Improving geographic equity: A location-allocation model to redistribute hospital supply

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The question

How do we change the distribution of hospital supply to improve equity by populations?

Previous methods for analysing hospital changes have relied on crude assumptions on patients' behaviour, neglected the process of demand for hospital care, and neglected the interaction between hospital size and the levels of utilisation of alternative hospitals

Structure of the presentation

A. The problem
B. A location-allocation model for redistributing hospital supply
   B.I. The flow demand (econometric) model
   B.II. The mathematical programming model
C. Application to the Portuguese system
D. Discussion and concluding remarks
IMPROVING GEOGRAPHIC EQUITY: A LOCATION-ALLOCATION MODEL TO REDISTRIBUTE HOSPITAL SUPPLY

Slide 4

A. Problem: health system context

Objective: How to change the distribution of hospital supply in order to achieve greater equity in utilisation?

Context:
I. Equity objectives
II. Redistribution
III. Central planning and (mainly) public provision
IV. Hospital utilisation explained by patients or doctors preferences
V. Health system nearly free at the point of use

Slide 5

A. Problem: some evidence (hospital doctors)

Slide 6

A. Problem: previous literature

I. Location-allocation models
II. Previous literature:
   II.1. Spatial interaction models
   II.2. Entropy models
   III.3. Mathematical programming models

Pitfalls:
- Behavioural assumptions are simplistic and unsatisfactory modelling of hospital interaction
- No clear understanding of the process of health care demand
Slide 7

**B. Methodology: building a location-allocation model**

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**B. Methodology: key steps**

I. Build econometric model of flows and do the regression: 
   \[ U_{i,j} = f(D_{j,...}) \]

II. Use econometric model as a constraint for MP model, which redistributes hospital supply; run MP model: 
   \[ \Delta D_j, \Delta U_{i,j} \]

III. Analyse outputs: 
   \[ \text{new} D_j, \text{new} U_{i,j} \]

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**B.I Methodology: the process of health care demand**
**Slide 10**

**B.I Methodology: the econometric model**

\[ \mathbb{E}[U_{i,j} | x] = \Pr(U_{i,j} > 0 | x) \times \mathbb{E}[U_{i,j} > 0 | x] \]

- PartA \times PartB
- Two parts: intuition
- Data characteristics
- Estimation: Logit (Part A) and GLM (Part B)
- Modelling interaction: a covariate for alternative hospital supply

**Slide 11**

**B.II Methodology: mathematical program structure**

- Maximises an equity function
- Multi-hospital system with a set of pre-determined, discrete and finite locations
- Utilisation flows as generated by the econometric model
- Total supply constrained to the current level
- Lower and upper bounds for redistribution

**Slide 12**

**B.II Methodology: objective function of MP model**

\[ \sum_{i} \sum_{j} \left( \log U_{i,j} - \log U'_{i,j} \right)^2 / N \]
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**B.II Methodology: linking the objective function with the two-part model**

\[
\log U_{i,j} - \log U'_{i,j} = \log \left( \frac{U_{i,j}}{U'_{i,j}} \right) = \text{BEHAVIOURAL MODEL}
\]

\[
= \log \left( \frac{\hat{P}_{i,j} * U_{i,j}}{U'_{i,j}} \right) = \log \hat{P}_{i,j} + \log U_{i,j} - \log U'_{i,j} \quad \text{FIXED}
\]

\[
= \text{THE EQUITY REFERENCE}
\]

Slide 14

**C. Application to Portugal: econometric issues**

- **Expected empirical findings**
  - One cannot analyse hospital policies without accounting for other variables of the health system

- **Modelling difficulties:**
  - Multicollinearity
  - Capturing the specifics of central hospital sites

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**C. Application to Portugal: GLM results**

(Second part; log link; Poisson distribution)

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<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
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<tbody>
<tr>
<td>Other constant</td>
<td>6.468201*</td>
<td>1.245652</td>
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<td>Distance</td>
<td>-0.0423718*</td>
<td>0.0000776*</td>
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<td>Population</td>
<td>2.95e-07*</td>
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<td>Need and socio-economic factors</td>
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<td>2.97e-12*</td>
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<td>Institutional factors</td>
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</table>

**Model summary:** 2217 observations; LogLikelihood=-297950

* Statistically significant at 1% level; ** Statistically significant at 5% level.
Geographic redistribution $(newD_j's)$:
south and interior hospitals; peripheral hospitals of urban areas; model concentrates redistribution to a small number of hospitals

Reduction in utilisation $\left( \sum_i \sum_j newU_{i,j} \right)$

- Utilisation is reduced: a price for equity?
- Supply is concentrated in a small number of hospital sites: manipulating hospital supply as an insufficient tool for influencing the patterns of utilisation?

An interdisciplinary approach is possible and useful (HE vs. OR)

Implementation is a big issue!!!