if an audit of current practice showed there was a large number of centres performing relatively few revision procedures.

**FIGURE 1**

NUMBER OF REVISIONS PERFORMED BETWEEN 1 JULY 2008 AND 30 JUNE 2010 IN THE 359 INSTITUTIONS ENTERING REVISION KNEE DATA ON TO THE NATIONAL JOINT REGISTRY, ORDERED BY REVISION VOLUME; RED = 20 REVISIONS, ORANGE = 50 REVISIONS, GREEN = 100 REVISIONS

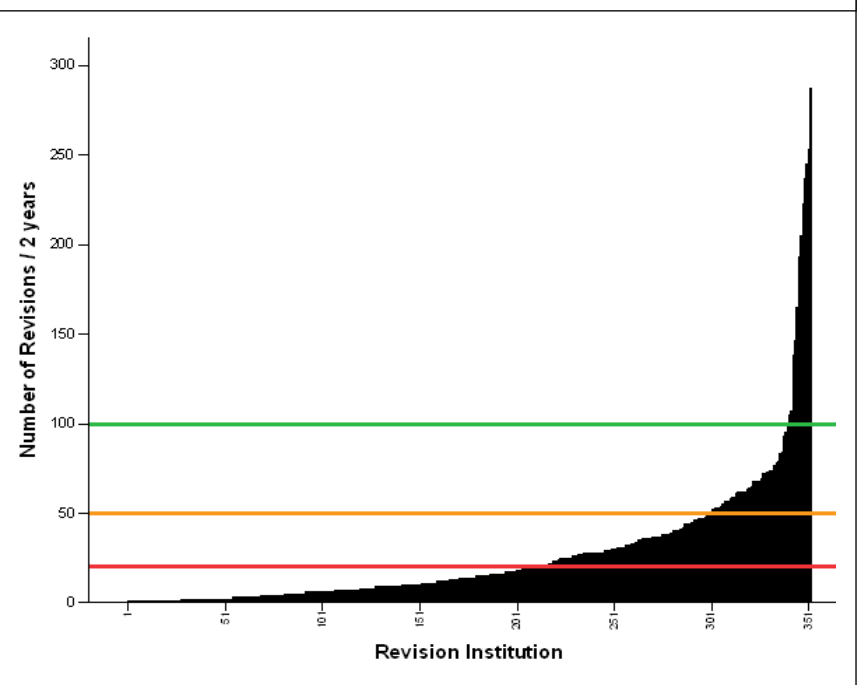
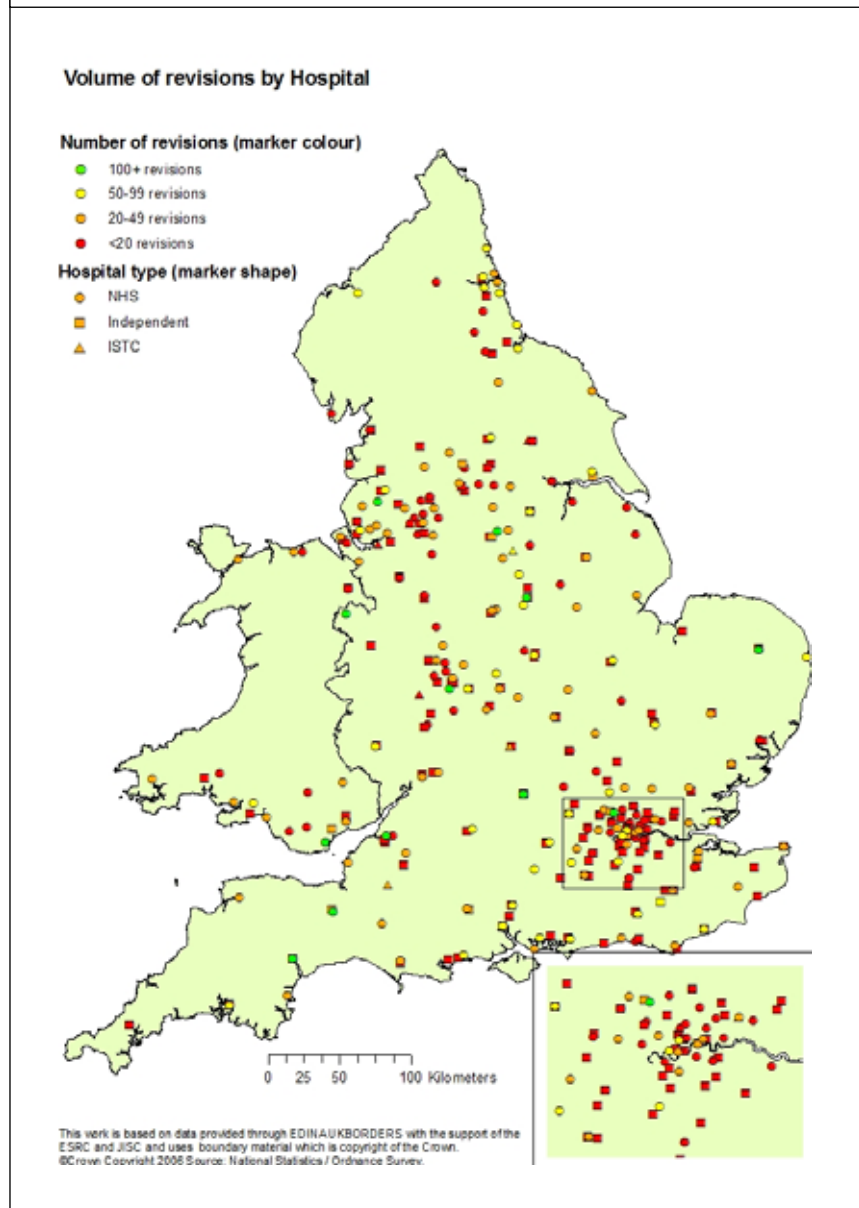


