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Consequences of Variations in Social Care on the Performance of the Acute Health Care Sector

José-Luis Fernández and Julien Forder

PSSRU

LSE Health and Social Care

London School Economics

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Abstract: The lack of social care resources is being blamed for underperformance in the acute health care sector. In particular, the lack of community and residential social care services is assumed to have lead to significant delays in discharge, a decrease in hospital throughputs and thus increases in waiting lists and waiting times. The paper uses two-years worth of data from 150 English local authorities to quantify econometrically the extent to which local variations in social care resources translate into variations in performance in the acute sector, and in particular in the rates of hospital delayed discharges and hospital emergency readmission. The analysis presents two modelling perspectives. A reduced form approach investigates the effect of variations in overall social care resources and prices of factors of production on outcomes, controlling for the characteristics of local authorities. A structural model investigates the effect of levels of community and residential care services on several indicators of acute sector performance, modelling explicitly the interrelationships between them.

1. Introduction

Every winter newspapers report the stories of trolley-bound patients lingering in hospital corridors and of A&E patients waiting for hours on end before receiving treatment. One of the commonly cited causes for such occurrences, in addition to under funding, is the inefficient use of hospital resources and in particular the effect of the so-called ‘bed-blockers’. These (predominantly elderly) patients, although ready for discharge from hospital following acute treatment, find themselves unable to cope unassisted in the community, thus trapped in a hospital awaiting the availability of a community care package or a residential or nursing home placement. In the meantime, hospital throughputs are reduced and waiting lists and waiting times increased.

Out of such concerns, the U.K. Secretary of State for Health announced on 30 September 1998 the establishment of a National Beds Inquiry (NBI), whose aim was to ‘review assumptions about growth in the volume of general and acute hospital services and their implications for health services and hospital bed numbers looking 10 to 20 years ahead’. The Department of Health believed that the long-term decline in hospital capacity had gone too far, so that hospitals were now ill prepared for dealing with increasing waiting lists and the recurrent winter pressures on emergency beds. At the same time, it was of the opinion that significant inappropriate and avoidable use of hospital resources was going on.

In their report (Department of Health, 2000b), the NBI stressed how hospital services should be considered in a wider context, including other parts of health and social care systems such as primary, community, rehabilitative and long-term care. In particular, the report collected circumstantial evidence for England suggesting that the need for hospital services and beds was influenced by the availability of these other services, which ‘can help prevent the need for acute interventions, can enable safe discharge to community or home-based care and can act as either substitutes for or complements to hospital services’.

The NHS plan (Department of Health, 2000a) announced a very significant expansion of intermediate care services, pledging a £900 million investment on community-based health and social care services by 2003/2004. Such funds were in addition to the £200 million already allocated to Health Act schemes promoting partnership working (Department of

Health, 1999). Through these services, the government expects among other things to be able to achieve a significant reduction in the average rate of delay discharge from hospital for people aged 75 and over (Department of Health, 2001b).

Within the context outlined above, the paper investigates what impact social care services have on two key indicators of acute health system performance, the rates of hospital delayed discharges for patients over 75 years old and of emergency readmissions following an acute episode. It also attempts to unravel some of the interrelationships/trade-offs between rates of delayed discharges, emergency readmissions, average length of stays and hospital throughputs, exploring in particular whether improvement in delayed discharges imply trade-offs with other .

