Report to TAGRA Remote and Rural Subgroup, 29th March 2012

1. Background

Research into *The effects of rurality and remoteness on hospital costs* was undertaken by Dr. Patricia Norwood, in the context of her PhD, and consisted of the analysis of Scottish hospital costs and the role rurality and remoteness played in driving those costs.

This research was driven by both policy and theoretical motivations.

In terms of economic theory, the hospital cost function literature had been characterised by failing to address the question of rurality and remoteness in any systematic way. Most studies did not explicitly examine rurality and remoteness and the few studies that had included a remote/rural dimension, had done it indirectly. In terms of policy relevance, the research tried to answer an important question regarding the process of allocating resources in NHSScotland, which had been repeatedly identified as an area calling for further research: do rural and remote hospitals experience unavoidable higher costs and how much higher are those costs?

Thus, the main aim of the PhD thesis was to examine the influence of remoteness and rurality on hospital costs in Scotland by trying to identify the main determinants of hospital costs and then determine if rurality and remoteness influenced hospital costs, independent of other factors.

2. Description of the research and methods of estimation

a) methodology

The research focused on the modelling of a hospital cost function which took into account the principal factors thought to affect hospital costs (activity, number of available beds, average length of stay and rurality and remoteness), with special emphasis placed on the effect of rurality and remoteness.

A so called "hybrid functional form" was adopted, which was based on a flexible econometric estimation but also included some *ad hoc* features, such as the inclusion of

behavioural variables, in this case, a measure of rurality and remoteness. Flexible specifications have the great advantage of avoiding the risk of misspecification as they do not require restrictive assumptions to be made regarding the functional form. They also allowed the testing and quantification of possible economies of scale and scope, which might be associated with rurality and remoteness.

The model was estimated using a fixed-effects model which controls for all the "unobserved factors" that affect costs and thus takes into account heterogeneity in hospitals, where a number of unmeasured explanatory variables affect the behaviour of those same hospitals, as all hospitals differ from each other in fundamental unmeasured ways.

Therefore, the main advantage of this type of modelling was that it addressed a major problem that had before affected hospital cost function estimations, that is, the availability of an adequate list of independent variables to explain hospitals costs.

Issues such as case-mix differences between very diverse hospitals (in terms of size and type of activity) as well as factors thought to influence hospital costs but which are challenging to measure such as quality of care, uncertain demand, management style and the culture of the hospitals could now be taken into account without the need to explicitly include those variables.

A major drawback was the fact that this estimation process assumes these "unobserved factors" that influence costs would not vary over the short period of time of the analysis (between 1998/99 and 2002/03) and all time-invariant variables in a fixed-effects model are not estimated by the model so any hospital specific characteristics such as teaching status, that do not vary over the time period in analysis, will be wiped out.

b) data

The primary source of data for the research was the "Scottish Health Services Costs" book, published by the Information & Statistics Division (ISD) of NHSScotland. The data consisted of a single data set containing a series of observations covering 65 hospitals in Scotland, for a period of 5 years (year ended 31st of March 1999 until year ended 31st of March 2003), at

specialty level (25 specialties)[1]. Thus, the main level of analysis was specialty level costs, and not just hospital costs as such. The reasoning for this resided in the potential additional information that this level of data could provide, as it might be that rurality and remoteness would impact differently not only on different hospitals but also on the different specialties within each hospital. It was decided that only hospitals classified as acute by the ISD would be included in the analysis, consisting of teaching, large general, general and community hospitals. Non acute hospitals were excluded as their activities were considered to be too different and as such their costs would not be comparable with acute hospitals costs.

c) rurality and remoteness

A fundamental variable in the analysis was the measure of rurality and remoteness. Six new measures (Rur1, Rur2, Rur3, Rur4, Rur5, Rur6) were estimated that were based on the rural classification of settlements in use in Scotland[2] which consisted of an eight fold classification of settlements according to population density (so as to take into account rurality) and driving times to the nearest settlement (to account for remoteness). These new measures were calculated not only using different methods (either using discharges or costs to calculate the distribution of patients per postcode) but also various concepts of what type of settlements should be classified as rural and remote in order to test the sensitivity of the results to different definitions of rurality and remoteness[3].

Rur1 and Rur4 focus mainly on rural areas (with rurality being defined as a function of settlement size) while Rur3 and Rur6 focus more on remoteness (with remoteness being defined based on travel time to nearest urban settlement[4]). Rur2 and Rur5 are broader measures, which combine both aspects of rurality and remoteness.

