MJA
The Medical Journal of Australia

Appendix

This appendix was part of the submitted manuscript and has been peer reviewed.
It is posted as supplied by the authors.

Appendix to: Schilling C, Keating C, Barker A, et al. Predictors of inpatient rehabilitation after total knee replacement: an analysis of private hospital claims data. *Med J Aust* 2018; 209: 222-227. doi: 10.5694/mja17.01231.

Part 1. Technical appendix: methodology

Table 1. Description of variables

Variable	Description
Sex	Routinely collected at commencement of membership
Age band	Calculated based on date of birth which is routinely collected at commencement of membership
SEIFA	Socio-economic index for areas: 2011 index of relative socio-economic advantage and disadvantage (IRSAD), categorised into deciles. Linked to patient record via postcode that is routinely collected at commencement of membership.
Ever smoker	ICD-10 code if ever flagged during hospitalization funded by Medibank
Charlson comorbidity index	Charlson comorbidity index calculated from ICD-10 codes if ever flagged during hospitalization event funded by Medibank, categorised as 0, 1, and 2+.
Previous year expenditure	Medibank expenditure on patient in year prior to acute surgery admission
Lives alone	ICD-10 'Problems associated to living alone' as completed by the treating doctor at time of diagnosis
ICU	Acute TKR surgery required stay in intensive care unit (ICU)
HACC	Hospital acquired clinical complication (HACC) during acute TKR admission
Surgery	Primary acute unilateral TKR was identified by Diagnostic Related Group (DRG) item I04Z using AR-DRG version 5.1. 'Primary' refers to the initial replacement procedure undertaken on the knee, and excludes revision or removal procedures
Surgery length of stay	Acute TKR surgery length of stay
Surgery cost	Acute TKR surgery cost paid by Medibank
Inpatient rehabilitation count	Inpatient rehabilitation was defined as rehabilitation admission (DRG items Z60A, Z60B, Z60C, I69A, I69B and I69C) within 24 hours of discharge from the TKR event.
Inpatient rehabilitation length of stay	Inpatient rehabilitation length of stay
Inpatient rehabilitation cost	Inpatient rehabilitation cost as paid by Medibank

Table 2. Technical description of regression models

$$r = \alpha + \emptyset.Y + \varepsilon \quad (1)$$

$$r = \alpha + \emptyset.Y + \delta_j P_j + \varepsilon \quad (2)$$

$$r = \alpha + \beta.H + \varepsilon \quad (3)$$

$$r = \alpha + \beta.H + \delta_j P_j + \varepsilon \quad (4)$$

$$r = \alpha + \beta.H + \delta_j P_j + \theta.S + \varepsilon \quad (5)$$

Where:

r = rate of hospital inpatient rehabilitation; Y = year dummy; P_j = patient factors; H = hospital dummy; S = surgeon dummy.

Aim of each model

Models 1 and 2 investigated inpatient rehabilitation trends over time; models 3, 4 and 5 investigated inpatient rehabilitation across hospitals. Specifically model 3 calculated the actual observed rates for each hospital; model 4 estimated the patient-adjusted rates of inpatient rehabilitation for each hospital; while model 5 estimated the patient and surgeon-adjusted rates for each hospital.

Selection of linear versus logistic models

Linear models were preferred to non-linear logistic models to mitigate the incidental parameter problem[1] due to the large numbers of hospital and surgeon fixed effects. Linear panel data models also had the advantage that they always converged, and the marginal and fixed effects were easier to calculate and interpret than non-linear models.[2]

References

1. Lancaster T. The incidental parameter problem since 1948. J Econom 2000; 95: 391-413.

2. Greene W. The behaviour of the maximum likelihood estimator of limited dependent variable models in the presence of fixed effects. Econom J 2004;7: 98-119.

Part 2. Technical appendix: results

Multicollinearity between hospital and surgeon

The surgeon/hospital interaction is a complex one and we have not conducted a causal analysis on the relationship between surgeon and hospital. There is naturally some multicollinearity between the surgeons and hospitals but within our data we have a sufficient numbers of "movers" – surgeons who undertake surgeries at more than one hospital - such that it is possible to robustly separate these two effects for most hospitals (i.e. the impact of the multicollinearity is not severe for estimating the hospital effect for most hospitals). In particular only 8/170 hospitals have no movers performing surgeries, while over 85% of the hospitals have 5 or more movers and close to 50% of hospitals having 50 or more movers. Even after controlling for individual surgeons effects on the likelihood of inpatient rehabilitation we still find large and robust differences in hospital rehabilitation rates. When surgeon fixed effects are considered the identification of a hospital effect comes from the fact that these movers have very different rehabilitation rates for their patients depending on the hospital where they performed the surgery. In addition, the Shapley decomposition method used to quantify the contributions takes the average of all possible orders in which these factors could be combined.

Length of stay and inpatient rehabilitation

Within a given year and within a given hospital, the acute hospital LOS is on average positively associated with the inpatient rehabilitation rate (coef = 0.006, $p < 0.001$), indicating that a higher LOS, all else equal, increases the likelihood of inpatient rehabilitation. In this context, LOS is an indicator of patient and surgery complexity.

Conversely, both between hospitals and in terms of the trend in LOS over time, LOS is negatively associated with inpatient rehabilitation – those hospitals with a low average LOS in general have higher inpatient rehabilitation rates and as the rate of hospital LOS has reduced over time, the average rate of inpatient rehabilitation has increased. In this context, LOS is potentially a hospital-related or system-wide factor rather than a patient-related factor. This potentially indicates that some patients who may have otherwise had a longer acute stay and gone home for community based rehabilitation may now be having a shorter acute stay and also having inpatient rehabilitation. It should be stressed again that this association only explains a small proportion of the growth in inpatient rehabilitation rates over time and there are likely to have been factors other than the push for shorter acute stays that have led to the growth in inpatient rehabilitation rates.