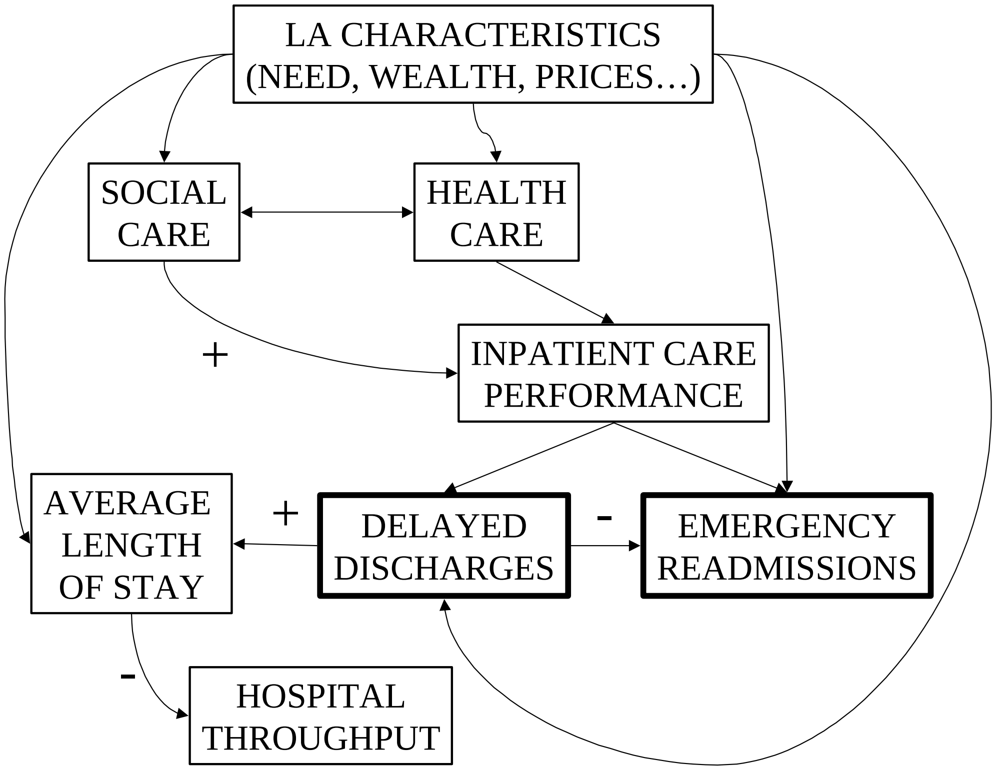
The reminder of the paper is organised as follows. Section 2 presents the analytical framework underpinning the analysis. Section 3 introduces the data and empirical methods used in the estimation of the models. Sections 4 and 5 present respectively the results of the estimations and a discussion of their implications for policy. Finally, section 6 introduces a preliminary microeconomic model supporting the estimation of the relationship between social care resources and delayed discharges.

2. Analytical framework

Reducing delayed discharge rates is perceived by Government as a particularly important policy objective. Caring for patients that no longer require acute treatment in hospital is much more expensive than doing so in the community, in residential care or in nursing care homes (whereas the cost per day of a hospital bed is around £200 (Netten and Curtis, 2000), the average daily price of residential and nursing home placements is around £40). Statistics in 2000 suggested that around 12% of acute beds for people aged 75 and over were occupied by patients awaiting to be discharged. Reducing the numbers of delayed discharges can therefore lead to a considerable boost in capacity for the acute sector. The relevance of social care services in doing so is evident given that the main reasons linked to delays are a lack of assessment (22%), no SSD funding (14%), and the unavailability of social care packages following hospital discharge (36%) (Department of Health, 2001a).

Reducing delayed discharge specifically benefits people delayed. However, it also has wider system effects. Patients awaiting treatment are likely to quickly take up any spare capacity gained from improved patient transition. As a result, average lengths of stays are likely to decrease and hospital throughputs to increase. Also, improving delayed discharge rates may be at the expense of deteriorations in other system outcomes, and in particular in terms of higher readmission rates. Figure 1 summarises the framework for analysis.

Figure 1 Framework for analysis



It is hypothesised that social and health care services are determined simultaneously by demand (e.g. need, resources) and supply (e.g. input prices and technologies) related factors. Demand for social care and hospital services is mediated by LA and HA' s resource constraints and policy priorities. Community care and residential/nursing care are assumed to be substitutes of one another.

Delays in hospital discharges are postulated to arise (in part) because of shortfalls in the levels of social care made available for hospital inpatients. Key to reducing delayed discharges is therefore insuring an adequate supply of social care. In turn, rates of emergency readmissions are assumed to be related to need levels, average length of hospital stays and social and health care services. In addition to LA characteristics, average length of stays are presumed to increase with rates of delayed discharges, and to have a negative effect on hospital throughputs, as measured by the number of finished consultant episodes. A fall in delayed discharge and concomitant reduction in average length of stay could therefore be at the cost of increased re-admission rates.

3. Data and empirical methods

3.1. Data sources

Given the focus of the paper, the analysis has been undertaken at the local authority level. Two years of data for the 150 local authorities in England formed the basis of the dataset: 1988/9 and 1999/00. These data were complemented with data from the 99 health authorities in England. Where health and local authorities are not coterminous health level data were allocated to local authority area on an elderly population basis (in 26 cases). Table 3-1 provides details of the sources of the data. Due to their widely recognised uncharacteristic nature 2 local authorities, City of London and Isles of Scilly, were dropped from the dataset. A further four observations (corresponding to Hertfordshire and Rutland) were excluded from the analysis due to the poor quality of the data.

