Characteristics of demand for antibiotics in primary care: an almost ideal model

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Objectives

- Determinants of antibiotic consumption structure (local mix) in outpatient care
- Complementary and substitution between different antibiotic classes
Motivation

Although antibiotic prescriptions have slightly decreased during the 90s and been roughly stable in recent years, prescribing practices still vary widely across countries (Elseviers et al. 2007)

and within countries (Filippini et al., 2006b)
Motivation

Regional **heterogeneity in antibiotic mix** within and between countries (Kern et al., 2006; Ferech et al., 2006; Elseviers et al., 2007). Optimal use?
Motivation

Physicians face tradeoffs (common respiratory infections):

1. Prescribe/delay antibiotic therapy under uncertainty of infection (viral/bacterial)
2. Substituting away some types of antibiotics with newer and more effective ones (broad vs. narrow spectrum). Variety may reduce resistance (Laxminarayan and Weitzman, 2002; Rowthorn and Brown, 2003)

> Doctors` attitudes towards a group of antibiotics: strategies influenced by patients' characteristics, antibiotic price and economic incentives
The literature

- **Resistance-induced antibiotic substitution** (Howard, 2004). No evidence that bacterial resistance significantly varies at local level. Other determinants?

- **Demand for specific antibiotic classes** (Ellison et al., 1997; Chaudhuri et al., 2003). Focus on two segments of the market: cephalosporins and quinolones. Chemist's view rather than physician's?

- **Determinants** of regional and local heterogeneity in the use of antibiotics within countries (Filippini et al., 2006a; 2006b). Consumption structure?
The model

**Almost Ideal Demand System** (Ma and al., 2004; Lazaridis, 2004; Boetel and Liu, 2003)

**Two-stage budgeting approach** (antibiotics vs. other types of goods > different categories of antibiotics)

**Decisions of rationale physicians**
Doctors concerned with the effectiveness of a broad category of antibiotics compared to another one. Choice among a limited set of antibiotic categories:

- **group 1**
  - Penicillins (classic)

- **group 2**
  - Penicillins (amoxiclav) and 1st–2nd generation cephalosporins

- **group 3**
  - 3rd generation cephalosporins and quinolones (more severe infections or alternative to 2nd generation)

- **group 4**
  - Macrolides (alternative to beta-lactams)
The model

Expenditure share of the $i^{th}$ group of antibiotics

\[ w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log(x/P) + \sum_{k=1}^{S} \nu_{ik} V_k + \sum_{l=1}^{L} \phi_{il} R_l + \sum_{t=1}^{T} \rho_{it} DT_t + u_i, \]

Additional determinants by a log-linear scaling procedure:

- $V_k =$ Demographic structure, cultural aspects (borderland location, language)
- $R_l =$ Practice regulation (self-dispensing)
- $DT_t =$ Time dummies

Data: short panel (2002 quarterly, 240 contiguous market areas)

Estimation: Zellner's Iterative Seemingly Unrelated Regression (SUR) procedure (classic penicillins dropped)
## Estimation results

<table>
<thead>
<tr>
<th></th>
<th>Penicillins (amoxi/clav) and 1&lt;sup&gt;st&lt;/sup&gt; - 2&lt;sup&gt;nd&lt;/sup&gt; generations cephalosporins</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; generation cephalosporins and quinolones</th>
<th>Macrolides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obs.</td>
<td>960</td>
<td>960</td>
<td>960</td>
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<tr>
<td>R²</td>
<td>0.262</td>
<td>0.369</td>
<td>0.387</td>
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<td>Coeff.</td>
<td>S.E.</td>
<td>Coeff.</td>
<td>S.E.</td>
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<td>Constant</td>
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<td>0.211***</td>
<td>0.211***</td>
</tr>
<tr>
<td>P&lt;sub&gt;1&lt;/sub&gt;</td>
<td>-0.021**</td>
<td>0.077***</td>
<td>-0.050***</td>
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<tr>
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<td>0.086***</td>
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<td>0.031</td>
<td>0.032*</td>
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<td>0.032*</td>
<td>0.104***</td>
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<td>x/P</td>
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<td>0.004</td>
<td>-0.013***</td>
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<tr>
<td>POP&lt;sub&gt;1&lt;/sub&gt;</td>
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<td>0.035*</td>
<td>-0.027</td>
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<td>-0.005</td>
<td>-0.004</td>
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<td>0.032***</td>
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<tr>
<td>DBOR</td>
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<td>-0.015**</td>
</tr>
<tr>
<td>DLAT</td>
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<td>0.042***</td>
<td>-0.025***</td>
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<td>-0.034***</td>
<td>-0.003</td>
<td>0.040***</td>
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<td>0.020***</td>
<td>0.024***</td>
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<td>DT&lt;sub&gt;2&lt;/sub&gt;</td>
<td>0.004</td>
<td>0.012***</td>
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<td>DT&lt;sub&gt;3&lt;/sub&gt;</td>
<td>0.042***</td>
<td>-0.007*</td>
<td>-0.050***</td>
</tr>
</tbody>
</table>

* significant at 10%, ** significant at 5%, *** significant at 1%
Main findings (determinants)

• Population characteristics
  Elderly people increases the use of new cephalosporins/quinolones and reduces the use of macrolides

• Cultural aspects
  The Latin culture is associated with a more substantial use of new cephalosporins/quinolones and macrolides and a lower proportion of penicillins amoxi/clav and cephalosporins I–II

• Regulation
  Self-dispensing practices have a tendency to shift upward the demand for newer and more expensive antibiotics and to reduce the demand of traditional and less expensive antibiotics (penicillins amoxi/clav and cephalosporins I–II)
Main findings (own-price elasticity)

The highest **own-price elasticity** is found for the **most expensive antibiotic category** (group 3) and the **traditional** and less frequently used antibiotics (classic penicillins)
(Allen) Elasticity of substitution

- Classic penicillins
  - Penicillins (amoxiclav) and cephalosporins I-II
    - 0.509
    - 6.873
    - 0.388

- Macrolides
  - Cephalosporins III and quinolones
    - 1.749

- Complementary effects
- Substitution effects
Main findings (cross elasticities)

Complementary effects between antibiotics with a relative narrow spectrum and antibiotics with a relative large spectrum, and between classic penicillins and macrolides.

Degree of substitution between other categories.
Discussion

Own-price elasticity:
Latest generation cephalosporins/quinolones used to reduce uncertainty
Comparative advantage of traditional antibiotic therapy substantially undermined

Cross-price elasticity:
Switching to classic penicillins/macrolides rather than latest generations of cephalosporins/quinolones preferred
Patients' tastes > no switching between classic penicillins and macrolides
Conclusions

Contribution
We propose a **model** of the demand for antibiotics for respiratory infections prescribed in outpatient care. The approach includes **determinants** of the demand structure other than price, such as demographic and cultural characteristics of the population and practice self-dispensing status.

Improvements
Data on the incidence of **bacterial resistance** at a local level.

Policy implications
Local **taxation** of antibiotic components associated with levels of bacterial resistance may affect the antibiotic mix and, therefore, improve efficiency in consumption.