FIGURE 2

## DISTRIBUTION OF THE CENTRES PERFORMING KNEE REVISION SURGERY WITH VOLUME OF REVISIONS



We therefore audited all centres performing revision knee procedures for a two-year period. All centres were audited against two pre-defined standards linked to hospital volume: 1) operative volume should be >10 revisions per year; 2) more than 2.5 revisions should be performed for every 100 primary arthroplasties implanted.

### Methods

National Joint Registry for England and Wales (NJR) data were accessed for all knee revisions performed between 1 July 2008 and 30 June 2010. In total, 359 centres undertook at least 1 revision during this period. For each centre, information was available on the volume of primary and revision knee procedures undertaken. Additional information on the

hospital name, hospital type (National Health Service [NHS], independent hospital, independent sector treatment centre [ISTC]) and associated NHS trust) was collected. This information was verified independently using the hospital internet home page and the Dr Foster Hospital Guide (<http://www.drfoosterhealth.co.uk/hospital-guide>).

### Development of audit standards

For each centre, two aspects of surgical volume were audited: the annual revision volume and the proportion of revisions per 100 primary procedures. These were chosen as both influence the exposure to revision and development of revision experience.

Based on the work of Lavernia and Guzman,<sup>6</sup> Judge *et al*<sup>11</sup> and Yasunaga *et al*<sup>12</sup> on the effects of surgical volume in primary and revision arthroplasty, hospitals were defined as 'low volume' if they performed fewer than 20 revisions over the two-year period (10 per year). Centres performing 20 or more revisions over the course of the two-year period were defined as 'high volume'. These centres were further stratified based on volume (20–49 per 2 years, 50–99 per 2 years, >99 per 2 years) to help determine the geographical spread of the highest-volumes centres. The number of revisions performed per 100 primary knee arthroplasties has not been described previously. Centres performing fewer than 2.5 revisions per 100 primary arthroplasties were therefore defined arbitrarily as 'low ratio revisers'.

### Distribution of centres in England and Wales

Using hospital postcodes, each hospital was plotted on a map of England and Wales to demonstrate the distribution of centres undertaking revision surgery and their associated surgical volume. Postcodes were linked to grid references via the National Statistics Postcode Directory for August 2010, available from <http://edina.ac.uk/>. Analysis was performed using SPSS® version 13 (SPSS, Chicago, IL, US). Mapping was undertaken in ArcGIS® 9.3 (Esri, Aylesbury, UK).

