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Early discharge and home intervention reduces unit costs after total hip replacement: Results of a cost analysis in a randomized study

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ABSTRACT

Total hip replacement (THR) is a common and costly procedure. Number of THR is anticipated to increase over the coming years. Two pathways of postoperative treatment were compared in a randomized study.

As an outcome measure Oxford Hip Score (OHS) was used. All costs regarding the treatment were for the two groups both in hospitals and after discharge were collected. The data is studied using regression and cost-effectiveness analysis.

A shorter hospital stay augmented with better preoperative education and home treatment appears to be more effective and costs less than the traditional in hospital pathway of treatment – a more efficient treatment.

JEL classification: I11; I18; D61; C25

Keywords: Cost-effectiveness analysis; Total hip replacement; Home intervention

1. Introduction

During the last few decades the number of total hip replacement (THR) operations has steadily increased in Iceland up to 133 per 100,000 at present, and the annual need for primary THR in the country is expected to increase by one third, from 221 operations in 1996 to 300 in 2015 (Ingvarsson et al. 1999). Orthopedic surgeons are under pressure to reduce costs for THR (Metz and Freiberg 1998). So-called clinical pathways are an attempt to standardize the treatment in order to better economize with available hospital resources. The implementation of such pathways has resulted in a 31% shorter hospital stay on average and cost reduction of 11% for THR (Kim et al. 2003). In this study a comparison of total cost between an established clinical routine and a new concept based on preoperative education and postoperative home intervention after a shortened hospitalization is evaluated with respect to costs.

2. Patients and Methods

2.1. Study design

The study started at the University Hospital Landspitalinn in Reykjavik in December 1997. At the beginning of April 1999 the first patient included in the study was operated on at Akranes Hospital. The last patient to enter the study was operated on at Akranes in December 2000.

The patients were randomized into one of two groups, a study group (SG) or a control group (CG). A total of 50 patients participated, 27, of which were 14 women, in the study group and 23, of which 12 were women, in the control group. Twenty-nine of the participating patients were operated on in Reykjavik and 21 in Akranes. The mean age in the SG was 69 years and 67 years in the CG. Only five patients had other diagnoses than osteoarthrosis.

The CG was treated according to the contemporary routine with the exception of being asked to fill in a general questionnaire the day before the operation and two, four and six months after the operation.

The SG patients were invited to participate in a preoperative training session about one month before the planned operation. They answered the questionnaire two to three weeks before the operation and two, four and six months after the operation. A physiotherapist and/or an occupational therapist provided the preoperative information and training. During the training patients were informed in detail about postoperative rehabilitation and received training in exercise, which they should perform before and after the operation. Patients were made familiar with various helping aids used postoperatively and equipped with these devices already prior to the operation. They also received an illustrated information brochure including information on how to exercise and behave after the operation.

When a patient in the study group was discharged from the ward the physiotherapist or occupational therapist accompanied the patient home if needed. The nurse administered daily anti-thrombosis injections, changed wound dressings, removed skin stables and assisted in the care of the patient as long as it was needed. During the first days after homecoming the physiotherapist or occupational therapist visited the patient as often as needed (median number of times 4, range 2-9) to ensure that the rehabilitation scheme was followed.

2.2. Selection of patients

The study was initially designed with the Landspitalinn University Hospital in Reykjavik in mind. Patients on the waiting list for primary hip replacement at the Department of Orthopedics were asked to participate.

All patients diagnosed as having osteoarthrosis of the hip, rheumatoid arthritis, primary segmental collapse of the femoral head, conditions after developmental diseases and hip trauma living in their own home were invited to participate. Primary hip fracture, tumour metastasis, and demented patients were not considered for the study. In order to be able to conduct proper postoperative treatment the study was limited to patients living in the Reykjavik area.

After the study had started, Landspitalinn underwent a major reorganization and during the latter half of the study period health authorities decided to move the Department of Orthopedics to another location. This decision led to problems in recruiting patients to the study and is the reason for why only 55 were contacted of 88 patients available. During the same period a hip replacement unit at the nearby Akranes Hospital was evolving and expanding. The majority of patients in Akranes undergoing hip replacements were living in the Reykjavik area. Therefore it was decided to include patients undergoing primary hip replacements at Akranes Hospital as well, during the latter half of the study period. Patients living in the town of Akranes were also invited to participate.