Table 3-1. Data sources

Category	Variable	Source
Output	• Local authority supported clients: residential care, nursing home care, domiciliary care (contact hours and households); by providing sector • Service provision: Places in residential and nursing homes (all registered beds)	Department of Health *Community Care Statistics*, various Statistical Bulletins
	Hospital episodes (people over 75)	Department of Health, *Hospital Episode Statistics*
	District Nurses Whole Time Equivalent	DH Non-Medical Workforce Census
Expenditure	Local Authority Personal Social Services Gross Expenditure; by service type and cost type (provision cost, overheads etc..)	Social Services Performance Bulletins, Revenue Outturn (R03) statistics, Department of Health and DETR.
Input costs	Capital: Property prices	HM Land Registry.
	Labour: Local wage rates • Weekly gross earnings • LA labour cost index for Area Cost Adjustment	New Earnings Survey DH Baseline estimates
LA characteristics	Population profiles: • by age group • migration	Population statistics, Office of National Statistics

Social care indicators

The analysis employed two indicators of residential/nursing care activity, the number of LA supported nursing home beds per individual over 65 years old, and the number of residential places per individual over 65. The level of home care activity was measured as the number of hours of home care supported by the LA per individual over 65 years old. In addition, the reduced form models used as the indicator of LA social care budget the gross expenditure per individual over 65 years of age.

Delayed discharge indicator

The indicator of delayed discharges was defined as the proportion of people over 75 occupying acute hospital beds on a given survey day that were professionally classified as eligible for discharge conditional on receiving support services but where these services were unavailable. The source of these data was NHS Performance reports (NHS Executive, 2000).

Emergency readmissions

The indicator of emergency readmission was defined as the age and gender standardised rate of emergency readmissions to hospital within 28 days of discharge, as a percentage of live discharges, for all types of hospital discharges. The source of the indicator was the PAF reports (Common Information Core).

Finished consultant episodes

The total number of in-patient episodes finished during one year (irrespective of diagnosis or treatment, but excluding mothers giving birth in hospital and babies delivered in hospital). Source: Hospital Episode Statistics data. For modelling purposes, this indicator was standardised by population over 65 years of age.

Average length of stays

Number of beds days (from Hospital Episode Statistics data) in one year divided by the number of finished consultant episodes.

3.2. Empirical methods

The paper addresses two main questions. First, to what extent do variations in local social care resources explain variations in two measures of acute health care system performance, hospital delay discharge rates and rates of emergency readmissions? Second, what are the main interrelationships between social care services, delay discharge rates, rates of emergency readmissions, average lengths of hospital stay and overall hospital throughputs?

In order to address the two questions, the paper adopts two perspectives of analysis. First it estimates reduced form models for the two key variables in the analysis, delayed discharge and emergency readmission rates. These attempt to map the relationship between aggregate resources, input costs and delayed discharge and emergency readmission rates.

The paper then explores in greater detail the effect of particular types of health and social care on delayed discharge and emergency readmission rates, and the interrelation between them and average length of stays in hospital and finished consultant episodes.

Since persons discharged from hospital are a key source of demand for residential and home care social services there is a possibility of circularity or 'endogeneity' in assessing how delayed discharge might be affected by changes in service levels. As a result an instrumental variables (three stage least squares) regression technique was employed for the structural model.[1] Using 3SLS also allows the model to take into account the structure of the coefficients of all equations as well as the likely correlation between the error terms of the different equations in the system. Since health care services are determined on a bureaucratic basis they were not expected to be endogenous and tests supported this hypothesis. The reduced-form model estimates relationships between delayed discharges and readmission rates and the instrumental variables only (i.e. no service levels). It does not as a consequence suffer from endogeneity problems. Fixed time effects were included in all models estimated.

Table 3-2 reports descriptive statistics of the endogenous variables in the analysis.