### Data quality

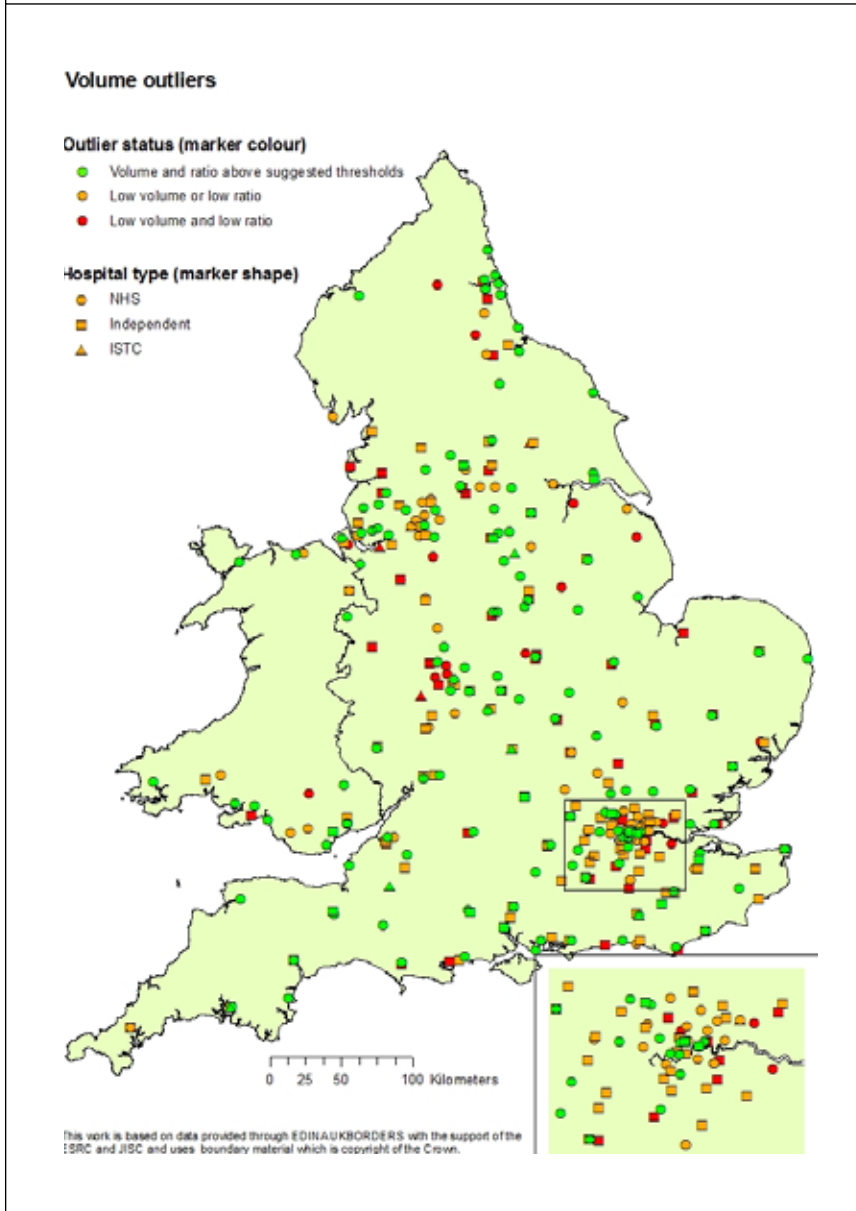
The quality of NJR data is linked to three key measures: linkability, consent and compliance.<sup>13</sup> For the purpose of this analysis, we were interested in compliance, which refers to the NJR's ability to capture all procedures performed. This aspect of data quality is measured by comparing the number of procedures recorded against the levy returns for the number of implants sold, and for 2009 it was 97.8%.<sup>13</sup>

### Results

During the two-year study period, 396 different centres performed 153,133 primary knee arthroplasties. Of these, 359 (91%) performed 9,659 knee revisions, equivalent to 6.3 revisions for every 100 primary arthroplasties performed. Revision centres included 208 NHS hospitals (58%) performing 8,148 revisions, 141 independent hospitals (39%) performing 1,258 revisions and 10 ISTCs (3%) performing 253 revisions.