2.3. Health Evaluation

When entering the study the patients were asked to fill in a general questionnaire. As an outcome measurement for utility in this study the Oxford Hip Score (OHS) (Dawson et al. 1996) was used. It contains 12 questions divided in two subscales, pain and functional impairment. Each question has five response categories that are summed to produce subscale scores from 6 to 30. Higher scores indicate worse pain and functional impairment. It was developed and validated specifically to assess function and pain in relation to the hip. The OHS was also the scoring system found to be most consistent on the outcome in the study (Siggeirsdottir et al. 2005) and to be the easiest to apply to the results of the study as far as patient satisfaction was concerned.

The National Bioethics Committee, Reykjavik, Iceland, approved the study. Data was gathered according to instructions from the Icelandic Data Protection Authority in Iceland. All participating patients returned written consent for their involvement in the study according to the Helsinki agreement.

2.4. Cost evaluation

Costs are evaluated from the societal point of view. The cost of a procedure is determined by the quantity of resources used and their unit price. Estimation of quantity of resources used is based on data collected for each patient during his or her treatment. A unit price is then assigned to it, opportunity costs considered. Price level is standardized by applying 1999 prices for all units. Thus, all results are according to the price level in 1999, calculated from ISK to USD at the average exchange rate in 1999.

The various types of costs are categorized based on resource type. Costs are partly paid either by the patient, the state-run hospitals and rehabilitation centers or the State Social Security Institute (SSI) – SSI covers most of the outpatient costs not paid by the patient.

The costs considered were:

Operation costs and re-operation cost based on estimates provided by Halldorsdottir and Herbertsdottir (2000) in the case of patients operated on in Reykjavik and the office of Akranes Hospital for patients operated on in Akranes. Patient hospital-stay costs are based on estimates by Halldorsdottir and Herbertsdottir (2000) for patients staying in Reykjavik and the office of Akranes Hospital for patients staying in Akranes. Measures were taken to account for the fact that the first days are more expensive than later days, except when a patient is reinstated. This was done, in accordance to estimates, using a formula weighting inpatient costs for the first days.

$$f(t) = \alpha + \beta \cdot t + \varepsilon \quad C \equiv \alpha + \beta \quad \beta \equiv 0.85 \cdot C \qquad (1)$$

Where C is the estimated average inpatient cost per day utilized to define α and β, t is length of stay and ε is cost due to inpatient complication etc. The database used enables identification of expenses related to the incidence of patient-specific complications.

Accrued costs for control group patients related to stays at convalescence homes. Expenses are partly paid by the State and partly by the patient himself, depending on which institution (of three possible) was used.

The cost database also included expenses accrued due to visits to GPs and specialists, as well as expenses related to visits to physiotherapists and occupational therapists (Sigurdardottir 2003). The patient foots part of that bill. The same procedure applied to home visits by physiotherapists and occupational therapists except that an estimated cost of travel for the providers was added. Expenses related to services of registered nurses was based on the number of visits and the negotiated nurse wage, assuming a fixed number of hours per visit and standardized length of travel if the patient was visited at home.

The database included information on pharmaceuticals use according to type and cost. Expenses related to pharmaceuticals administrated as a consequence of the hip treatment was identified and accounted for, as were expenses related to x-rays, electrocardiograms and blood samples (Sigurdardottir 2003).

Furthermore, care was taken to correctly account for job-loss of employed persons due to the operation and convalescence. The wage rate used to estimate job loss is the median wage as reported by Statistics Iceland. The opportunity cost for unemployed, retired or other non-workers was estimated as the average job-loss of the employed participants but the wage-rate was lowered (somewhat arbitrarily) by 50%.

Length and cost of travel was also accounted for. When patients were transported by private car, the cost was estimated by employing the reimbursement tariff that the Ministry of Finance uses when compensating state employees for use of own car.

2.5. Economic evaluation and Statistics

An economic evaluation should compare cost and consequences of two or more alternatives. A cost-effectiveness analysis (CEA) was conducted for the economic evaluation of total hip replacement and home therapy. CEA is utilized when a single effect is under consideration, using natural units for valuation of consequences. Cost accrued is related to level of success and compared across procedures. It has been customary to subdivide costs into direct, indirect and intangible cost in the literature on economic evaluation. In this paper we avoid this, as advised by Drummond et al. (1997), and divided the costs into the three categories; operation and inpatient costs, outpatient costs paid by the State and direct patient costs.

