School of Social Sciences
CITY UNIVERSITY LONDON

Department of Economics

Using the EQ-5D as a performance measurement tool in the NHS

Nancy J. Devlin[1]
Office of Health Economics

David Parkin[2]
City Health Economics Centre, City University London

John Browne
London School of Hygiene and Tropical Medicine

Department of Economics
Discussion Paper Series
No. 09/03

[1] Office of Health Economics12 Whitehall London SW1A 2DY Telephone: +44 (0)20 7747 8858
[2] City Health Economics Centre, Economics Department, City University, London EC1V OHB Phone: +44 (0) 20 7040 0171 e-mail: *d.parkin@city.ac.uk*

Using the EQ-5D as a performance measurement tool in the NHS

Nancy J. Devlin[1], David Parkin[2] and John Browne[3].

1. Office of Health Economics, London
2. City Health Economics Centre, Department of Economics, City University, London.
3. London School of Hygiene and Tropical Medicine, London

Correspondence to:

Professor Nancy J. Devlin
Office of Health Economics
12 Whitehall
London SW1A 2DY
Telephone: ++44 (0)20 7747 8858
Fax: ++44 (0)20 7747 8851
Mobile: 07 515 974 978

Keywords: EQ-5D; PROMs, health outcomes; performance indicators.
Word count: 5,976

Using the EQ-5D as a performance measurement tool in the NHS

Abstract

In a landmark move, the UK Department of Health (DH) is introducing the routine use of Patient Reported Outcome Measures (PROMs) as a means of measuring the performance of health care providers in improving patient health. From April 2009 all patients will be asked to complete both generic (EQ-5D) and condition specific PROMs before and after surgery for four elective procedures; the intention is to extend this to a wide range of other NHS services. The aim of this paper is to report analysis of the EQ-5D data generated from a pilot study commissioned by the DH, and to consider the implications of the results for their use as performance indicators and measures of patient benefit. The EQ-5D has the potential advantage in the context of PROMs of enabling comparisons of performance across services as well as between providers; and in facilitating assessments of the cost effectiveness of NHS services. We present two new methods we have developed for analysing and displaying EQ-5D profile data: a Paretian Classification of Health Change, and a Health Profile Grid. Using these methods, we show that EQ-5D data can readily be used to generate useful insights into differences between providers in improving overall changes in health; results are also suggestive of striking differences in changes in health between surgical procedures. We conclude by noting a number of issues that remain to be addressed in the use of PROMs data as a basis for performance indicators.

1. Patient Reported Outcomes and health sector decision making.

There has been a marked shift, internationally, in thinking about what health is and how it is measured. Traditional clinical ways of measuring of health and the effects of treatment are increasingly accompanied by or indeed replaced with patient reported outcomes (PROs). The United States' Food and Drug Administration, which recently recommended the inclusion of PROs in clinical trials [1], notes that "the use of PRO instruments is part of a general movement toward the idea that the patient, properly queried, is the best source of information about how he or she feels' [2]. In the UK, the National Institute for Health and Clinical Excellence (NICE) has, since its inception, required the use of PROs data in evidence submitted to it [3]. More recently, the potential for using PROs data in still other ways, to inform a wide range of different decisions, has been recognised [4,5,6].

A landmark development in this area is currently taking place in the National Health Service (NHS) in England. From April 2009, the English Department of Health (DH) will require the routine measurement of patient reported health outcomes for all NHS patients before and after receiving surgery, via its PROMs (Patient Reported Outcome Measures) initiative. Initially this requirement applies to four surgical procedures - hernia repair, hip and knee replacement and varicose veins [7] – but the intention is to roll out PROMs across a wide range of NHS services.

The DH plans to use the PROMs data to measure and manage the performance of hospitals in improving patient health. The results will be included in the information provided to patients being referred for surgery, to assist them in choosing the hospital at which they will receive treatment. Ultimately, and as it is rolled out over a wider range of NHS-funded treatments in subsequent years, the data will also be used to inform wide ranging issues about productivity in the NHS [8], value for money, resource allocation and demand management [4,5]. The possibility of directly linking hospitals' reimbursement to their performance in terms of PROMs, rather than to the delivery of services, has also been proposed [9]. A related UK development is the proposal to introduce 'value based pricing' for pharmaceuticals, with prices to be based on 'value to patients', presumably reflecting improvements in patient reported health outcomes and extensions in length of life [10].

This is a significant development for the NHS. For the first time, the NHS will seek to measure what it produces in terms of *health*, rather than in terms of the production of *health care*. The

overarching intention is that, in addition to clinical measures of outcome, PROMs will enable patient perspectives to be taken into account at a variety of levels within the UK health care system. This reflects key themes in NHS reforms to improve responsiveness to patients' views, preference and choices. [11]

From an economics perspective the PROMs initiative is of considerable interest. A key aspect of PROMs is that they will allow each hospital's performance to be benchmarked against others'. Analyses of productivity and efficiency can be refocused on health rather than the traditional measures of activity. Further, the initiative represents the first attempt internationally to use the EQ-5D [12] as a routinely collected performance indicator. The EQ-5D, a generic PRO instrument that is described in the following section, is widely used in studies to determine the cost effectiveness of health care – for example, it is the instrument required by NICE for evidence submitted to its technology appraisals process [3]. Because the EQ-5D is accompanied by value sets [13], it facilitates the estimation of Quality Adjusted Life Years (QALYs). The use of the EQ-5D in the context of PROMs will therefore enable these data also to be used to undertake economic evaluations. Whereas economic evaluation has tended to focus on new technologies, these data will enable much broader assessments of value for money across the NHS, comparing both new technologies and extant services.

The aim of this paper is to report analysis of the EQ-5D data included in a pilot study which preceded the implementation of PROMs, and to consider the implications of these results for PROMs' use as performance indicators and measures of patient benefit.

2. The PROMs initiative

The data to be collected in the DH's PROMs initiative include a condition-specific health status measurement instrument relevant to each surgical procedure and the EQ-5D, a generic instrument [2]. The EQ-5D comprises two elements. The first, the EQ-5D self-classifier, asks patients to classify themselves as having one of three *levels* of health - no problems, some problems or extreme problems - in each of five *dimensions* of health - mobility, self-care, usual activities, pain/discomfort and anxiety/depression. This results in an EQ-5D health profile for a patient. These profiles may be described by the levels (1, 2 and 3) within each of the five dimensions in the order noted above. For example, 21232 is some problems with mobility, no problems with self-care, some problems with usual activities, extreme problems with

pain/discomfort, and some problems with anxiety/depression. The second element is a visual analogue scale, the EQ-VAS, which records patients' overall assessment of their health on a scale from 100 (best imaginable health) to 0 (worse imaginable health).

The DH's introduction of the routine collection and reporting of these PROMs was informed by evidence from a pilot study commissioned from a team of researchers based in the London School of Hygiene and Tropical Medicine (LSHTM) and the Royal College of Surgeons (RCS) [14]. The first phase of the project, PROMs1, entailed a critical review of the literature. PROMs2 was a pilot study to determine the feasibility of collecting pre- and post-operative PROMs from patients undergoing elective surgery, and to investigate how such data could best be analysed and presented. The Patient Outcomes in Surgery (POIS) project currently underway [15] is an extended pilot with a larger sample of patients and hospitals.

The PROMs2 study entailed recruitment and tracking of prospective cohorts of patients receiving surgery for each of 5 surgical procedures: unilateral hip replacement; unilateral knee replacement; groin hernia repair; varicose vein surgery; and cataract surgery. These had been selected by the DH for the variety of medical complexity and specialty that they represented.

In each case, the PROMs data were collected from patients both before and after surgery. They included the EQ-5D profile, but not the EQ-VAS, the SF-36 [16] and a disease specific measure. Data were also collected on a wide range of clinical and other patient characteristics, for example age, sex, duration of symptoms, previous surgery, co-morbidity, pre-operative health status and post-operative complications.

Funnel plots were used as the principal means of comparing performance between centres, both for health outcomes and post-operative complications. The health outcome was defined as the health state reported by patients *after* surgery. For the EQ-5D, this was the mean of a post-operative 'score', generated for each patient by assigning to their EQ-5D profile its value from the 1993 Measuring and Valuing Health (MVH) study [17]. The use of these EQ-5D 'social values' is common practice in economic evaluation. These mean scores for each centre were plotted against the number of operations in each centre. Superimposed on this is a benchmark of the mean post-operative score across all centres and a confidence interval around that. These figures were also risk-adjusted, using linear regression to estimate post-operative scores from pre-operative scores, patient characteristics and the Index of Multiple Deprivation (IMD).

Figure 1 shows an example funnel plot for hip replacement surgery. The hollow circles represent each centre's unadjusted post-operative EQ-5D score; the solid circles show the score adjusted for various risk factors. The horizontal line represents 'target performance': the mean post-operative score for all centres combined, which in this case = 0.74. In the case shown here, there is no statistically significant difference, at the 95% control limit, between each centre's adjusted post-operative EQ-5D score and the target performance.