Table 3-2. Descriptive statistics – endogenous variables

Variable	Obs	Mean	Std. Dev	Mi	Ma	Skew	Kur
Finished consultant episodes*	292	1.583	0.328	0.199	2.501	-0.40	4.57
Delayed discharge rate	292	0.130	0.073	0.007	0.551	1.86	8.64
Standardised emergency readmission rates	292	5.902	0.699	4.243	7.422	0.22	2.27
Average length of stay in hospital	292	4.162	0.559	3.218	5.885	0.94	3.45
LA supported hours of home care*	292	0.403	0.193	0.057	1.466	1.71	7.41
Supported nursing home beds*	292	0.009	0.004	0.001	0.024	0.74	3.73
Residential home beds*	292	0.030	0.012	0.006	0.094	1.41	7.44

[1] This approach removes the dependence of service levels on discharge rates by (in the first-stage) estimating demand only on factors (instruments) that are not determined by demand levels such as local market labour prices and capital costs.

[*] rate per individual over 65.

The discharge rate indicator was somewhat skewed and leptokurtic (Skewness 1.86, Kurtosis 8.64), but since this was not extreme and not materially improved by logging anyway, a linear functional form was chosen for the reduced form model estimation.

The sample sizes of the final regression samples are the same as those indicated in the above table. For one variable – district nurse whole-time-equivalents – 4 LAs had missing data (7 cases in the pooled dataset) and these were replaced using the sample mean or imputed from values of neighbouring years.

4. Results

All the regression models reported below were significant overall. Individual coefficients that are statistically significant at the 90% and 95% confidence level are marked with one and two asterisks respectively. All regressions satisfied diagnostics relating to specification. Against the possibility of heteroscedasticity, robust standard errors were estimated. Tests for endogeneity, where appropriate, were also undertaken and these were all consistent with the specifications estimated.

4.1. Reduced form models

4.1.1. Delayed discharge rates

Table 4-1 reports the results of the reduced form estimation of delay discharge rates. Unsurprisingly given their close link with levels of demand for hospital services and therefore hospital discharges, higher standardised mortality rates (SMR) are associated with higher rates of delay. Even though it remains positive over the range observed of the indicator, the nature of the effect described in the model suggests the net effect of marginal increases to fall with SMR levels.

Higher numbers of hospital beds are linked to higher delay rates. Other things equal, increases in the number of hospital beds should lead to increases in the number of hospital discharges. Within a given level of social and community health services this means more people likely to be delayed. That the effect is best defined in a quadratic form may be related to changes in the nature of the case mixes with increases in hospital capacity.

The analysis corroborates the hypothesis held by the National Beds Inquiry that social care resources affect delayed discharge rates very significantly. Hence, 'richer' social care departments appear to enjoy lower levels of delays. However, the levels of social care services purchased are dependent, among other things, on the input prices faced by the providers of the services. Increases in input prices (property prices and average gross weekly earnings) are found to worsen delay rates. Other things being equal, higher input prices imply higher production costs, thus higher production prices and ultimately lower service demand. The length of the chain of this argument testifies to the strength of this effect on delay rates.

Holding constant hospital capacity, increases in the revenue of the health care sector are also found to reduce significantly the observed rates of delay.

Table 4-1. Delayed discharges – reduced-form model

Variable definition				Functional form	Coeff
Unit cost of factors of production					
LA average house prices				Linear	3.18E-07*
Average gross weekly earnings				Linear	5.51E-04**
Resource levels					
LA total gross elderly expenditure per individual over 65				Linear	-0.13367**
HA net total revenue per individual over 65				Linear	-0.01764**
Need indicators					
Standardised mortality rates				Linear	0.02051**
				Squared	-9.41E-05**
Hospital capacity					
Number of beds per individual over 65				Squared	74.66*
Time fixed effect					
Year 1999/00					9.22E-03
Unspecified factors					
Constant					-1.07722**
Model summary					
Dependent variable		Proportion of persons over 75 in acute beds delayed from discharge to social care on a given day			
Number of obs		292		F prob	<0.0001
R^2		0.2204			
Diagnostics					
Specification	Linktest	Linear	-0.29	Prob > F =	0.771
		Squared	2.09	Prob > F =	0.038
	Ramsey RESET		2.20	Prob > F =	0.088
Normality	Shapiro-Wilk test		7.317	Prob > F =	0.000

** Significant at 5% confidence level; * Significant at 10% confidence level; Model estimated with robust standard errors.