The difference of six months post op OHS less their pre op score (OHS gain) is used as a measure of effect. Four patients are for various reasons missing either value, and are thus excluded from effectiveness calculations. The CEA measure used is the average patient cost per OHS gained for each group (C/E).

$$C_i / E_i = \frac{1}{N_i} \sum_{n=1}^{N_i} \frac{C_{in}}{E_{in}} \quad i = SG, CG \quad N_{SG} + N_{CG} = N \qquad (2)$$

The difference, C/E of the CG less that of the SG, is the C/E gain or loss by implementing the new procedure. But for two reasons the C/E results are also further broken up into pre op OHS ranges. Firstly, it gives an intuitive insight into cost in relation to condition. And secondly, since the OHS scale is ordinal by construction since it is created to rank patients by the seriousness of their condition. By breaking the OHS up we are able to measure similar groups within the sample.

Regression analysis with cost data as dependent variables was performed. It reveals both real cost gain/loss after adjusting the data for factors affecting the cost accumulation and to what extent these factors affect the cost. There are eight possible explanatory variables of the regression models. The indicator variable, *Study group* is assigned the value zero for a person in the study group, one for a person in the control group. The variable *Pre-op Hip-score* reports the result of the OHS test prior to the operation. The indicator variable *Hospital* is assigned the value one for the University hospital in Reykjavik and zero for Akranes hospital. The variable *Age* is the age of the patient. The indicator variable *Gender* is assigned the value one if the patient is male and zero if female. *Deviation of Body-Mass Index from ideal* is the numerical deviation of the body mass index from 22.5, the middle of the assumed ideal range. The indicator variable *Living alone* is assigned the value one if the patient is the only person in the household, and the indicator variable *Manual work* is one if the patient is or has been a manual laborer.

All eight explanatory variables are treated as if independent of one and other. Thus an ordinary least squares regression is considered sufficient. The general to specific approach is utilized in the regression analysis. Below is the unadjusted (Equation 3) and the adjusted model (Equation 4) utilized in the regression analysis.

$$\begin{aligned} TotalCost = \alpha + \beta_1 Group + \beta_2\, preopOHS + \beta_3 Hospital + \beta_4 Age \\ + \beta_5 Gender + \beta_6 BMIdev + \beta_7 LivingAlone + \beta_8 ManualWork \end{aligned} \tag{3}$$

$$\begin{aligned} \ln(TotalCost) = \alpha + \beta_1 Group + \beta_2 (preopOHS)^2 + \beta_3 Hospital + \beta_4 (Age)^2 \\ + \beta_5 Gender + \beta_6 (BMIdev)^2 + \beta_7 LivingAlone + \beta_8 ManualWork \end{aligned} \tag{4}$$

The following tests for specification, heteroscedasticity (different variance among variables) and normality of the estimated errors were run. The RESET test tests for specification error (Ramsey 1969). The Shapiro-Wilk test (Shapiro and Wilk 1965, Royston 1992) and the Jarque-Bera test (Jarque and Bera 1980) test for normality of estimated errors. And the Breusch-Pagan test (Breausch 1978) for heteroscedasticity.

3. Results

Table 1 describes the cost components for the two groups studied. The average total cost per patient in the SG is $9,587, while it is $13,401 in the CG. That is on average $3,814 less per patient, or a 28% cost reduction. The difference in cost is predominantly due to a shorter hospital stay and to home intervention instead of a stay at a convalescent home. The difference in hospital “Hotel care” between the groups makes for more than half the total. For outpatient costs the greatest difference between the groups is due to home intervention instead of convalescent home.

For the CEA each individual’s improvement needs to be taken into account. Improvements are illustrated in Figure 1 with each participant’s pre op OHS plotted against their six months post op score. The higher the individual’s pre op score, the greater the gain in OHS. The benefit increase is somewhat greater for the study group. The cost-effectiveness gain is the average of cost per OHS gain for the SG minus that for the CG. The OHS gain is the patient’s 6 months post-op OHS less the pre-op OHS. On average the patients in the SG cost $578 per OHS gained, while patients in the CG cost $1,054. That is a $476 reduction in effective cost, or a cost-effectiveness gain of 45%. The resulting cost-effectiveness figures are shown in Table 2.

Table 3 shows the CEA results divided by patient’s pre-op OHS intervals ranging 7 points. The average cost is lower for the SG in all intervals, and varies less than for the CG. The SG gained considerably more post op than the CG measured by a drop in OHS which changed proportionally to the pre op score. This is reflected in much greater cost-effectiveness gain for the SG than the CG. This is shown in the last column of Table 3 as the ratio of the SGs C/E to the CGs.