[1] Total of 8,125 observations.
[2] Scottish Executive Urban Rural Classification, 2003-2004
[3] See Annex for more detailed discussion of rurality and remoteness measures.
[4] Settlements are classified as urban when their size is 10,000 or more.

d) main results

The following table summarizes the main results of the model in terms of the coefficients of the main variables (measure of rurality and remoteness, number of inpatients, number of outpatients, number of day cases and day patients, average length of stay and number of beds).

Interaction terms between the variables and dummy variables for years and specialties were included in the model but not reported in this table. The rurality measure used was Rur3 but sensitivity analysis regarding the remaining rurality and remoteness measures is included in the Annex.

Table 1: Main results of Regression

Variables	Coefficients
Rur3	**0.04***
Inpatients	**0.23***
Outpatients	**0.15***
Day cases/day patients	**0.11***
Length of stay	**-0.01**
Beds	**0.41***

*Significant at 5%

The results suggest that a 1% increase in rurality and remoteness is associated with an increase in hospital costs of 0.04%, after controlling for everything else.

The results of sensitivity analysis, in Annex, show that this impact varies between 0.02% and 0.11%, depending on the rurality measure used, which seems to indicate that the classification of "rural and remote" adopted is not irrelevant as different classifications produced different results. This lead to the conclusion that specific aspects of rurality and remoteness impact on hospital costs in different ways and the way rurality and remoteness is defined will determine the effect on hospital costs.

Furthermore, although there was evidence of the existence of economies of scale in all the models estimated, the effect of rurality on hospital costs did not seem to be associated with those economies of scale as the levels of economies of scale were fairly similar across all the models, with or without taking into account rurality. This seemed to disprove the existence

of a direct link between rurality and economies of scale and proved that if any link exists it is a much more complex one than a mere connection between size, rurality and costs.

3. The Rural General Hospitals (RGH) case

Currently there are six hospitals classified as RGH:

- Balfour Hospital, Kirkwall
- Belford Hospital, Fort William
- Caithness General Hospital, Wick
- Gilbert Bain Hospital, Lerwick
- Mackinnon Memorial Hospital, Broadford
- Western Isles Hospital, Stornoway

Of these hospitals only Balfour, Gilbert Bain and Western Isles hospitals are included in the dataset used in the analysis.

The reason for the exclusion of Belford, Caithness and Mackinnon hospitals is that only acute hospitals were included in the analysis and, at that time period (between 1998/99 and 2002/03), these hospitals had beds managed by more than one trust (Highlands Acute Hospital NHS Trust and Highland Primary Care Trust) and as such their costs were considered not to be comparable to other hospitals.

4. Analysis of General Rural Hospitals included in the dataset

In terms of how distinct the RGHs included in the analysis (Balfour, Gilbert Bain and Western Isles) are from the remaining hospitals, the following descriptive statistics of the main variables included in the model for both the three Rural General Hospitals (RGHs) and the other hospitals in the dataset (Other) provide an indication that there are substantial differences:

Table 2: Main variables descriptive statistics for Rural General Hospitals and Other Hospitals

Variables	N		Minimum		Maximum		Mean		Std. Deviation	
	RGHs	Other	RGHs	Other	RGHs	Other	RGHs	Other	RGHs	Other
No Inpatients	54	1573	44	9	1844	17728	662.7	2034.8	508.3	2618.4
No outpatients	54	1573	1	1	9420	94251	2219	10562	1895.5	13164.6
No day patients and day cases	54	1573	1	1	952	14833	257.5	1037.9	310.5	1451.4
No beds	54	1573	2	2	70	296	20.2	37.2	17	41.9
Length of stay	54	1573	117	7	359	533	238.7	265.6	55.4	72.4

This table shows that RGHs are markedly smaller than the Other Hospitals, with lower activity level (RGHs have around 33% the average number of inpatients of Other Hospitals, 21% of average number of outpatients and 25% of the average number of day cases and day patients) and less number of beds (around half the average of Other Hospitals). The lengths of stay are, in average, quite similar for both sets of hospitals.