**FIGURE 3**

DISTRIBUTION OF THE CENTRES PERFORMING KNEE REVISION SURGERY WITH CLASSIFICATION BASED ON VOLUME OF REVISIONS AND RATIO OF REVISIONS TO PRIMARY PROCEDURES



**Annual revision volume**

The median number of revisions performed per hospital was 14 over the course of 2 years (range: 1–287). There was a difference in the number of revisions performed by hospital type, with NHS hospitals performing a median of 28 (range: 1–287), compared with 6 (range: 1–84) for independent hospitals and 22 (range: 1–73) for ISTCs (NHS vs independent: Kruskal–Wallis test,  $p < 0.001$ ).

Figure 1 demonstrates the volume of knee revision procedures performed at each centre. Twenty-eight centres performed only one revision per two years (Table

1). Two hundred and twelve centres (59%) were classified as low volume (<20 revisions per 2 years), accounting for 1,573 revisions (16%). In contrast, the 12 highest-volume centres (>99 revisions per 2 years) performed 2,304 revisions (24%). Overall, 78 of the 208 NHS hospitals (38%) were classified as low volume, compared with 128 of the 141 independent hospitals (91%) and 6 of the 10 ISTCs (60%). The geographical distribution of centres performing revisions is shown in Figure 2.

**Revisions per 100 primary arthroplasties**

The median number of revisions per 100 primary knee arthroplasties was 5 (range:

0–300). Prior to further analysis, the hospital with a value of 300 was excluded as this was found to be a significant outlier representing an independent hospital that performed 2 primary procedures and 6 revisions during the period of analysis. There was a difference in revisions per 100 primaries that was dependent on hospital type, with NHS hospitals performing a greater number (median: 7, range: 0–76) than either independent hospitals (median: 3, range: 0–16) or ISTCs (median: 2, range: 0–6) (NHS vs independent and/or ISTC, Kruskal–Wallis test,  $p < 0.001$ ).

In total, 80 centres were classified as low ratio revisers (22 NHS hospitals, 52 independent hospitals, 4 ISTCs). Fifty-seven centres performed more than ten revisions per hundred primary procedures, including all of the twelve highest-volume hospitals, possibly indicating the tertiary nature of their practice.

**Combining audit standards**

Of the 359 centres performing knee revisions, 212 were classified as either low volume or low ratio revisers and therefore fell below the audit standards. All 80 low ratio revisers were also low-volume centres. Ninety-one per cent (128/141) of all independent hospitals fell below the audit standards. Of the 147 centres meeting the audit standards, 130 were NHS hospitals (63% of the 208 NHS hospitals), 13 were independent hospitals (9% of the 141 independent hospitals) and 4 were ISTCs (40% of the 10 ISTCs).

A final geographic plot was constructed based on the following three groups: i) volume <20 per 2 years and <2.5 revisions per 100 primary procedures; ii) volume <20 per 2 years or <2.5 revisions per 100 primary procedures; iii) volume  $\geq 20$  per 2 years and  $\geq 2.5$  revisions per 100 primary procedures. This demonstrated that the 147 centres in the third group were evenly distributed across England and Wales (Figure 3).

**Discussion**

A significant proportion of centres in England and Wales are performing knee revisions in small volumes. The majority of centres (212/359, or 59%) fell below one or the other of our audit standards for volume (<20 revisions per 2 years or <2.5 revisions per 100 primary procedures) and 80 centres fell below both. This included

Number of revisions	Number of centres	Percentage	Cumulative percentage	Centre type
1	28	7.8%	7.8%	Indep = 21 ISTC = 1 NHS = 6
2–5	65	18.1%	25.9%	Indep = 43 ISTC = 2 NHS = 20
6–10	61	17.0%	42.9%	Indep = 40 ISTC = 0 NHS = 20 N/A = 1
11–19	59	16.4%	59.3%	Indep = 25 ISTC = 3 NHS = 31
20–49	91	25.3%	84.7%	Indep = 11 ISTC = 2 NHS = 77 N/A = 1
50–99	43	12.0%	96.7%	Indep = 1 ISTC = 2 NHS = 40
>99	12	3.3%	100.0%	Indep = 0 ISTC = 0 NHS = 12

nearly all independent hospitals. The distributions of both the annual revision volume and the number of revisions per 100 primary procedures are skewed to the right, indicating that there are a high number of low volume centres and centres performing considerably more primary procedures than revisions.

