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## *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*



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## *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

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## *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



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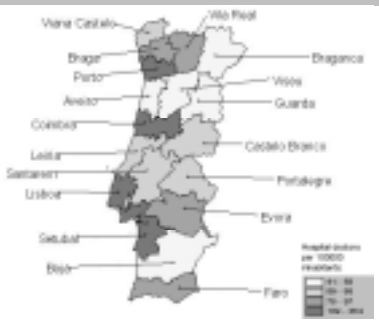
## *A. Problem: some evidence (hospital doctors)*



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## *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*

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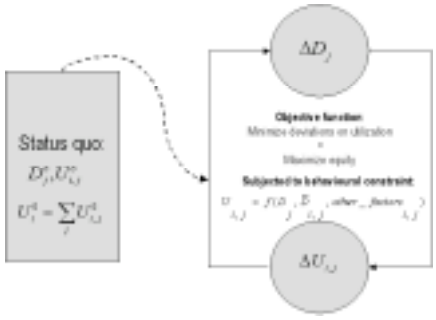
## B. Methodology: building a location-allocation model



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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: $[newD_j, newU_{i,j}]$



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## B.I Methodology: the process of health care demand

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

$$E[U_{i,j} / x] = \Pr(U_{i,j} > 0 / x) * E[U_{i,j} / > 0, x]$$
$$= PartA * PartB$$

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



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

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



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

$$\frac{\sum_i \sum_j \left(\log U_{i,j} - \log U_{i,j}^r\right)^2}{N}$$

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## B.II Methodology: linking the objective function with the two-part model

$$\log U_{i,j} - \log U^{r}_{i,j} = \log\left(\frac{U_{i,j}}{U^{r}_{i,j}}\right) =$$

BEHAVIOURAL MODEL

$$= \log\left(\frac{\hat{p}_{i,j} * U^{'}_{i,j}}{U^{r}_{i,j}}\right) = \log \hat{p}_{i,j} + \log U^{'}_{i,j} - \log U^{r}_{i,j}$$

FIXED

THE EQUITY REFERENCE



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## 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:*
  a. Multicollinearity
  b. Capturing the specifics of central hospital sites



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## C. Application to Portugal: GLM results *(second part; log link; Poisson distribution)*

| Indicator | Variable | Coefficient |
|---|---|---|
| Other | Constant | 6.468201* |
| Distance | Distance(i,j)<br>Distance(i,j)*distance(i,j) | -0.0423718*<br>.0000776* |
| Perceptions | Population(i)*gravity accessibility index(i) | 2.95e-07* |
| Need and socio-economic | Population(i)*demographic need index(i)*Illiteracy rate(i)<br>Population(i)*population(i) | .0000354*<br>-2.97e-12* |
| Geographic variations | Dummy population in north region(i)<br>Dummy population in centre region(i) | -.2022617**<br>-.3838279* |
| Primary care | Primary care utilization(i)/population(i) | -.1160661* |
| Supply availability | Discharges(j) | .0000352* |
| Alternative supply | Hospital competition "index" (i,j) | -.1873067* |
| Institutional factors | Dummy for first hospital(i,j)*discharges(j)<br>Dummy for second hospital(i,j)*discharges(j)<br>Dummy for central hospital(i,j)<br>Dummy for population in the north using the Porto hospital site(i,j)*discharges(j)<br>Dummy for population in the centre using the Coimbra hospital site(i,j)*discharges(j)<br>Dummy for population in the south using the Lisbon hospital site(i,j)*discharges(i) | 0000231*<br>.0000141*<br>-4.304794*<br>.0000158*<br>.0000255*<br>-.0000136* |

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

* Statistically significant at 1% level; ** Statistically significant at 5% level.

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## C. Application to the Portuguese system: outputs

- 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 $(\sum_i \sum_j newU_{i,j}'s)$



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## D. Discussion

- ✓ 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?*



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## D. Concluding remarks

- ✓ An interdisciplinary approach is possible and useful (HE vs. OR)
- ✓ *Implementation is a big issue!!!*