The pilot study made considerable headway in establishing the feasibility of collecting PROMs data, and in understanding the nature of the data likely to emerge from larger scale use of them in the NHS. However, questions remain about the data and findings relating to the use of the EQ-5D in this context.

First, as noted above, the EQ-5D profile data were analysed by calculating a single summary score, by assigning each profile its 'social value'. Although having a single value to represent a health state makes the data more amenable to statistical analysis, it means that the descriptive richness provided by the profile is lost, with the potential to lose information that might inform the assessment of performance.

Moreover, the method of assigning a summary score has conceptual and statistical problems attached to it. The 'social values' were obtained by statistical modelling of valuation data obtained from members of the general public, using the Time Trade Off (TTO) method for EQ-5D states that were hypothetical to them [17]. Although the rationale for using social values in economic evaluation is clear and widely accepted, it is less clear that there is a compelling rationale for their use in PROMs. Arguably, the use of social values means that the data can no longer be regarded as purely *Patient* Reported Outcome Measures, since each patient's score incorporates values that reflect the preferences of the general public, not those of the patients. More importantly, this process also introduces an exogenous source of variance into the data, unrelated to the underlying levels of and changes in health reported by patients. Specifically, the statistical significance of any changes in health might be affected by the particular set of values chosen [18]. There is therefore a risk of concluding that a significant change has occurred in a given direction – an improvement or deterioration in health - and with a given magnitude, when that result is contingent upon the properties of the particular value set used.

If a single score is required for the purposes of statistical analysis, this problem may be avoided by using the EQ-VAS scores. However, the PROMs2 study did not collect these.

Secondly, the analysis focused on *post*-operative scores as the indicator of final health outcomes arising from surgery. However, economic analysis would usually regard the outcome of health care as the *changes* in health that it produces. Re-focusing the analysis on the change in patient-reported health might reveal a different picture of variations between surgical procedures, patient types, and providers.

In the light of these concerns, specific objectives of this paper are: (i) to test the insights that emerge from focusing the analysis on the change in health outcomes instead of post surgical outcomes; and (ii) to develop and test new ways of analysing EQ-5D profile data that require the use of neither social value sets nor patients' EQ-VAS scores. Even when EQ-VAS data are available to summarise the EQ-5D profile, or where the use of social value sets is clearly justified, the profile data themselves comprise an important source of information about patients' perceptions of their own health. Analysis of the profile data adds important insights into underlying changes in patient reported health. EQ-5D profile data tend to be under-analysed - and there is relatively little guidance currently available to users on useful and creative means of doing so.

In the following section we describe the data available from PROMs2. We describe standard ways of reporting EQ-5D profile data, and then outline new analytical approaches we have developed for that purpose, and the corresponding results. We conclude by discussing the implications of our results, and note a number of remaining issues and challenges for this innovative use of the EQ-5D.

3. Data

Data were obtained from the PROMs2 pilot study described above. Patients were recruited at 24 health care providers: 7 NHS treatment centres; 13 NHS acute hospital trusts; 2 independent sector hospital treatment centres; 1 private hospital (exclusively treating NHS-funded patients) and 1 NHS general practice (for hernia repair only). 570 patients were recruited for groin hernia repair; 677 for cataract surgery; 397 for hip replacement; 400 for knee replacement; and 363 for varicose vein surgery.

Patients were surveyed before and after surgery, using paper based self-completion questionnaires. In each case, the questionnaire included both the generic (EQ-5D) profile, and a condition specific instrument. These were the VF-14 (for cataract surgery); Aberdeen Varicose Vein questionnaire (varicose vein surgery); Oxford Knee Score (knee replacement) and Oxford Hip Score (hip replacement). In the case of groin hernia repair, no disease specific instrument was available, so the SF-36 was used. SF-36 data were also collected for patients undergoing hip replacement.

In addition to patients' self-reported health, data were collected on clinical characteristics (frequency and duration of symptoms; previous surgery; co-morbidities; general health) and socio-demographic characteristics (age; sex; and an indicator of socioeconomic deprivation based on participants' postcodes). Post surgical questionnaires additionally sought the patients' views about the results of their surgery and post surgical complications.

The overall response rate to the post-operative questionnaires was 86%, ranging from 75% for varicose vein patients to 92% for hip replacement. Full details of the sample recruitment and questionnaires are available in Browne et al (2007) [14].

4. Analysing and reporting EQ-5D profiles

Simple approaches to reporting of EQ-5D profiles and profile changes

The EQ-5D profile data in effect consist of five ordinal variables, one for each dimension. The simplest way of reporting these data is to describe the number and proportion of the sample reporting each of the levels on each of the dimensions. The *change* in numbers and proportions as a result of health care can then be calculated. Table 1 gives an example of this for hip replacement surgery. This gives a more detailed picture of the changes in self-reported health arising from hip replacement surgery than an index score change would provide, with the potential to show some interesting and perhaps unexpected findings. For example, it might be expected that hip replacement surgery would mainly affect pain/discomfort, mobility and usual activities because, as the pre-operative data show, these are the dimensions that are most affected in this patient group. However, the data also suggest that improvements in anxiety/depression and self care are proportionally even greater than the other dimensions.

This way of presenting the health profile data can be useful, particularly when, as in this case, the impact on quality of life of the disease and its treatment are clear. However, the disadvantage of reporting EQ-5D profiles in this way is that it is difficult to get a clear picture of overall health and how it has changed, which will be especially important where more subtle impacts and changes are involved. We therefore proceed by developing and testing a number of ways in which the overall changes in health on the EQ-5D profile might be summarised without creating a single summary score.

Using Paretian principles to judge overall improvements in EQ-5D profiles

The challenge is in judging whether overall health has improved when we cannot compare the relative importance of changes in different dimensions of health. This is analogous to the task in welfare economics of judging whether overall social welfare has improved when changes in the utility of different individuals are not interpersonally comparable. A well-known solution to the latter is to apply the Pareto principle: that there is an improvement if at least one person is made better off and no-one is made worse off [1]. Translated to the health profile context, this suggests the following:

- A health profile is better than another if it is better in at least one dimension, and is no worse in any other dimension.
- A health profile is worse than another if it is worse in at least one dimension, and is no better in any other dimension.
- Overall health has improved if it has improved in at least one dimension, and has not worsened in any other dimension.
- Overall health has worsened if it has worsened in at least one dimension, and has not improved in any other dimension.

Using this principle, it is possible for every pair of different EQ-5D health profiles, x and y, to determine logically one of three relationships: x is better than y; x is worse than y; or they are non-comparable. Non-comparability arises when there is a mix of 'better' and 'worse' across dimensions and no weight is assigned to the relative size or value of these differences. This in turn means that there is a logical ordering of all of the possible health profiles within the EQ-5D descriptive system, but it has many tied ranks and is therefore a partial rather than a full

[1] This is the strong variant of the Pareto principle. The weak variant is that if all persons are better off, then the change improves social welfare. The corresponding interpretation of the weak variant for health profiles is that if all dimensions are improved, then overall health state has improved.

ordering. Moreover the relationships 'better than' and 'worse than' are both transitive, but the relationship 'cannot be compared to' is not, making the ordering much more complex[2].

In comparing two actual EQ-5D health profiles - which, in the context of PROMs, means before and after surgery - there are therefore four possibilities:

1 The health profiles are the same; there has been no change in health state.
2 The second profile is better than the first; there has been an unequivocal improvement in health.
3 The second profile is worse than the first; there has been an unequivocal worsening in health.
4 The first and second health profiles are non-comparable; there has been a change in health but without further information we cannot say if it is an improvement or worsening.

Table 2 shows the overall distribution of changes for the five surgical procedures in the PROMs data according to this *Paretian Classification of Health Change*.

The advantage of reporting profile data in this way, compared to Table 1, is that it is much simpler and captures what is happening at the level of the patient rather than at the level of the dimension. A potential disadvantage is that if the 'mixed change' category dominates, the Paretian approach will not be of much practical use. However, for each of these five surgical procedures, more than 90% of the changes are *not* mixed but fall quite straightforwardly into the other categories. This is especially interesting because it is only these mixed changes that require the use of value sets to weigh up improvements in health in some dimensions against the deterioration of health in others.

Looking at the results themselves, there are interesting differences across the surgical procedures on this categorisation. Hip and knee surgery result, in the vast majority of patients, in an unequivocal improvement in health. However, only around half of the patients who had hernia or vein surgery and just one fifth of those who had cataract surgery experience an unequivocal improvement in health. These data are displayed as pie charts in Figure 2. Pie charts have the merit of being readily understood (by patients, for example), and have the additional advantage

[2] Denoting 'better than' as > and 'worse than' as <, if x>y and y>z then x>z and if x<y and y<z then x<z. However, denoting $\Re$ to mean 'not comparable to', if x $\Re$ y and y $\Re$ z, it is not necessarily true that x $\Re$ z. For example, 12121 $\Re$ 12211 and 12211 $\Re$ 12122, but 12121 > 12122.

in this context of avoiding an implied ordering of the categories. While 'improve' is clearly better than 'worsen', 'mixed change' could potentially be better than 'improve' or worse than 'worsen'.