4.1.2. Emergency readmission rates

The results in Table 4-2 for emergency readmissions almost mirror those found for delayed discharge rates. Whereas both gross SSD expenditure and local health revenue appear significantly negatively correlated with rates of readmission, house prices and local wages increase them very significantly.

In addition, two local need-related indicators, the proportions of individuals in the LA receiving income support and the proportion of population with a limiting long-standing illness, appear to increase significantly readmission rates.

Table 4-2. Emergency readmissions– reduced-form model

Variable definition	Functional form	Coeff
Unit cost of factors of production		
LA average house prices	Squared	3.81e-12**
Average gross weekly earnings	Linear	.00209**
Resource levels		
LA total gross elderly expenditure per individual over 65	Linear	-.784**
HA net total revenue per individual over 65	Linear	-.202**
Need indicators		
Proportion receiving income support	Linear	2.92**
Proportion of population with a limiting long-standing illness	Squared	12.22**
Time fixed effect		
Year 1999/00		.217**
Unspecified factors		
Constant		3.84**

Model summary					
Dependent variable		Rate of emergency readmissions to hospital within 28 days of discharge, as a percentage of live discharges, for all types of hospital discharges.			
Number of obs		292		F prob	<0.0001
R^2		0.3016			
Diagnostics					
Specification	Linktest	Linear	-0.54	Prob > F =	0.588
		Squared	1.01	Prob > F =	0.313
	Ramsey RESET		0.46	Prob > F =	0.712
Normality	Shapiro-Wilk test		1.772	Prob > F =	0.090

** Significant at 5% confidence level.

4.2. Structural form model

The results of the structural model, summarised in Table 4-3, corroborate the findings from the reduced-form estimations. During estimation, they proved to be robust to changes in specification (particularly instruments). The provision of community-based and institution-based social care is found to reduce significantly delayed discharge rates and residential and nursing home support to reduce emergency readmission rates. The effect of the indicator of community care support is not significant in the readmissions model. Moreover, it shows a counterintuitive sign. However, exploratory analysis suggests that when the indicator is replaced with a measure of intensive home care support (proportion of households receiving more than 10 hours per week of home care support) the effect becomes borderline significant and with the expected sign. This variation was not introduced in the final model for reasons of parsimony (with respect to an already intricate system of equations).

Table 4-3Structural model

	Finished consultant episodes per individual over 65		Average length of stay in hospital		Delayed discharge Rates		Standardised readmission rates		Residential home beds per individual over 65		Supported nursing home beds per individual over 65		Hours of home care per individual over 65	
	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.
Hospital performance indicators														
Average length of stay in hospital	-0.406	0.00					-0.413	0.00						
Delayed discharge rates			10.185	0.00										
Formal services														
District nurse WTE per individual over 65					-7.549	0.07	-183.224	0.00						
Gross SSD spending per individual over 65									0.021963	0.00	0.014868	0.00	0.554	0.00
Hospital beds per individual over 65	86.327	0.00			3.924	0.00								
Hours of home care per individual over 65					-0.082	0.01	0.388	0.28	-0.017251	0.05	-0.015648	0.00		
Residential home beds per individual over 65					-2.946	0.00	-15.438	0.00			-0.089883	0.00	-3.745	0.00
Supported nursing home beds per individual over 65					-8.800	0.00	-50.114	0.03	-2.420119	0.00			-30.428	0.00
Need indicators														
Limiting long standing illness							9.157	0.00						
Proportion of population over 85 years old			12.308	0.00					0.214731	0.00				
Proportion of residents living alone			6.323	0.00									1.968*	0.00
Proportion of residents receiving attendance allowance/ disability living allowance			3.126	0.01			2.913	0.05						
Standardised mortality rates					4.24E-04	0.44			0.000566	0.00	0.000122	0.00	0.007	0.00
Factor prices														
Average gross weekly earnings									-0.000021	0.08				
Average house price (all dwellings)									-3.19E-13*	0.00			-5.54E-07	0.01
House prices											-4.99E-08	0.00		
LA characteristics														
ONS classification: coast and country resorts									0.011146	0.00				
ONS classification: ports and industry											0.001863	0.00		
Other indicators														
Year 2001	0.005	0.43	0.020	0.80	-0.001	0.92	0.094	0.18	-0.002093	0.07	-0.000663	0.07	-0.019	0.19
Constant	1.719	0.00	-1.337	0.03	0.232	0.00	6.712	0.00	-0.023191	0.09	-0.000810	0.78	-0.483	0.00

* Indicator entered under squared form.