Regression analysis statistics of the adjusted and unadjusted models, general and specific, is summarized in Table 4. The variables *Group* and *Pre-op Hip-score* have significant effect on total cost at the 5% level in both variations of the model. Other variables are not significant at that level. Hence, we also report a specific version of the models where the other variables are left out. By moving a patient from the CG to the SG would result in a reduction of $3,423 in total costs according to the unadjusted model, or a 30% cost reduction according to the adjusted model. Both results are compatible with our findings reported above. Hence, the regression analysis strongly supports that the design and the implementation of the study does not bias results, which is of concern as the number of participants in the study is not high.

The RESET test for specification error suggests that the unadjusted model may be misspecified at the 10% level of significance. The Shapiro-Wilk and the Jarque-Bera tests suggest that a null-hypothesis that the estimated errors are normally distributed could not be rejected for any of the specification at 5% level of significance. The Breusch-Pagan test suggests that heteroscedasticity could be of concern for the unadjusted model, which is reasonable, since cost figures and health indicators are not measured in the same units. In conclusion, adjusting for dissimilarities in the data makes for a better approach.

4. Discussion

Our results appear to indicate that shortening hospital stays down to 5 days and transferring parts of the treatment to the patient home is more cost-efficient than the usual pathway which also includes a stay at a convalescent home in some cases. Home exercise programs in order to prevent falls have also been found to be cost effective (Robertson et al. 2001) indicating that home treatment as such might be beneficial to patients. There have been doubts that hospital at home treatment reduces hospital stay and lowers costs (Hughes et al. 1997). In some instances a cost increase has even been noted but improvements in quality of life has also been observed among patients participating in such programs (Hughes et al. 2000). No reduction in costs has been reported for postoperative rehabilitation in patients after total hip or knee replacement whereas hospital at home was more expensive after hysterectomy and for chronic obstructive lung diseases (Shepperd et al. 1998). Other studies have shown 22% cost reduction after 31% fewer hospital days when treating patients recovering after joint replacements (Kim et al. 2003).

In our study the most monetary gain for the SG patients as compared to the CG seems to be at different levels:

During the inpatient period lower total "hotel" costs in the SG are explained by fewer ward days. However, the average cost for the operation itself was somewhat higher in the SG, probably because of fewer operations in the SG at Akranes, which had lower unit cost for the operation.

The cost difference between the two hospitals might be to some extent due to differences in cost estimates, but the hospitals do differ in size and location. The University Hospital Landspitali is a comparatively large teaching hospital located in the capital, while Akranes hospital is a small unit in a small community.

The cost of the operation itself is the single most expensive factor in the pathway, about one half of the total inpatient costs, one third of the total costs for both groups. The extra costs of longer hospital stays and convalescence home stays, are the largest contributors to this difference. Overall about 60% of the costs in our study were sustained while in hospital. In a Canadian study about 90% of the costs were incurred during an average hospital stay of 11.4 days (Laupacis et al. 1994) indicating that longer hospital stay tends to absorb most of the postoperative costs.

During the immediate postoperative period the cost for the home treatment in the SG was more than outweighed by the cost for convalescent homes incurred in the CG. These costs together with costs for transports to and from the convalescent home were also the major factor in higher direct patient costs in the CG.

There are always several aspects to the claimed economical gain in studies like this. On one hand is the outright monetary gain, on the other is the non-pecuniary gain, which includes some kind of a treatment effectiveness measurement. In our case the OHS turned out to be a useful measurement of effectiveness. When taking improvement in OHS into account the cost reduction increases from 28% for the normative costs up to 45% for the effective costs. Thus we claim when taking into account better improvement in the SG that even more benefits are to be expected than those usually revealed by changes in pecuniary costs only. The effect of shorter hospital stay on function, pain and quality of life (QOL) differ between the two groups. The OHS for the SG was significantly better after two months (p=0.032), and the difference remained more or less constant throughout the study (Siggeirsdottir et al. 2005). From these combined results the concluding remark can be drawn that patients in the SG were far less costly per health gained. In other words, for the same amount of money, more health was gained by applying the new method.

CEA has been very popular to date (Drummon et al. 1997) and one of its most common forms is the calculation of the cost-effectiveness ratio ($\Delta C/\Delta E$). It can easily be seen from Table 2 that here it would be $ -976. However, since the OHS gain is utilized as measure of effect it was considered irrelevant – the figure has no intuitively interpretable meaning in this content. The ratio of the SGs C/E to the CGs (also refereed to as the cost-effectiveness ratio in some occasions) gives a more intuitive measure.