A notable feature of the results in Table 2 is the number of patients reporting 'no change' in their EQ-5D profile. That is, these patients' self reported health on the EQ-5D after surgery was identical to that before surgery. We investigated further those with 'no change', which revealed that some cataract, hernia and veins patients classified as having 'No change' had, according to the EQ-5D, no problems in any dimension both before and after their operation. There were no such cases for hip or knee operations. Taking account of this gives the distribution of outcomes in Table 3.

In each case, more patients can be categorised as having 'No problems' than 'No change' and there are in particular a very large number of cataract patients who did not have any problems before surgery according to the EQ-5D. The effect of considering such patients separately is to improve the view of how effective the procedures are. This is clearly demonstrated when these data are represented as histograms, as in Figure 3. Histograms are one alternative to pie charts as a means of visually displaying these data; they are a better means of comparing different sets of proportions across multiple series of data. If those with 'no problems' are included as having no change, as in the second column of histograms, this gives a less clear indication of the dominance of improvements, in the cases of hernia and veins, and of worsening, in the case of cataracts, compared with if they are excluded, as in the third column of histograms.

Displaying individual changes in health status using a Health Profile Grid

The EQ-5D has five dimensions, with three levels within each, which defines $3^5 = 243$ possible unique profiles. The number of possible pairs of health states in before-and-after treatment comparisons is 243 x 243 = 59,049. Because of these large numbers, it is difficult to display each individual change in the health profile. However, it is possible to do this in graphical format on a *Health Profile Grid* if the 243 health profiles can be placed in rank order.

Many EQ-5D profiles can be ranked by prior logic – for example, state 22222 is logically 'better' than 22223. However, not all profiles can be ranked in this way, for example 22223 and 32222. The ranking in this case will depend on how one weights health in the first dimension (mobility) compared to the fifth dimension (anxiety/depression). There are a number of ways in

which a fully ordered ranking of the EQ-5D profiles might be achieved – for example, by considering the average EQ-VAS score reported by the patients reporting themselves in each of the EQ-5D profiles. Another means of imposing a ranking ordering is to use a social value set. For illustrative purposes, we proceed using the UK TTO value set [17]. These values do not in fact provide a full ordering, since 10 pairs of profiles have tied ranks; in those cases, the order is chosen at random[3]. It is then possible to display the health impact of the operation as before and after pairs of health profiles, as in Figures 4-9.

Figure 4 show the changes for hip operations. The diagonal line represents the same health profile before and after. Patients whose health profiles lie on the line, marked as '+', experienced no change in their health state. Those whose profiles lie above the line, marked as 'o', experienced an improvement; and those below the line, marked as 'x', experienced a worsening. It should be noted that improvement and worsening are not according to the 'Paretian' definition, but represent a positive or negative change in the UK TTO values.

The most obvious aspect of this display is the dominance of patients whose health has improved, but there are more subtle aspects. The pre-operative health states are quite varied, but the post-operative health states are within a relatively narrow band. The pre-operative health states appear to be clusters that manifest themselves as horizontal lines with gaps between them that are sometimes large; however, this is an artefact that arises from the fact that many EQ-5D health states are rarely, if ever, found in nature. It would be possible to reduce this effect by including only those health states actually found within the data, at the cost of reducing comparability between different sets of data.

To explore this issue, we looked at some large data sets, totalling over 20 000 observations of patient and general public self-reported health using the EQ-5D. In this, 161 of the 243 EQ-5D profiles are not found at all, and 22 profiles cover 90% of health states found. Although not demonstrated here, it is possible to produce a set of Health Profile Grids with different degrees of focus and comparability, based on the percentage of health states found in nature. The Health Profile Grid in Figure 4 shows 100% of the 243 states; alternative Grids could display 90%, 95% and 99% of the most frequently occurring states. The 90% Grid would contain only 22 states

[3] In the diagrams shown here, we impose a condition of 243 unique ranks. An alternative would be to allow ties, for example between any states which have the same value. Profiles with tied ranks were infrequently found in these data.

and reduce the artefactual clustering problem but limit comparability; a 99% Grid might contain only 100 states but be very informative.

The Grid for knee operations is quite similar to that for hips, and is therefore omitted. The Grids for hernia and varicose vein operations are quite different to those for hip and knee operations; however they are similar to each other and therefore only the Grid for hernia operations is shown - see Figure 5.

A few obvious observations can be based on a comparison with the Grid for hip operations. The dominance of improvement is much less marked. The improvements are also mainly for patients who had relatively good health both before and after the operation. However, the same is true for those whose health worsened. More subtle observations are that those with poorer health before the operation virtually all improved; and that those who got worse were virtually all in reasonable health before. The same is true for varicose vein operations.

Figure 6 shows the same Grid for cataract operations, which shows a picture that is different to both hip or knee and hernia or varicose vein operations.

This demonstrates most obviously the more equivocal nature of the effectiveness of cataract operations in improving health, as indicated by the EQ-5D.

It is possible to incorporate the Paretian Classification of Health Changes described earlier into these Health Profile Grids, by distinguishing those above and below the line according to whether the change in their health state was unambiguously an improvement or worsening, or is defined as such only by the index. Unambiguous changes are marked as 'o' or '+' or 'x', as before, and those that are 'mixed changes' are marked as '◊'. Figure 7 demonstrates this for hip and cataract operations, chosen because of the differences between them in terms of severity and pattern of changes.

Earlier, it was observed that 'mixed changes' on the Paretian classification represent a small proportion of all cases. We can also observe from these graphs that mixed changes do not appear to act as 'confounders' in making judgements about effectiveness. Hip operations demonstrate a preponderance of unambiguous improvements, and the mixed changes are also predominantly categorised as improvements according to the MVH values. Cataract operations

have slightly more unambiguous worsening than improvement, and the mixed changes are also predominantly categorised as worsening according to the MVH values.

Comparing providers

One of the main catalysts in the introduction of PROMs is their potential in comparing provider performance. The analyses described above can be undertaken to distinguish between providers. This introduces additional complexity into the analysis that requires further development of these techniques; the following is provided for illustrative purposes to demonstrate the potential of these analyses as a basis for performance indicators.

Table 4 shows the breakdown of outcomes in terms of changes in health classified in terms of the 'Paretian' definition, and taking account of those with no problems before or after treatment. The percentages in each category are recorded for three different types of facility. Although these are real data, the actual type of facility is not reported here to avoid any possible over-interpretation of results based on such a small sample of providers.

Taken at face value, these results suggest that Type 1 attracts a less severe case mix than Types 2 and 3. Looking at patients who do have problems according to the EQ-5D, Type 1 and Type 2 both have equal numbers who are made better or worse, but Type 3 makes many more patients worse than better, as well as having a slightly higher proportion who have no change.

Because there are different numbers of patients receiving treatment in each of the different types, the graphical representation is harder to interpret as can be seen in Figure 8, which is provided for illustration only.

Finding clusters of patient types

Figures 4-8 above are suggestive of 'clusters' of patients, defined according not only according to improvements but also by their start and end health profiles. Identifying such clusters would clearly be of great value, particularly if it identified pre-operatively the likely outcomes of an operation. Unfortunately, the problem described earlier, that some EQ-5D health states are rarely if ever encountered, does at present confound cluster analysis of this sort. The following is therefore a simple illustration of the potential of this technique. Figure 9 is the result of a cluster analysis using the kmeans procedure, identifying 6 clusters of hip operation patients.

These clusters are obviously not perfect, and they are confounded by the artefactual gaps between profiles. However, taking them at face value, Cluster 4 identifies mainly patients with poor health pre-operatively who remain at poor health; Clusters 5, 6, 3 and 1 represent patients who all experienced an improvement in health to approximately the same post-operative level, but who had increasingly severe levels of ill-health pre-operatively; and Cluster 2 represents patients who had a reasonable level of health pre-operatively – better than Cluster 5, but worse than Cluster 6 - but a mixed pattern of improvement and worsening. Clearly, this interpretation of Cluster 2 is highly dubious, but the others are more plausible.

Analysing factors that affect outcomes

One of the most valuable potential uses of outcome data is to analyse the factors that are associated with better outcomes. This has value in its own right, but it is also an important component of performance measurement, to ensure that this is not distorted by possible confounding factors, such as the different case mix that providers have. The PROMS2 report analysed post-operative EQ-5D index scores in this way as 'risk indicators'; here we analyse the Paretian change categories. Because some of these categories have small numbers of cases, the results should be interpreted with particular caution and regarded as indicative only of the potential of analysing the data in this way.

These outcome data are categorical, and cannot even be ordered because of the 'mixed change' category. We therefore estimated a multinomial logistic model, using Stata's maximum-likelihood mlogit command. Because the analyses are for demonstration, we report analyses for cataract and hip operations only, chosen because they demonstrate very different patterns of outcome categories.

