Developing a composite index of spatial accessibility across different healthcare providers: a German example

Martin Siegel  Daniela Koller  Verena Vogt  Leonie Sundmacher

Berlin Centre for Health Economics Research (BerlinHECOR)  Technische Universität Berlin

7th annual meeting of the dggö  Monday, March 16th, 2015
Motivation

- analyses of spatial accessibility often restricted to single healthcare sectors/providers
- focusing on a single healthcare sector allows only partial analyses
- aim: to derive a composite index of healthcare accessibility
- methodological approach:
  - concept of regional multiple deprivation to combine different healthcare sectors
  - Improved Gravity Model (IGM) to measure geographic access
- data sources
  - physician numbers: versorgungsatlas.de
  - population numbers: regionalstatistik.de
  - hospital beds: regionalstatistik.de
  - travel times between districts: kindly provided by BBSR
Healthcare domains I

- combine similar healthcare providers into healthcare domains
- group by regional unit of capacity planning
- capacity planning directive (Bedarfsplanungsrichtlinie) §§ 11–13 for ambulatory care
- hospitals planned at state level
- no similar scheme available
- suggestion: derive inpatient domains similar to outpatient domains
## Healthcare domains II

<table>
<thead>
<tr>
<th>$d$</th>
<th>domain</th>
<th>includes e.g.</th>
<th>regional level</th>
<th>weight $w_d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ambulatory GP</td>
<td>GPs, internists providing GP care</td>
<td>small area level</td>
<td>30%</td>
</tr>
<tr>
<td>2</td>
<td>ambulatory SP</td>
<td>eye doctors, women’s doctors, ENTs, ...</td>
<td>district level</td>
<td>15%</td>
</tr>
<tr>
<td>3</td>
<td>ambulatory specialized SP</td>
<td>cardiologists, pulmonary specialists, anesthesists, ...</td>
<td>administrative levels</td>
<td>5%</td>
</tr>
<tr>
<td>4</td>
<td>inpatient general care</td>
<td>inpatient general care beds (internal medicine, surgery, orthopedics)</td>
<td>state level</td>
<td>25%</td>
</tr>
<tr>
<td>5</td>
<td>inpatient spec. care</td>
<td>inpatient specialized care beds (e.g. geriatrics, eye clinics, ...)</td>
<td>state level</td>
<td>25%</td>
</tr>
</tbody>
</table>

- weights: chosen by area unit of planning
- the **larger** the area unit on which population to provider ratios must be met, the **smaller** the weight
- ambulatory and inpatient domains weighted 50/50
First, measure accessibility separately for each type of care

- geographic accessibility: Improved Gravity Model (IGM)
- free choice of physicians $\Rightarrow$ each person is a potential user of each healthcare provider
- patients may travel between areas to use health services
- probability of use decreases with increasing travel times
2-Stage computation of the Improved Gravity Model (IGM)

1. Compute supply per potential user $S_i^*$ for region $i$ including population in adjacent areas

$$S_i^* = \frac{S_i}{\sum_j \frac{P_j}{t_{ij}^{1.5}}} = \frac{\text{supply (total number of physicians or hospital beds)}}{\text{potential demand (distance-weighted sum of population)}}$$

2. Compute the accessibility score $\alpha_i$ for region $i$ as the distance-weighted sum of supply per potential user

$$\alpha_i = \sum_j t_{ij}^{-1.5} S_j^* = \sum_j t_{ij}^{-1.5} \times \frac{S_j}{\sum_k t_{ij}^{-1.5} P_k}$$

where

- $P_i$: population in region $i$
- $S_i$: supply in region $i$
- $t_{ij}$: travel time in minutes by car between regions with $t_{ii} = 1$
Then summarize healthcare accessibilities to scores

- combine accessibility scores \( \alpha \) into univariate score for each domain \( d \)
- domain score = weighted average of accessibilities
- weights obtained through explorative factor analysis
- rank districts \( i \) by combined accessibility scores in descending order

\[
\rho_{di} = \frac{1}{n} \quad \text{for district with highest combined accessibility score}
\]

\[
\rho_{di} = 1 \quad \text{for district with lowest combined accessibility score}
\]
Exponential transformation of domain ranks $\rho_{di}$

- Low accessibility in one domain should not easily be canceled out.
- Domain scores $\delta_{di}$: exponentially transformed ranks rescaled to $(0;100)$
- Only the worst-off decile ($\rho_{di} > 0.9$) receives scores $\delta_{di} > 50$

$$\delta_{di} = -23 \ln \left\{ 1 - \rho_{di} \left( 1 - \exp \left\{ -\frac{100}{23} \right\} \right) \right\}$$
Summarize domain scores $\delta_{di}$ to an index of accessibility

\[ I_i = \sum_d w_d \delta_{di} \]

The index of healthcare accessibility $I_i$ is the weighted sum of the exponentially transformed domain scores.
Healthcare accessibility in Germany

- lower accessibility mostly in rural areas
- higher accessibility in more urban districts
- $\approx 13\%$ population in the 83 districts with lowest accessibility → mostly rural districts
- $\approx 32\%$ population in the 82 districts with highest accessibility → mostly urban districts

<table>
<thead>
<tr>
<th>domain</th>
<th>weight $w_d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ambulatory GP</td>
<td>30%</td>
</tr>
<tr>
<td>ambulatory SP</td>
<td>15%</td>
</tr>
<tr>
<td>specialized ambulatory SP</td>
<td>5%</td>
</tr>
<tr>
<td>inpatient general care</td>
<td>25%</td>
</tr>
<tr>
<td>inpatient specialized care</td>
<td>25%</td>
</tr>
</tbody>
</table>

results are available from the author on request
Discussion

- accessibility correlates with population numbers
- unequal distribution of accessibility persists when using a holistic measure
- rural districts surrounding urban districts receive low accessibility scores but urban district is corresponding center → result of German administrative area boundaries
- interpret carefully: $A$ is a purely ordinal measure
  - best-off quintile may still be underserved
  - worst-off quintile may still be overserved
  - both seem rather unlikely
A set of normative choices must be made

- how to value distance
- which domains are more/less important
- which services are similar enough to form a domain
- altering domain weights had only little impact
- more obvious changes when altering geographic model
- having those choices also makes the index adaptable
THANK YOU FOR YOUR ATTENTION