The regression approach can be used to deduce more information. One could ask how the post-operation OHS is affected by the various variables reported (including the pre-operation score). The OHS index is ordinal in nature while many of the other measures included in our study are cardinal. Hence, one would expect the relationship between these variables to be highly non-linear. We have however concentrated on the cost of improving patient OHS score rather than explain determinants of post-operation OHS score.

The regression analysis model shows the robustness of our data. For the specific adjusted model the R^2 and adjusted R^2 are 0.45 and 0.43 respectively, indicating the degree of explanation. Which can be interpreted as; that almost half of the variation in cost is explained by the model.

Calculations claiming a reduction in inpatient costs have been subjected to some criticism. Jönsson and Lindgren (1980) defined five fallacies in estimating the economic gains of early discharge:

Firstly: Reduction in hospital stay with one day does not mean an equivalent cost saving to the average cost of one day in hospital. Usually the first days are the most expensive, mainly because of the operation, which takes place at the first or second day. In our study we separated the cost of the operation from the rest of the "hotel" costs in order to get more comparable figures. Moreover, we weighted the first days in hospital as 15% more expensive than the following days. Thus we have more reliable calculations on when the costs where inured in the hospital in each of the groups. According to our calculations it was the "hotel" costs and the stay at a rehabilitation unit, not the costs related to the operation that contributed to the main difference during hospitalization in the groups in our study.

Secondly: A reduction in length of stay may not necessarily reduce the waiting lists correspondingly. A shorter hospital stay can hamper productivity by lack of operating capacity. The lack of beds on the ward was the factor mostly responsible for the waiting lists both at Akranes and in Reykjavik.

Thirdly: Shorter hospital stay cannot be achieved without a corresponding increase in the primary care sector. In our study we also kept track of spending in the primary care sector and found that the care provided there was far cheaper than care at a hospital or a rehabilitation unit.

Fourthly: The length of a hospital stay cannot be reduced without increasing the care input of the patient's family and friends. In our study the home rehabilitation team carried a considerable part of the burden for the care of the patients.

Lastly: Shortening hospital stay may endanger the welfare and the health of the patient. This was not the case in our study. The SG did not suffer more complications than the CG and were more confident and had better quality of life than the CG (Siggeirsdottir et al. 2005).

The results of this study indicate that a shorter hospital stay augmented by pre operative education and home treatment is not only safe but appears also to be cheaper. Shortening the period spent in hospital after THR might therefore be used to increase the efficiency of the ward with the possibility of shortening waiting lists.

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Table 1. Results of the cost evaluation in USD. Mean cost, standard deviation (SD) and median cost for the study group and control group respectively.

	Study Group			Comparison Group		
Source of cost	mean	SD	median	mean	SD	median
Healthcare sector						
Op. in Akranes	1,448			1,448		
Op. in Reykjavik	3,882			3,882		
Total op-cost	3,071	1,169	3,882	2,612	1,243	1,448
Hotel care Akranes	3,182	856	2,782	5,850	1,314	5,484
Hotel care Reykjavik	2,590	580	2,289	3,429	983	3,173
Total hotel care	2,788	725	2,331	4,692	1,683	4,583
Total hospital cost	*5,858*			*7,304*		
Cost of reinstatement	0			253	502	0
Convalescence home	-	-	-	1,414	1,773	729
GP and specialists	57	39	44	88	90	41
Nurse and ph.therap.	70	194	4	157	316	0
Nurse at home	164	71	139	-	-	-
Ph.therap. at home	248	127	225	-	-	-
Pharmaceuticals	3	8	0	6	29	0
Research	12	27	0	37	74	0
Traveling	1	4	0	5	19	0
Total post-op gov. cost	*556*			*1,960*		
Total healthcare cost	6,414			9,265		
Patient						
Convalescence home	-	-	-	535	691	0
GP and specialists	12	8	8	17	15	11
Nurse and ph.therap.	33	87	11	42	95	0
Pharmaceuticals	11	24	0	8	16	0
Research	5	10	0	8	13	0
Productivity loss	2,946	2,398	2,215	3,188	2,423	2,215
Traveling	166	57	148	339	262	480
Total patient cost	3,173			4,137		
Grand total cost	9,587			13,401		

Table 2. The average cost and standard deviation, (SD), OHS gain and C/E of the groups.