A common set of explanatory variables was included: the preoperative score on the relevant condition-specific measure, VF-14 [19] for cataracts and the Oxford Hip Score [20] for hips; sex, with female coded as 1 and male as 0; age; symptom duration, in months; the number of co-morbidities; general health, comparing those who responded "fair" or "poor" to the question, "Would you say that in general your health is excellent, very good, good, fair, or poor?" with others; the Index of Multiple Deprivation (IMD); and categorical variables representing the type of centre at which they were treated. For the cataract patients, a variable was also included

representing whether one or two eyes were operated on. We also examined models which included individual treatment centres instead of the centre type. However the results for other variables were very similar between the two models and as the analysis of centre types is of more interest in this context, especially since the centres were anonymous, the results including individual centres are excluded.

Table 5 shows the results. The baseline in each case is the category 'No change'. For hip operations, there were no patients that fell into the 'No problems' category. In general the models were of low explanatory power, although that might be expected given the small number of observations.

For both cataracts and hips, the preoperative condition-specific measure had a significant impact on all categories except 'Worsen', and in each case the sign was as expected for 'Improve', representing a better outcome for a better condition-specific score[4], and was the same for both 'Improve' and 'Mixed change'. For cataracts, a better VF-14 score also raised the probability that the patient would be classified as having no problems. Neither age nor symptom duration had any effect on outcomes for either operation. For both operations, the number of co-morbidities decreased the probability of improved health, but had no other effect on outcomes; however cataract patients with more co-morbidities were less likely to be classified as having no problems. Sex had no impact except that male cataract patients were more likely to have a mixed-change outcome. The general health measure did not have any impact on outcomes, except that cataract patients with fair or poor health were less likely to be classified as having no problems. A higher IMD score raised the probability that cataract patients would improve and lowered the probability that hip patients would be classified as mixed change. Whether one or two eyes were operated on had little impact on cataract operation outcomes, though if two eyes were done, this raised the probability that the patient would be classified as having no problems. In general, centre type appeared to have little effect on outcomes, and those effects that were detected had no obvious pattern.

5. The EQ-5D as a performance measurement tool in the NHS: further challenges and remaining questions.

[4] Higher scores on the VF-14 represent better health; on the Oxford Hip Score they mean worse health.

Measures of patient-reported health potentially have a number of important applications in health sector decision making, from macro-level analyses of NHS productivity to micro-level considerations of referral and demand management of patients. The introduction of PROMs in the NHS appears to have been motivated principally by the policy agenda around patient choice and the 'payment by results' reimbursement system. The performance of providers in improving patient health is the dominant consideration in patients' stated preferences regarding choice of provider at the point of referral [21], and the PROMs initiative is in part a response to the need to generate data to inform those choices.

There are clearly other uses of the PROMs data reported here – for example, because the EQ-5D can generate 'utility' scores and therefore Quality Adjusted Life Years, the data would facilitate cost effectiveness analysis of the surgical procedures. The availability of condition-specific and generic health outcomes data can also be used to identify issues around the appropriateness of referral and surgery, and to develop explicit means of prioritising patients on waiting lists in terms of their ability to benefit [22]. However, the policy emphasis on patient choice and 'Payment By Results' means that the initial focus is on the use of the EQ-5D and other PROMs data to generate an indicator that identifies differences *between providers* in the production of health benefit.

A PROMs-based performance indicator will provide a useful signal if the provider can influence patient reported health outcomes and if the provider's influence can be isolated from other factors that might affect health outcomes – notably, the characteristics of the patients themselves and of the local health economy. While Browne *et al* (2007) examined the effect of patient and clinical characteristics on health outcomes from surgery, they did not attempt to control for the influence of services received outside the hospital, following surgery [14]. For example, the quantity and quality of physiotherapy and other rehabilitation services received by patients after discharge may plausibly affect health outcomes attributed to a hospital, while not being under its control.

For PROMs to be useful to patients as indicators of hospital performance, considered alongside a range of other variables, the indicator also needs to be relatively simple to understand, interpret and display visually. The more readily that the information can be disseminated to patients, the greater its potential impact in promoting patient choice. Further research is required both to

ensure that variations in hospital-level indicators reflect variations in performance 'caused' by the hospital, and to develop simple, high-impact ways of capturing the relevant differences.

Finally, the two ways of analysing and reporting EQ-5D profile data demonstrated in this paper, the Paretian Classification of Health Change and the Health Profile Grid, while essentially simple, yield some though provoking results. For example, with respect to cataract surgery, one third of patients receiving surgery report no problems on the EQ-5D before surgery and, following surgery, more patients reported a worsening in health than reported an improvement. These results are obscured somewhat when the analysis focuses just on the final (post-operative) outcome, and when the profiles are summarised by their values.

Taken at face value, these results might suggest important issues about the benefit of cataract surgery for some patients. Cataract removal is one of the most common operations performed in the NHS. While some of the worsening in health may be due to aging or deteriorations in co-morbidities, the size of the group reporting worse health after surgery, and the absence of corresponding improvements in *any* dimension of their health following surgery, is of concern. And while the absence of any problems prior to surgery does not mean these patients are perfectly healthy, the value of treating such patients merits investigation, given the opportunity cost of the resources devoted to cataract surgery.

An alternative interpretation of these results is that the EQ-5D descriptive system is not sensitive enough to detect the particular effects on quality of life associated with visual problems. There is evidence elsewhere of the apparent failure of generic instruments, such as the SF-6D and EQ-5D, to reflect changes in visual acuity [23]; although others papers have shown clear relationships between reduced visual acuity and quality of life [22, 24].

Data currently being collected in the POIS pilot study will enable us further to develop the methods reported in this paper, and to conduct further analysis of the relationships between the condition-specific and generic patient data.

Acknowledgements

We are grateful to the PROMs research team, led by Professor Nick Black, for providing access to the data used in this study. Helpful comments on this paper were received from David Nuttall, Jon Sussex and Adrian Towse, and from participants at the London Health Economics Group seminar at City University, October 2008.

Conflicts of interest

None.

References

1. Food and Drug Administration. (2006) *Guidance for Industry: Patient Reported Outcome Measures: Use in medical product development to support labelling claims.* Draft Guidance. www.fda.gov/cder/guidance/index.htm

2. Bren L. (2006) The importance of patient-reported outcomes…Its all about the patients. *FDA Consumer Magazine*, November-December. Food and Drug Adminstration. www.fda.gov.fdac/features/2006/606_patients.html (accessed 3rd February 2009).

3. National Institute for Health and Clinical Excellence (2008) *Guide to the Methods of Technology Appraisals*. Publication reference N1618. London: NICE.

4. Appleby J, Devlin N. (2004) *Measuring success in the NHS: using patient assessed health outcomes to manage the performance of health care providers*. London: Dr Foster. www.drfoster.co.uk/library/reports/measuringSuccess.pdf

5. Office of Health Economics (2008) *NHS Outcomes, performance and productivity.* Report of the Office of Health Economics Commission. OHE: London.

6. Kind P, Williams A. (2004) Measuring success in healthcare: the time has come to do it properly. *Health Matters*, issue no.9, University of York. http://www.york.ac.uk/healthsciences/pubs/HPM9final.pdf

7. Department of Health (2008) *Guidance of the routine collection of Patient Reported Outcome Measures (PROMs).* Department of Health document DH_081179[1].pdf

8. Black N, Browne J, Cairns J. (2006) Health care productivity. *British Medical Journal* 333:312-3.

9. Advancing quality in the North West (2008) Health Service Journal 27 November. www.hsj.co.uk/news/news_analysis/2008/11/advancing_quality_in_the_north_west.html

10. Office for Fair Trading (2007) *The Pharmaceutical Price Regulation Scheme. An OFT Market Study*. London: OFT. www.oft.gov.uk/shared_oft/reports/comp_policy/oft885.pdf

11. Darzi, Lord (2008) *High Quality Care for all. NHS Next Stage Review: Final Report*. London: Department of Health www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_085825

12. Brooks R, Rabin R, de Charro F. (eds) (2003) *The measurement and valuation of health status using EQ-5D: A European perspective.* Dordrecht: Kluwer.

13. Szende, A., Oppe, M., Devlin, N. (2007) *EQ-5D valuation sets: an inventory, comparative review and users' guide*. Rotterdam: EuroQol Foundation. Springer.

14. Browne, J., Jamieson, L., Lawsey, J., van der Meulen, J., Black, N., Cairns, J., Lamping, D., Smith, S., Copley, L., Horrockes, J. (2007) *Patient Reported Outcome measures (PROMs) in*

elective surgery. Report to the Department of Health. www.lshtm.ac.uk/hsru/research/PROMs-Report-12-Dec-07.pdf

15. https://www.poisaudit.org.uk/

16. Ware JE Jr, Sherbourne CD. (1992) The MOS 36-item short-form health survey (SF-36): I. Conceptual framework and item selection. *Medical Care.* 30 : 473-483.