In addition to social care support, district nursing services are also found associated with significant reductions in the two rates.

The instrumentation of the social care service indicators appears to work well. Level of services increase with need indicators and gross SSD spending and fall with house prices, local wages, and levels of substitute services. In addition, LAs belonging to the 'coast and country resorts' and 'ports and industry' ONS classifications were found to provide higher than average levels of residential and nursing home beds respectively.

The results in Table 4-3 suggest some very clear relationships between the different indicators of acute system performance. As hypothesised in Figure 1, whereas local average lengths of stays are positively associated with rates of delay discharges (hence increasing the number of finished consultant episodes), lower delayed discharge rates are found to bring about increases, other things equal, in the rates of emergency admissions.

In other words, other things equal, although reducing the level of delayed discharges is found to bring about lower average lengths of stays and therefore higher hospital throughputs, it is also found to bring about increases in the rates of readmissions following discharge.

5. Discussion

The analysis provides substantial evidence about the processes behind hospital delayed discharges and emergency readmissions. It corroborates the commonly held assumption that the performance of the social and health care systems are interdependent, and hence the need for closer coordination.

The results also confirm the major impact that input prices (wages and house prices) have on local authority level of demand for services, and therefore on the performance of the acute health care system. Given the extreme geographical variability in prices in England, further attention needs to be paid to understanding the extent to which Local Cost Adjustment factors incorporated into local allocation formulae do or do not fully compensate for local variations in prices.

Finally, the results illustrate some of the dangers of focusing policy attention on a single measure of performance, in this case, delayed discharges. Indeed, the results suggest that other things equal improvements in delayed discharges are associated with deteriorations in readmission rates, so that some of the gains associated in term of increases in hospital throughputs may in fact be lost through the need to provide otherwise avoidable hospital care. Further work should explore in greater detail the nature of such a trade-off, if possible looking at final outcomes.

The limits of the implications that may be drawn from the results are bound by the methodology used in their estimation. The analysis has been based on data aggregated at the local authority level, whereas it may be argued that the natural unit for the analysis is the individual case (see for instance Fernández and Davies (2001)). As a result, the effect of important micro-relationships such as the interaction between patients, carers and health and social care professionals will not have been fully controlled for. More generally, the results cannot inform policy about the effect of alternative arrangements between health and social care systems for patients suffering from different health conditions, with different levels of support and/or socio-economic status.

The models estimated reflect observed practice. Hence, estimated substitution effects echo current prioritisation of services. For instance, estimates of the effect of gross local authority expenditure on delay rates reflect existing mixing of services and sharing of resources between hospital discharge cases and other cases. Inferences based on them will perpetuate these relationships, and cannot be used to illuminate the likely effect of structural changes.

Also, even though the structural model appears to behave well, 3SLS models are reputed for their instability, and for their *cunning* ability to spread the effects of misspecifications in one equation across the entirety of the model. So caution needs to be taken when drawing inferences from the coefficients estimated.

6. Appendix: microeconomic models of the effect of social care resources on inpatient system performance

This section presents the (partial) microeconomic model of the interaction between social care services and performance in the acute health care sector. The model presented at this stage only applies to delayed discharges (the modelling of other performance measures and in particular readmission rates is to be finalised).

6.1. Delayed hospital discharge

Total persons delayed over the course of a year in hospital is given by:

(6-1) $n^d = n^D - n^f$

where n^d is the number of persons delayed, and is given by the numbers of people due for discharge to social care, n^D, less the number of people actually discharged on time to social care, n^f. The number of people delayed can also be written in terms of the discharge rate $\tau = \frac{\left(a^D - a^f\right)}{a^A}$, where a^D represents the number of people due for discharge to social care per day, a^f represents the number of people actually discharged to social care, and a^A represents the overall number of people over 75 occupying inpatient beds.