Group	Cost (SD)	OHS gain(SD)	C/E (SD)
Study	9,579 (2,698)	19.4 (8.6)	578 (369)
Control	13,387 (3,587)	15.5 (5.7)	1,054 (603)

Table 3. Number of patients and average of cost, OHS gain and C/E for the SG and CG, with the ratio C/E of SG over CG, divided by patient's pre-op OHS intervals ranging 7 points.

Pre op OHS	Number		Cost		OHS gain		C/E		Ratio
	SG	CG	SG	CG	SG	CG	SG	CG	
23 - 29	12	3	9,007	11,017	12	12	854	943	0.90
30 - 36	5	8	9,391	12,343	21	15	461	1,174	0.39
37 - 43	8	4	9,022	15,032	25	18	432	826	0.52
44 - 50	1	4	11,209	17,142	28	16	400	1,124	0.36

Table 4. Regression models determinants and respective p-values. Both general and specific versions of the unadjusted model and that for the model adjusted for non-linearity.

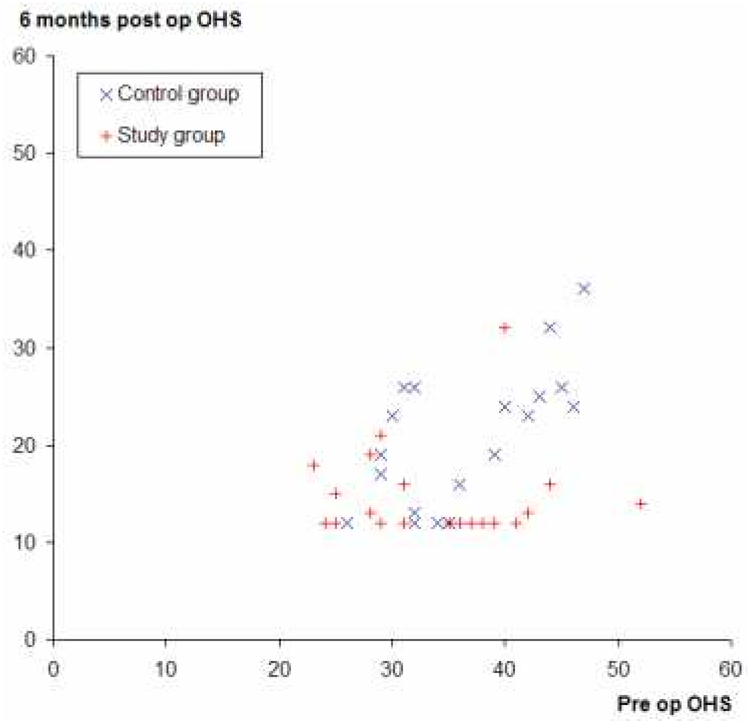
	Unadjusted model [a]				Adjusted model [b]			
	General	p-value	Specific	p-value	General	p-value	Specific	p-value
Constant	7,329	0.070	5,659	0.016	9.19	0.000	9.14	0.000
Study group	-3,423	0.001	-3,048	0.001	-0.30	0.000	-0.27	0.000
Pre-op Hip-score	190	0.005	210	0.001	2.E-04	0.003	2.E-04	0.001
Hospital	929	0.342			0.08	0.321		
Age	-34	0.501			0.00	0.429		
Gender	1,077	0.330			0.09	0.299		
Deviation of Body-Mass Index from ideal	114	0.278			0.00	0.223		
Living alone	1,111	0.257			0.12	0.118		
Manual work	-1,957	0.121			-0.17	0.082		
R^2	0.49		0.42		0.54		0.45	
adj-R^2	0.39		0.40		0.45		0.43	
RESET	3.44	0.043	2.54	0.091	1.42	0.255	1.31	0.281
Shapiro-Wiik	0.96	0.121	0.98	0.478	0.98	0.606	0.98	0.606
Jarque-Bera	4.36	0.113	2.37	0.306	1.11	0.575	0.86	0.649
Breusch-Pagan	4.57	0.033	8.33	0.004	0.05	0.825	1.41	0.235

[a] See Equation 3, [b] See Equation 4

Legend to Figure 1.

Scatter plot of patients pre-op and 6-months post-op OHS.

Figure 1.



6 months post op OHS
60
50
40
30
20
10
0
Control group
Study group
0
10
20
30
40
50
60
Pre op OHS

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