17. Dolan P. (1997) Modelling valuations for EuroQol health states. *Medical Care*. 35(11):1095-108.

18. Parkin D, Rice N, Devlin N. (2009) *Statistical analysis of EQ-5D profiles: does the use of value sets bias inference? Medical Decision Making* (forthcoming).

19. Steinberg EP, Tielsch JM, Schein OD, Javitt JC, Sharkey P, Cassard SD, Legro MW, Diener WM, Bass EB, Damiano AM, Steinwachs DM, Sommer A (1994) The VF-14: an index of functional impairment in patients with cataract *Archives of Ophthalmology.* 112 : 630-638.

20. Fitzpatrick R, Dawson J (1997) Heath-related quality of life and the assessment of outcomes of total hip replacement surgery. *Psychology and Health* 12 : 793-803.

21. Burge, P, Devlin, N**,** Appleby J, Gallo F, Nason E, Ling T. (2006) *Understanding patients' choices at the point of referral*. Technical report TR359-DOH, Cambridge: RAND Europe. www.rand.org/pubs/technical_reports/TR359/

22. Derrett S, Devlin N, Hansen P, Herbison P. (2003) Prioritising patients for elective surgery. A prospective study of Clinical Priority Assessment Criteria in New Zealand. *International Journal of Technology Assessment in Health Care* 19(1):91-105.

23. Espallargues, M., Czoski-Murray, C.J., Bansback, N.J., Carlton, J., Lewis, G., Hughes, L., Brand, C., Brazier, J. (2005) The impact of age-related macular degeneration on health status utility values. *Investigative Ophthalmology and Visual Science* 46: 4016-4023.

24. Clarke, P.M., Simon, J., Cull, C., Holman, R. (2006) Assessing the impact of visual acuity on quality of life in individuals with Type 2 diabetes using the SF-36. *Diabetes Care* 29: 1506-1511.

Table 1. Numbers and proportions reporting levels within EQ-5D dimensions: pre- and post-operation for hip replacements.

Level	Mobility		Self-care		Usual activities		Pain/discomfort		Anxiety/depression	
	pre-op	post-op	pre-op	post-op	pre-op	post-op	pre-op	post-op	pre-op	post-op
1	19 (4.3%)	239 (54.4%)	168 (38.6%)	319 (73.3%)	15 (3.4%)	199 (45.6%)	1 (0.2%)	219 (50.5%)	240 (55.5%)	349 (80.8%)
2	420 (95.7%)	200 (45.6%)	264 (60.7%)	115 (26.4%)	347 (79.6%)	221 (50.7%)	240 (55.3%)	200 (46.1%)	183 (42.4%)	74 (17.1%)
3	0 (0%)	0 (0%)	3 (0.7%)	1 (0.2%)	74 (17.0%)	16 (3.7%)	193 (44.5%)	15 (3.4%)	9 (2.1%)	9 (2.1%)
Total[5]	439 (100%)	439 (100%)	435 (100%)	435 (100%)	436 (100%)	436 (100%)	434 (100%)	434 (100%)	432 (100%)	432 (100%)
Number reporting some problems[6]	420 (95.7%)	200 (45.6%)	267 (61.4%)	116 (26.6%)	421 (96.6%)	237 (54.4%)	433 (99.8%)	215 (49.5%)	192 (44.5%)	83 (19.2%)
Change in numbers reporting problems	-220		-151		-184		-218		-109	
% change in numbers reporting problems	-52%		-57%		-44%		-53%		-57%	
Rank of dimensions in terms of % changes	3		1=		4		2		1=	

[5] Results are for those who responded to both the pre- and the post-operative questionnaire. 84% of respondents to the pre-operative EQ-5D also responded to the post-operative EQ-5D.
[6] 'Some problems' = levels 2 + 3

Table 2. Changes in health for five surgical procedures according to the Paretian classification

	Hip	Knee	Hernia	Veins	Cataract
No change	21 (4.8%)	45 (10.0%)	127 (29.5%)	72 (27.1%)	335 (47.1%)
Improve	356 (82.0%)	329 (73.3%)	203 (47.2%)	148 (55.6%)	149 (21.0%)
Worsen	18 (4.2%)	34 (7.6%)	71 (16.5%)	34 (12.8%)	188 (26.4%)
Mixed change	39 (9.0%)	41 (9.1%)	29 (6.7%)	12 (4.5%)	39 (5.5%)
Total	434	449	430	266	711

Table 3. Changes in health state for three conditions according to the Paretian classification, taking account of those with no problems

	Hernia	Veins	Cataract
Number with problems (% of those with problems):			
No change	53 (14.9%)	29 (10.9%)	99 (13.9%)
Improve	203 (57.0%)	481 (55.6%)	149 (21.0%)
Worsen	71 (19.9%)	34 (12.8%)	188 (26.4%)
Mixed change	29 (8.2%)	12 (4.5%)	39 (5.5%)
Total with problems	356 (82.8%)	223 (83.8%)	475 (66.8%)
No problems	74 (17.2%)	43 (16.2%)	236 (33.2%)

Table 4. Changes in health state for cataract operations in three different types of facility

	Type 1	Type 2	Type 3	Total
Percentage of those with problems:				
No change	18.5	21.0	22.1	20.8
Improve	39.3	35.2	25.1	31.4
Worsen	38.5	36.2	41.7	39.6
Mixed change	3.7	7.6	11.1	8.2
Percentage with no problems	40.8	28.1	30.3	33.2
Total number of patients	228	146	337	711

Table 5. Multinomial logistic regression analysis of factors affecting outcomes of cataract and hip operations

Cataracts	No problems		Improve		Worsen		Mixed change	
Preoperative VF14	0.0230*	(0.00968)	-0.0225**	(0.00821)	-0.0142	(0.00790)	-0.0333**	(0.0105)
Male	0.110	(0.272)	0.274	(0.282)	0.177	(0.266)	0.811*	(0.406)
Age	-0.0255	(0.0145)	0.00773	(0.0153)	0.0106	(0.0145)	0.0121	(0.0217)
Symptom duration	0.00801	(0.0446)	-0.0549	(0.0514)	-0.0346	(0.0473)	-0.0218	(0.0728)
Comorbidity	-0.615***	(0.0980)	-0.166*	(0.0821)	-0.136	(0.0753)	-0.183	(0.122)
Fair/poor	-1.548***	(0.439)	-0.496	(0.342)	-0.00499	(0.305)	-0.0177	(0.477)
Eyes	0.667*	(0.284)	0.177	(0.298)	0.254	(0.278)	0.0537	(0.421)
IMD score	-0.00261	(0.0115)	0.0257*	(0.0110)	0.0163	(0.0105)	0.0138	(0.0154)
Centre Type 2	-0.436	(0.386)	-0.403	(0.386)	-0.291	(0.381)	0.353	(0.663)
Centre Type 3	-0.749*	(0.318)	-0.762*	(0.332)	-0.171	(0.315)	0.796	(0.569)
Constant	2.069	(1.389)	2.034	(1.376)	1.091	(1.317)	0.0639	(1.918)

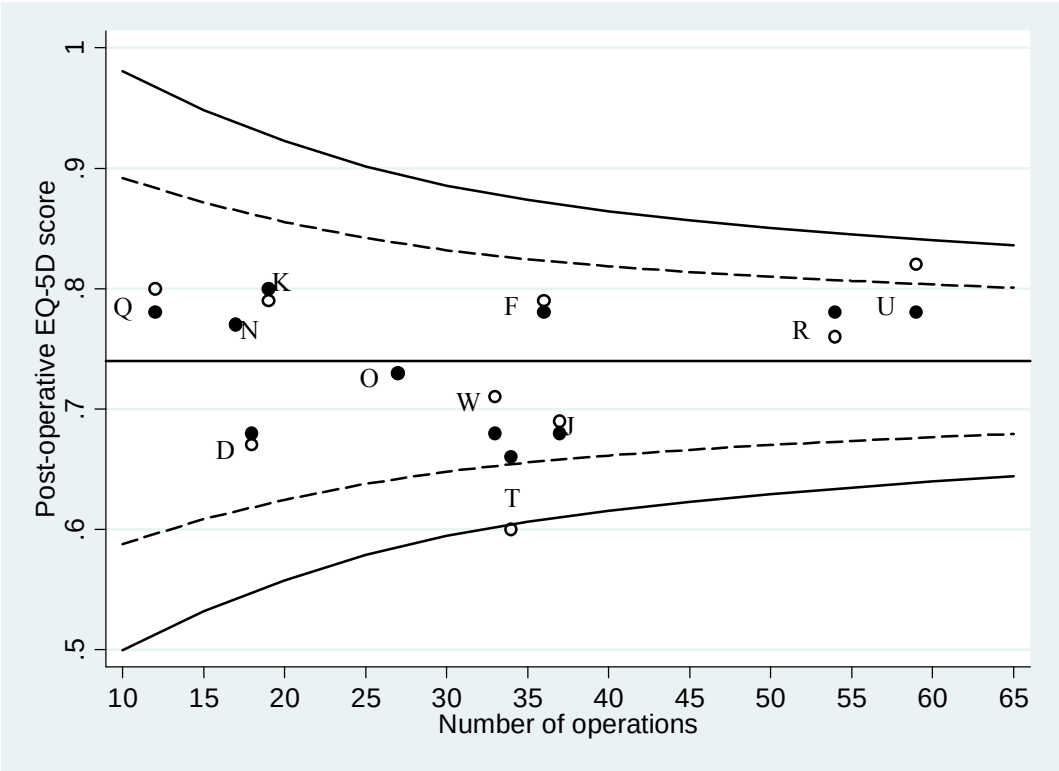
N = 679; Log likelihood = -894.2, $\chi^2(40) = 222.9$, P < 0.0000; Pseudo $R^2 = 0.1108$