Given that the relationship between numbers of patients on a day a and numbers of episodes per year n is given by $n = \frac{a \cdot 365}{m}$, where m represents mean length of stay, we have that

(6-2) $\tau = n^D \frac{m^d}{365 \cdot a^A} - \frac{m^d}{365 \cdot a^A} n^f$

The function n^f can be expressed in terms of the services setting into which people were discharged, $n^f = \chi^{h1} + \chi^{h2} + ... + \chi^{hK}$. The superscript h refers to a transfer from hospital. In turn this equation can be expressed in terms of total demand for the j services using the ratio $\phi^j = \frac{\chi^{hj}}{\chi^{hj} + \chi^{cj}} = \frac{\chi^{hj}}{X^j}$, where the superscript c refers to a transfer of people into social care from the community. Hence, in general terms this ratio can be written $\phi^j = \phi^j\left(X^1,..., X^K, B, \Gamma\right)$, functions of the known total social care service activity The parameters of the utility function Γ will reflect the relative importance that the local authority places on meeting needs of those people from the community and those people from hospital. The difference $\partial U/\partial\chi^{cj} - \partial U/\partial\chi^{hj} = \Gamma_{\chi^{cj}}\left(\delta^c\right) - \Gamma_{\chi^{hj}}\left(\delta^h\right)$ at any given point (budget) measures this relative preference, and could be expected to depend on relative need δ^l for $l = c, h$, and perhaps also the degree of coordination between health and social care professionals. Along with budgetary considerations and preferences about services mixes, these factors will determine ϕ^j, the rate at which services supported by the local authority go to people being discharged from hospital. This is a parameter to be estimated empirically, using (6-2) and substituting for n^f, i.e.

$$(6\text{-}3) \qquad \tau = n^D \frac{m^d}{365 \cdot a^A} - \frac{m^d}{365 \cdot a^A} \sum_{j=1}^{S} \phi^j X^j$$

Assuming that the number needing discharge to social care is directly related to the number of patients, i.e $n^D = \theta \cdot n^A$, we have that

$$(6\text{-}4) \qquad \tau = \theta \frac{m^d}{m^A} - \frac{m^d}{m^A n^A} \sum_{j=1}^{S} \phi^j X^j$$

Now writing, $n^A = n^A(T, b)$ where T is the LA population aged 75 plus and b represents the number of hospital beds in the LA, and noting the dependence of mean length of stay on needs, we have:

$$(6\text{-}5) \qquad \tau = \theta(\delta) \frac{m^d(\delta^h)}{m^A(\delta^h)} - \frac{1}{n^A(T, b)} \frac{m^d(\delta^h)}{m^A(\delta^h)} \sum_{j=1}^{S} \phi^j X^j$$

For the purposes of estimation we approximate this function by polynomials, that is,

$$(6\text{-}6) \qquad \tau = \tau(T, X^1, ..., X^S, \delta^h)$$

We can average out the ratio of hospital sourced to total transfers to social care as:

$$(6\text{-}7)\, \phi = \frac{\sum_{j=1}^{S} \phi^j X^j}{\sum_{j=1}^{S} X^j}$$, we have:

$$(6\text{-}8)\, \tau = \theta(\delta) \frac{m^d(\delta)}{m^A(\delta)} - \frac{1}{n^A(T)} \frac{m^d(\delta)}{m^A(\delta)} \phi(\delta) \sum_{j=1}^{S} X^j$$

or

$$(6\text{-}9)\ \theta = \frac{m^A}{m^d}\tau + \frac{1}{n^A(T)}\phi(\delta)\sum_{j=1}^{S} X^j$$

which can be re-arranged to give:

$$(6\text{-}10)\ \phi = -\frac{\left(d\,\frac{m^A}{m^d} - \theta\right)n^A(T)}{\sum_{j=1}^{S} X^j}$$

So when $\tau = 1$, then $m^A = m^d$ and so $\phi = 0$. When $\tau = 0$, then $\phi = \theta\, n^A(T) \Big/ \sum_{j=1}^{S} X^j$.

Reduced-form discharge equations can be found by substituting the reduced-form service equations into (6-6) for each service *j*. The latter are functions of need and input prices (*w*)

$$(6\text{-}11)\quad \tau = \tau^R\left(T, B, Z(w), \delta^h\right)$$

Elasticities with respect to input prices, *w*, are therefore:

$$(6\text{-}12)\quad \frac{\partial\tau}{\partial w^h}\frac{w^h}{\tau} = \frac{\partial\tau^R\left(T, B, Z(w), \delta^h\right)}{\partial Z}\frac{\partial Z(w)}{\partial w^h}\frac{w^h}{\tau}$$

6.2. Cost implications of changes in delay discharge rates

The cost implications of changes in delayed-discharge rates will vary with the mix of social care services provided and the extent to which these are concentrated on patients awaiting discharge.