Table 3: Rurality and remoteness measures descriptive statistics for Rural General Hospitals and Other Hospitals

Rurality Measures	N		Minimum		Maximum		Mean		Std. Deviation	
	RGHs	Other	RGHs	Other	RGHs	Other	RGHs	Other	RGHs	Other
Rur1	54	1573	0.41	0.01	0.72	1.00	0.62	0.24	0.08	0.19
Rur2	54	1573	0.98	0.01	1.00	1.00	0.99	0.29	0.01	0.26
Rur3	54	1573	0.97	0.00	1.00	1.00	0.99	0.15	0.01	0.25
Rur4	54	1573	0.41	0.01	0.75	1.00	0.64	0.24	0.09	0.19
Rur5	54	1573	0.98	0.01	1.00	1.00	0.99	0.29	0.01	0.26
Rur6	54	1573	0.97	0.00	1.00	1.00	0.99	0.16	0.01	0.15

In terms of the rurality and remoteness variables used in the modelling, regardless of the definition used, these hospitals are substantially more rural than the other hospitals, with means that reach almost 1 which is the maximum level of rurality and remoteness, meaning almost all the patients treated in these hospitals come from rural and remote postcodes (the exception being Rur1 and Rur4, which are the most restrictive measures and as such with lower values).

In terms of the regression results, it is not possible to include any sort of marker in our model that would identify these 3 Rural General Hospitals as during the period in analysis this classification remains constant and as such any sort of marker will be dropped in the estimation of the model. It is also not possible to analyse these hospitals separately as they are too small of a group to allow the estimation of the model.

As a result the following approach was adopted, two models were estimated, one with the full dataset, including the RGHs, and other model using a dataset where the RGHs were excluded. The objective was to access what impact this would have on the coefficients.

Table 4: Regression results for model with all hospitals included and model with hospitals excluding Rural General Hospitals

	All hospitals	Hospitals excluding RGH
Rurality (rur3)	0.0402*	0.0412*
No. Inpatients	0.2311*	0.2204*
No. Day patients/day cases	0.1119*	0.1087*
No. Outpatients	0.1454*	0.1396*
No. beds	0.4139*	0.4334*
Length of stay	-0.0115	-0.0207

* Significant at 5%

As expected, dropping these 3 hospitals did not produce any significant impact as they represent only 54 out of the total number of observations[5].

Still, the results from the model estimation (with all hospitals included) still provide information that allows for a comparison of those RGHs with the rest of the hospitals included in the dataset in terms of cost differentials. The following table summarizes the coefficients for rurality and remoteness produced by the model along with the average rurality and remoteness statistics for both groups of hospitals:

Table 5: Descriptive statistics and regression coefficients for rurality and remoteness measures

	Rur1 Mean	***Rur2 Mean***	***Rur3 Mean***
RGH	0.62	0.99	0.99
Others	0.24	0.29	0.15
	Rur1 coefficient	***Rur2 coefficient***	***Rur3 coefficient***
	0.11	0.10	0.04

(Note: From table 2 above and table A3 in Annex)

[5] 3 hospitals*5 years*number of specialties in each hospital

Taking into account Rur1, RGHs have, on average, a rurality and remoteness measure of 0.62 while for other hospitals this is 0.24, which means that RGHs are 158%[6] more rural and remote than Other Hospitals.

The coefficient from the model estimation for Rur1 is 0.11, which means that a 1% increase in rurality will lead to a 0.11% increase in costs. Combining this with the information from above it means that RGHs are on average 17.4%[7] more costly than other hospitals.

Extending these calculations for Rur2 and Rur3:

Table 6: Increase in costs for RGHs

Rur1	17.4%
Rur2	24%
Rur3	22.4%

It can be concluded that RGHs incur higher costs than other acute hospitals and that, depending on the rurality and remoteness measure used, those costs are, on average, between 17 to 24% higher than other hospitals, after controlling for all other influencing factors.

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[6] ((0.62-0.24)/0.24*100)
[7] (158*0.11)

Annex: Rurality measures

The rurality measures estimated for this research were based on a classification which uses settlement size to measure the level of rurality and travel distances to take into account remoteness:

Table A1: Classification of settlements in Scotland

Travel time to nearest urban settlement (10,000 or more)	**Settlement size >125,000**	**Settlement size 10,000-125,000**	**Settlement size 3,000-10,000**	**Settlement size <3,000**
< 30 minutes	Large Urban Areas **(1)**[8]	Other Urban Areas **(2)**	Accessible Small Towns **(3)**	Accessible Rural Areas **(6)**
30-60 minutes	-	-	Remote towns **(4)**	Remote Rural Areas **(7)**
> 60 minutes	-	-	Very Remote Small Towns **(5)**	Very Remote Rural Areas **(8)**