Hips	Improve		Worsen		Mixed change	
Preoperative Oxford	0.113**	(0.0350)	0.0364	(0.0472)	0.0817*	(0.0411)
Male	0.512	(0.541)	0.244	(0.735)	0.453	(0.636)
Age	0.0365	(0.0270)	-0.00433	(0.0369)	0.0378	(0.0322)
Symptom duration	-0.0153	(0.0506)	-0.0740	(0.0917)	-0.00502	(0.0584)
Comorbidity	-0.385*	(0.176)	-0.0768	(0.248)	-0.125	(0.200)
Fair/poor	-0.320	(0.679)	-1.395	(1.256)	0.324	(0.771)
IMD score	-0.0277	(0.0154)	-0.0232	(0.0243)	-0.0393*	(0.0195)
Centre Type 2	1.022	(1.103)	1.049	(1.372)	2.524*	(1.218)
Centre Type 3	0.534	(0.567)	0.366	(0.808)	1.360	(0.725)
Centre Type 4	-0.286	(0.867)	0.545	(1.099)	0.817	(1.056)
Constant	-3.163	(2.352)	-0.538	(3.196)	-5.329	(2.858)

N = 410; Log likelihood = -246.4, $\chi^2(30) = 46.72$, Prob > 0.0265; Pseudo $R^2 = 0.0866$

Standard errors in parentheses* p<0.05, ** p<0.01, *** p<0.001

Figure 1. Funnel plot of post-operative EQ-5D scores in hip replacement surgery



Source: Browne et al (2007) [7]. Reproduced with the permission of the authors.

Figure 2. Changes in health for the five surgical procedures, according to the Paretian Classification of Health Change.

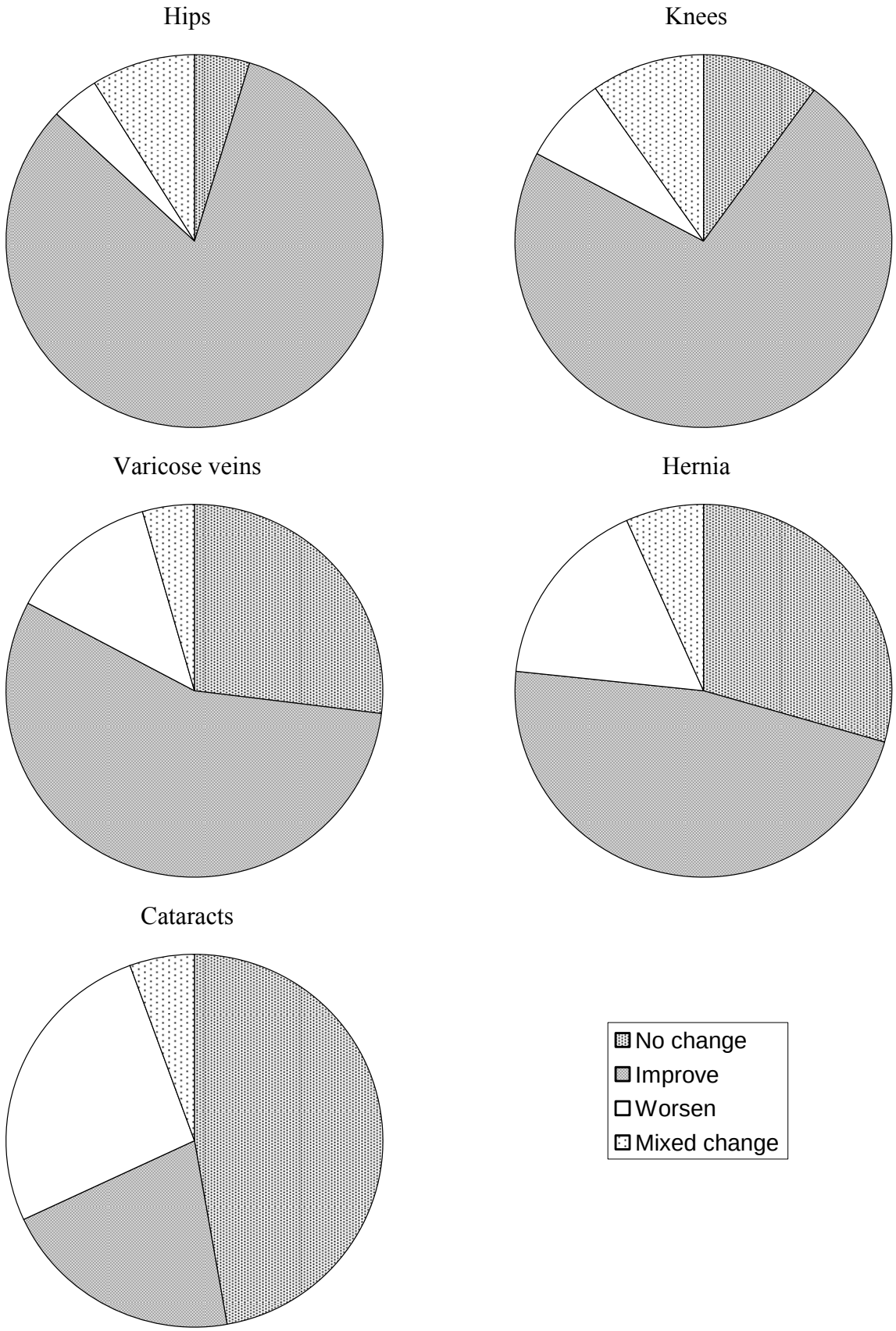
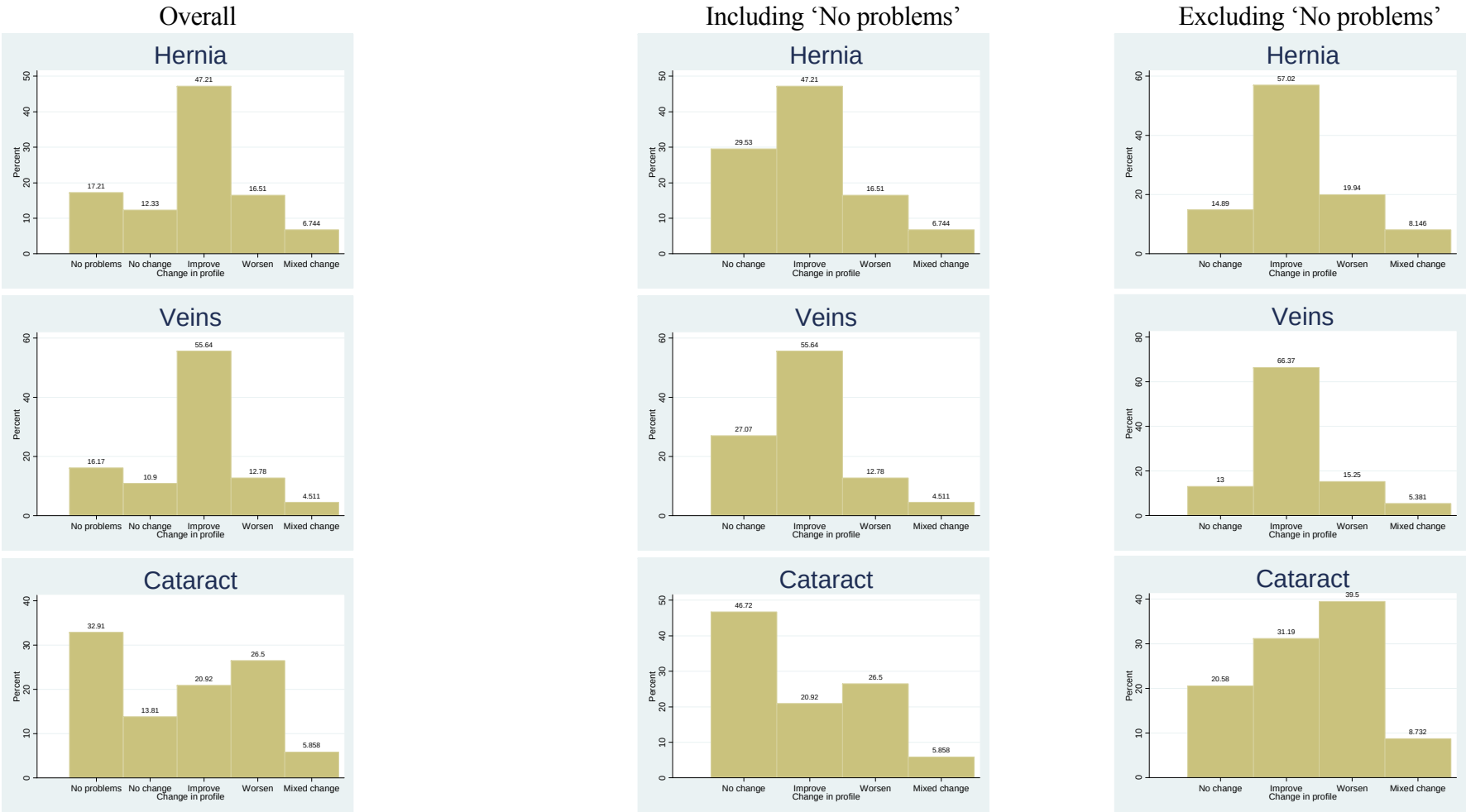