Let us define the share of total units of services allocated to service *i* as

$$\gamma^{cj} = \frac{\chi^{cj}}{\sum_{j=1}^{K}\chi^{cj} + \sum_{j=1}^{K}\chi^{hj}} \text{ , } \gamma^{hj} = \frac{\chi^{hj}}{\sum_{j=1}^{K}\chi^{cj} + \sum_{j=1}^{K}\chi^{hj}} \text{ and } \gamma^{j} = \frac{\chi^{cj} + \chi^{hj}}{\sum_{j=1}^{K}\chi^{cj} + \sum_{j=1}^{K}\chi^{hj}}$$

for users in the community, in hospital and overall respectively.

The relationship between changes in *B* and changes in service levels is defined as

(6-13) $$\frac{\partial\chi^{lj}}{\partial B} = \frac{\gamma^{lj}}{\sum_{j=1}^{K} p^{j} \cdot \gamma^{j}} \text{ for service } j \in \{1, \dots, K\}, \text{ and user type } l \in \{c, h\}.$$

Setting $\beta 0 = \theta(\delta)\frac{m^{d}(\delta^{h})}{m^{A}(\delta^{h})}$ and $\beta^{hj} = -\frac{1}{n^{A}(T)}\frac{m^{d}(\delta^{h})}{m^{A}(\delta^{h})}$ we can re-express equation (6-13) as

(6-144) $\tau = \beta 0 + \sum_{j=1}^{K}\beta^{hj} \cdot \chi^{hj}$.

The changes in levels of service implied by changes in delay rates are then defined as

(6-15) $$\frac{\partial\chi^{lj}}{\partial\tau} = \frac{\gamma^{lj}}{\sum_{j=1}^{K} \beta^{j} \cdot \gamma^{j}} \text{ for service } j \in \{1, \dots, K\}, \text{ and user type } l \in \{c, h\}.$$

Assuming a constant marginal relationship between changes in prices and levels of services $\frac{\partial p^{j}}{\partial\chi^{j}} = \lambda^{j}$, the changes in the price of service *j* that follow from a marginal change in delay rates are therefore equivalent to $\frac{\partial p^{j}}{\partial\tau} = \frac{\gamma^{j}}{\sum_{j=1}^{K}\beta^{j} \cdot \gamma^{hj}} \cdot \lambda^{j}$.

The effect on budget *B* of changes in delay rates is therefore

(6-15) $$\frac{\partial B}{\partial\tau} = \sum_{j=1}^{K}\left(\frac{\partial\chi^{j}}{\partial\tau} \cdot p^{j} + \frac{\partial p^{j}}{\partial\tau} \cdot \chi^{j}\right) = \sum_{j=1}^{K}\left(\frac{\gamma^{j}}{\sum_{j=1}^{K}\beta^{hj} \cdot \gamma^{hj}} \cdot \left(p^{j} + \lambda^{j} \cdot \chi^{j}\right)\right)$$

Equation (5-48) decomposes at the margin the cost of improving delay rates between the cost of paying for the new levels of services required at current prices and the cost of paying for existing levels of services at higher prices. Given that $\phi^j = \frac{\gamma^{hj}}{\gamma^j}$, this relationship can also be expressed as

$$(6\text{-}16)\quad \frac{\partial B}{\partial \tau} = \sum_{i=1}^{K} \left(\frac{\gamma^j \cdot \left(p^j + \lambda^j \cdot \chi^j\right)}{\sum_{j=1}^{K} \phi^j \cdot \gamma^j \cdot \beta^{hj}} \right)$$

Assuming approximately equal distributions of resources between client types across services, so that $\phi^u \approx \phi^v$ for all services $u \neq v$, equation (5-49) becomes

$$(6\text{-}18)\quad \frac{\partial B}{\partial \tau} \approx \frac{1}{\phi} \cdot \sum_{j=1}^{K} \left(\frac{\gamma^j \cdot \left(p^j + \lambda^j \cdot \chi^j\right)}{\sum_{j=1}^{K} \gamma^j \cdot \beta^{hj}} \right)$$

Equations (6-17) and (6-18) show how the levels of resources required to bring about a given reduction in delay rates decrease with ϕ, the degree to which the additional resources are concentrated on hospital patients waiting to be discharged.

7. References

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