An association between increased volume and a variety of outcomes – including functional scores,<sup>5,14,15</sup> mortality,<sup>6,11</sup> length of stay,<sup>4,6</sup> complication rates,<sup>1,11</sup> intensive care unit requirement<sup>16</sup> and rates of home discharge<sup>17</sup> – has been reported previously across a range of surgical procedures. Greater familiarity and experience with complex surgical procedures increases confidence and understanding at both the individual surgeon and hospital level. In a systemic review of 163 articles, Chowdhury *et al* found that 74.2% of the papers reviewed reported significantly improved outcomes in higher volume centres.<sup>1</sup> Increasing hospital volume has been shown to improve functional results at two years following total knee replacement,<sup>14,15</sup>

and to reduce mortality rates after primary and revision knee arthroplasty.<sup>6,11</sup>

Given the clear relationship between volume and outcome, thought should be given to whether the 80 centres falling below both audit standards should be performing revision procedures. The other 132 centres below one of the suggested audit standards should look at their practice as well as that of surrounding centres and consider amalgamating services to help ensure sufficient volumes are maintained. Theoretical benefits of restructuring service in this way include improved clinical outcomes, enhanced surgical training, integrated modern working practices, and the development of clinical and research networks through inter-unit collaboration.<sup>8</sup>

This poses two questions: What volume of surgery is enough and how might services be rationalised? A number of authors have suggested values for minimum surgeon volumes (>15 to >100

total knee replacements per year)<sup>15,18,19</sup> and trust volumes (>50 total knee/hip replacements per year)<sup>11</sup> for primary arthroplasties. As far as we are aware, no suggested minimum surgeon volume exists for knee revision, largely owing to methodological issues in the previous studies analysing this subset of patients.<sup>2</sup>

We have suggested that hospitals should undertake a minimum of 20 revisions every 2 years (10 per year), based on the articles of Lavernia and Guzman<sup>6</sup> and Yasunga *et al*.<sup>12</sup> This threshold is at the lowest end of those used in articles assessing the impact of hospital volume and should therefore only exclude the very lowest-volume users. It also seems intuitively reasonable when one considers that in many centres there may be multiple surgeons each performing only one or two revisions per year. We also felt that the proportion of revisions to primary procedures was an important variable to consider and suggest that centres should ideally be performing >2.5 revisions per 100 primary procedures.

Strategies to reduce the number of low-volume NHS centres ( $n=78$ ) could include centralisation of service at a local trust level and contracting knee revisions to neighbouring higher-volume centres/trusts. Consideration also needs to be given to whether independent hospitals and ISTCs are equipped suitably to undertake revision surgery. We found that the majority of these hospital types (134/151, or 89%) fell below the suggested audit standards. These hospitals undertook only 1,511 revisions, representing 16% of all revisions. By rationalising the use of independent hospitals and ISTCs, the number of centres performing revisions would be halved. Many larger NHS facilities have access to private facilities that could accommodate the private workload while maintaining higher centre volumes.

There are limitations to this audit. As discussed previously, the audit standards used lack supportive evidence from the literature, although they were chosen to exclude only the very lowest-volume centres. No centre doing 20 or more revisions per 2 years performed fewer than 2.5 revisions per 100 primary procedures. This serves to vindicate this value as a cut-off point. Unfortunately, we had no information on surgeon volume. However, the literature supports both centre and surgeon volume as independent predictors of outcome,<sup>16</sup> and it is therefore entirely appropriate to look at hospital volume in isolation.

## Conclusions

A significant number of institutions are performing small volumes of knee revision procedures. To ensure safe and sustainable practice with better outcomes for patients, consideration should be given to whether this service would be better concentrated in fewer centres performing higher revision volumes.

Centres performing the lowest volumes of knee revisions should either stop performing revisions or give consideration to amalgamating services locally to help ensure sufficient volumes are maintained.

## Ethical approval

This piece of work was undertaken as a service evaluation after discussion with the chairpersons of the local research and ethics committee. As such, it was exempt from formal ethical approval. This work was funded by a fellowship from the NJR. The authors conformed to the NJR's standard protocol for data access and publication. The sponsor was involved in data collection (as data were accessed directly from the NJR database) but was not involved in the design of this analysis, the interpretation of the data or the writing of the article.

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The authors have conformed to the NJR's standard protocol for data access and publication. The views expressed represent those of the authors and do not necessarily reflect those of the NJR steering committee or the HQIP, who do not vouch for how the information is presented.

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