Figure 3. Changes in health state for three conditions according to the Paretian Classification of Health Change, accounting for those with no problems[7]



[7] A disadvantage of histograms, compared to pie charts, is that the positioning of the bars on the horizontal axis is problematic. While there is an argument for placing 'no change' between the unequivocal 'improve' and 'worsen', 'mixed change' cannot be ordered in this way. We have therefore chosen here to avoid any implied ordering.

Figure 4. Health Profile Grid for hip operations

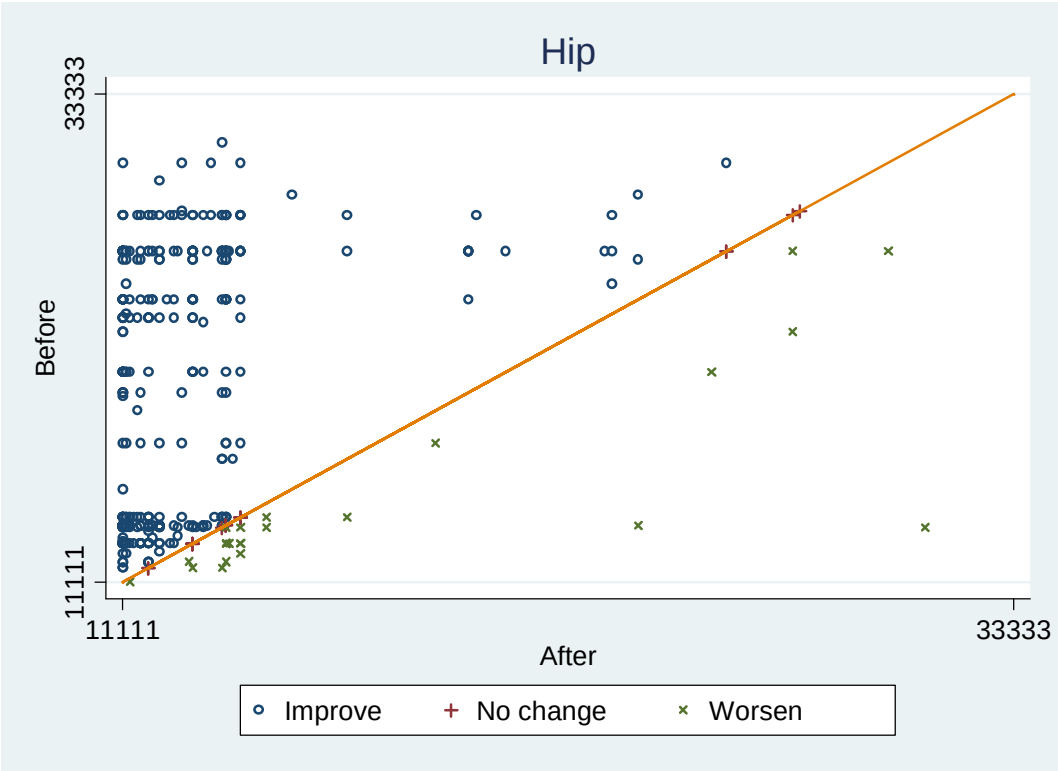