(adapted from Scottish Executive Urban Rural Classification, 2003-2004)

The categories in the table above were combined in three different ways to obtain a single measure of rurality. The first definition of rural settlements includes settlements classified as accessible rural areas; remote rural areas and very remote rural areas ((6) + (7) + (8)); the second definition includes remote towns and very remote small towns as well ((4) + (5) + (6) + (7) + (8)) whilst the third is equivalent to second but with the difference that it does not consider accessible rural areas(4) + (5) + (7) + (8). The different measures tried to reflect those different aspects of the rurality and remoteness problem. The first measure focuses on very rural areas; the second one is a combination of rurality and remoteness, and the third focuses more on remoteness.

These measures of rurality and remoteness considered, not the location of the hospital, but the rurality of the patients it treats. Taking into account the postcode of a hospital only

[8] Aberdeen, Dundee, Glasgow and Edinburgh

might lead to a misleading picture of the rurality and remoteness of that hospital, as some hospitals are located in postcodes classified as urban but are adjacent to large rural areas that supply a significant proportion of patients.

For a better understanding of the degree of rurality and remoteness of a hospital, it was more accurate to consider the postcodes of the patients it treated, as that would provide a better understanding of the surrounding 'market' area where the hospital is located. For instance, Raigmore Hospital, in Inverness, is located in a postcode that would be considered mostly urban, when the population it serves is mainly rural, which might have an impact on hospital costs, and that would be better reflected in a measure of rurality and remoteness based on where the hospital patients live as opposed to where the hospital is located.

Information on the breakdown of all hospital discharges and costs by postcode sector, specialty and hospital was used to build a measure of rurality based on the postcode sectors of the patients admitted to the specialty and hospital. This method allowed us to define the rurality of a specialty and hospital according to the rurality of the patients it treats:

Table A2: Rurality measures

Measures	Specification
Rur1	• discharges used to calculate the distribution of patients per postcode • accessible rural areas + remote rural areas + very remote rural areas
Rur2	• discharges used to calculate the distribution of patients per postcode • accessible rural areas + remote rural areas + very remote rural areas + remote towns + very remote small towns
Rur3	• discharges used to calculate the distribution of patients per postcode • remote rural areas + very remote rural areas + remote towns + very remote small towns
Rur4	• costs used to calculate the distribution of patients per postcode • accessible rural areas + remote rural areas + very remote rural areas
Rur5	• costs used to calculate the distribution of patients per postcode • accessible rural areas + remote rural areas + very remote rural areas + remote towns + very remote small towns
Rur6	• costs used to calculate the distribution of patients per postcode • remote rural areas + very remote rural areas + remote towns + very remote small towns

For example, considering a very simplified example where 5% of the patients discharged by hospital *h*, specialty *i*, come from postcode sectors which are 100% rural and the remaining 95% come from postcodes sectors which are totally urban, then we would have that the measure of rurality of that specialty and hospital will be 0.05 (0.05*1 + 0.95*0 = 0.05). If the situation were the opposite, that is, 95% of the patients coming from rural areas and only 5% coming from urban areas, our measure of rurality would then be much higher, 0.95 (0.95*1 + 0.05*0 = 0.95) .

Thus, the maximum degree of rurality and remoteness will be associated with values of 1, as it means that all the patients treated by the hospital *h*, specialty *i*, come from areas where 100% of the population lives in an area classified as rural, with the other extreme being when none of the patients treated originate from rural areas, where we obtain a value of zero.

After estimating the model, sensitivity analysis regarding the coefficients of the different rurality and remoteness measures produced the following results:

Table A3: Coefficients of the different rurality and remoteness measures

	Coefficients
RUR1 (discharges, 6+7+8)	0.11%*
RUR2 (discharges, 4+5+6+7+8)	0.10%*
RUR3 (discharges, 4+5+7+8)	0.04%*
RUR4 (costs, 6+7+8)	0.07%*
RUR5 (costs, 4+5+6+7+8)	0.06%*
RUR6 (costs, 4+5+7+8)	0.02%*

* Significant at 5%

Taking Rur3 as an example, an increase in rurality of 1% will lead to an increase in costs of 0.04%, but if a different rurality measure is considered, such as Rur1, that impact will almost treble to 0.11%.