Figure 5. Health Profile Grid for hernia operations

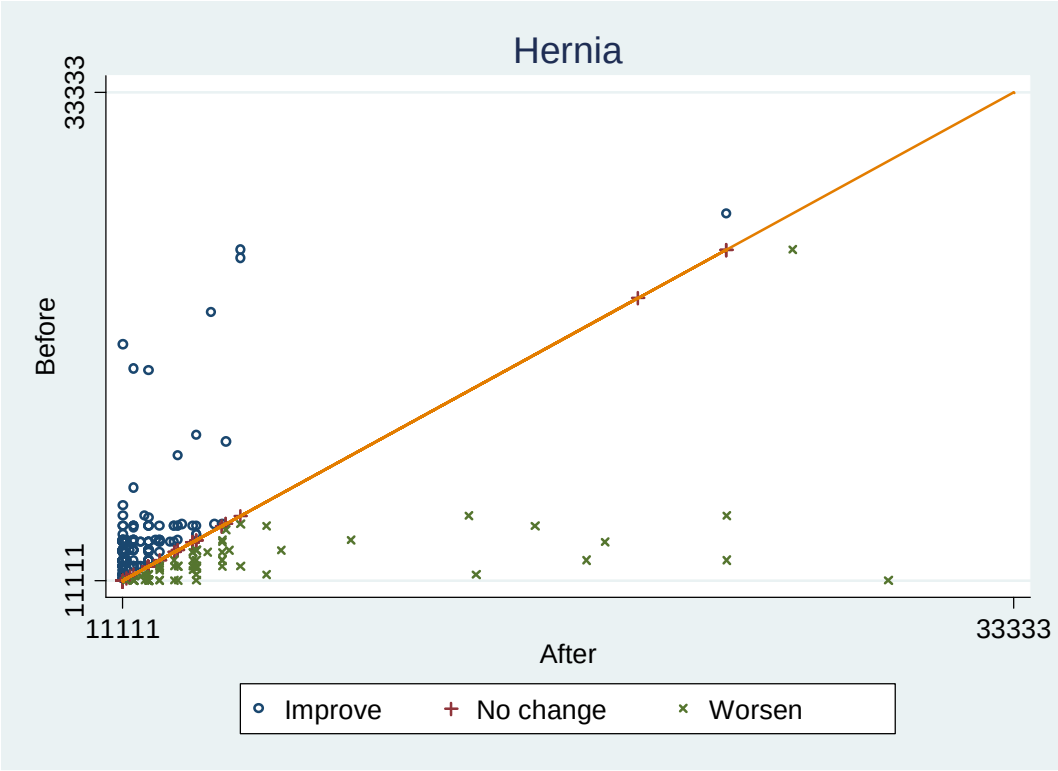


Figure 6. Health Profile Grid for cataract operations

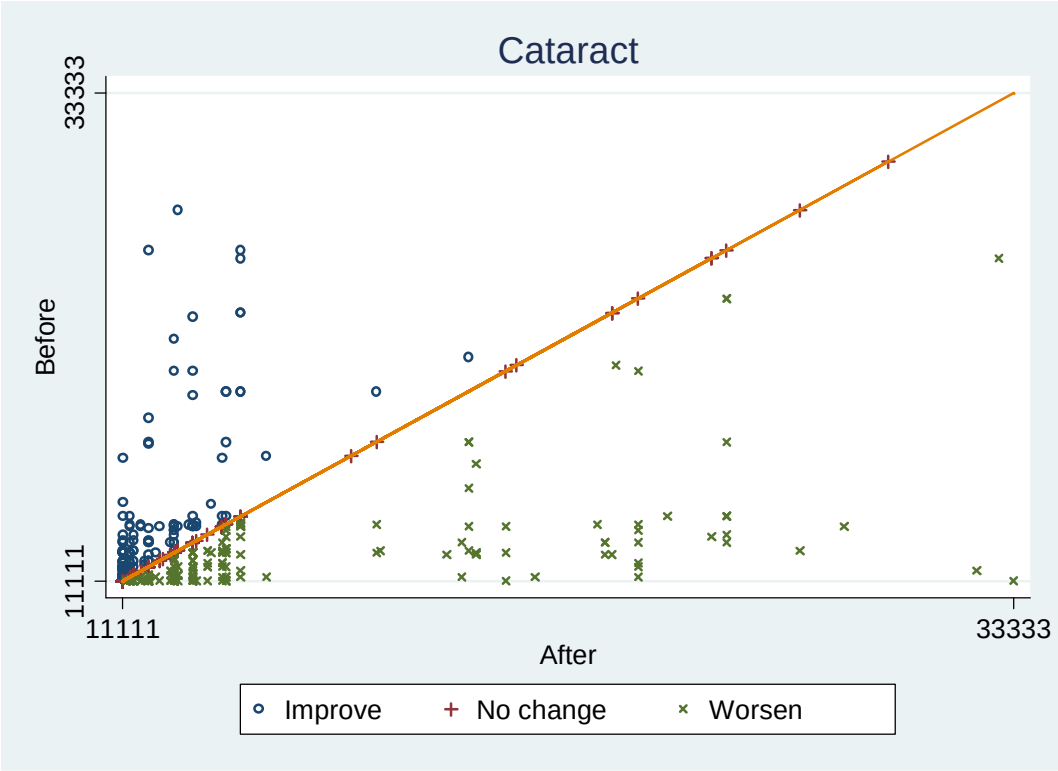
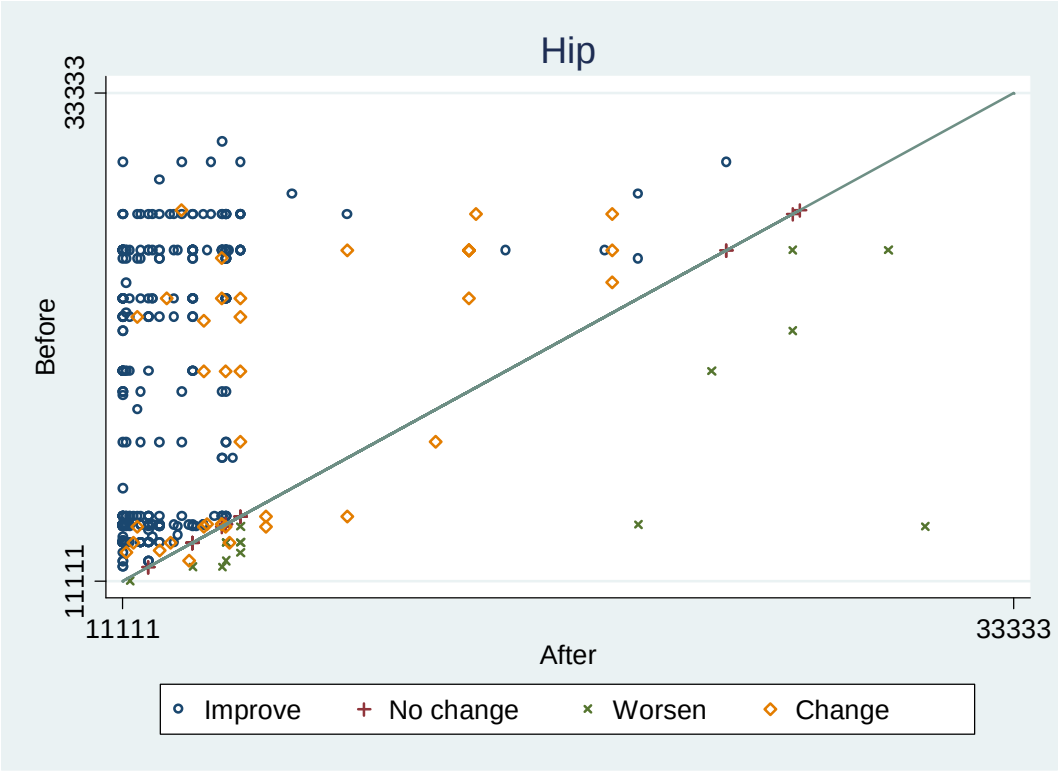


Figure 7. Health Profile Grids for hip and cataract operations, incorporating the Paretian Classification of Health Changes



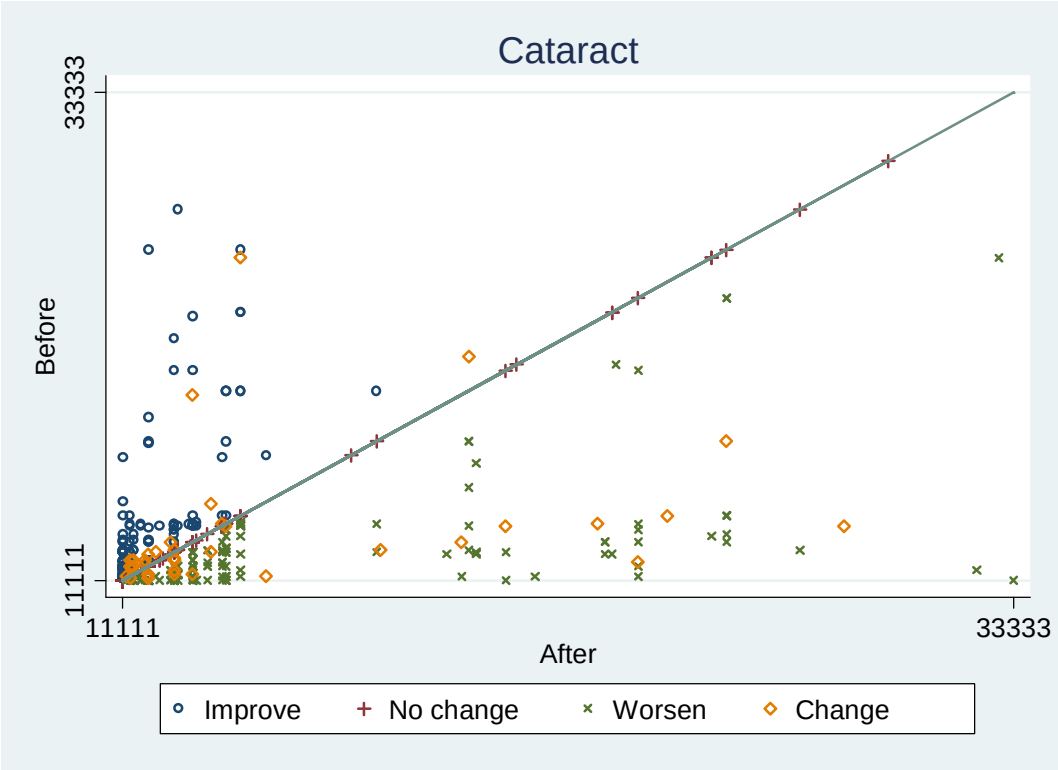


Figure 8. Health Profile Grid for cataract operations, by facility type

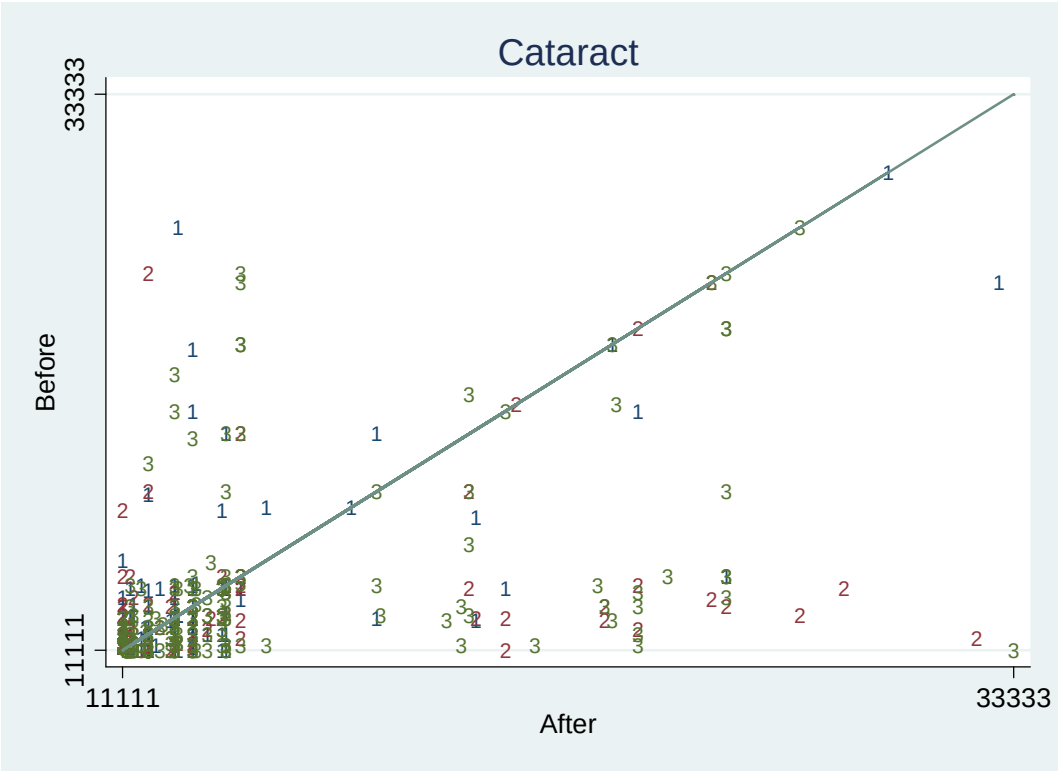


Figure 9. Health Profile Grid showing clusters of changes in health state for hip operations