A MULTI-INDICATOR APPROACH FOR COMPARING EMERGENCY DEPARTMENTS

Enrico di Bella*, Luca Gandullia*, Lucia Leporatti*, Marcello Montefiori*, Patrizia Orcamo**

* University of Genoa
** Regione Liguria, Health Regional Agency (Genoa)
OUTLINE

1. Introduction
   How Emergency Departments work in Italy
   Aims of the research
   Measuring Emergency Department activity

2. Data and Methods
   Description of the Dataset
   Partial Ordering techniques

3. Results

4. Conclusion and further work
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Focus on EDs:

- Very demanding (both in terms of economic resources consumption and programming)
- Responsible for patients hospitalization and diagnostic activity

The main challenges are:

- Cost containment and quality of assistance
- Inappropriateness and overcrowding problems
How Emergency Departments work in Italy: Patients’ flow
Aims of the research

- Identify suitable measures of emergency department activity;
- Use a new approach (alternative to composite indicators) to:
  - rank (when possible) emergency departments according to the efficiency and quality of the services offered;
  - identify and explain incomparability situations in order to address specific policy actions aiming at improving emergency departments management.

PARTIAL ORDERING APPROACH
Measuring efficiency

Provide effective and high quality treatments minimizing the waste in equipment and expenditure.

Measuring quality

Guarantee a fast recognition of medical conditions and an adequate treatment.
### Measuring Emergency Department activity

#### INDICATOR DESCRIPTION

<table>
<thead>
<tr>
<th>COST EFFICIENCY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>COST_Y</td>
<td>Average cost for treatments for a yellow triage patient</td>
</tr>
<tr>
<td>VISIT_Y</td>
<td>Average number of visits for a yellow triage patient</td>
</tr>
<tr>
<td>LAB_Y</td>
<td>Average number of laboratory treatments for a yellow triage patient (e.g. blood test)</td>
</tr>
<tr>
<td>NOLAB_Y</td>
<td>Average number of non laboratory treatments for a yellow triage patient (e.g. X-ray)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QUALITY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAIT_Y</td>
<td>Average waiting time before receiving the first visit for yellow triage (minutes)</td>
</tr>
<tr>
<td>WAIT20_Y</td>
<td>Percentage of yellow triage patients who wait more than 20 minutes</td>
</tr>
<tr>
<td>LOS_Y</td>
<td>Average length of staying in the ED for a yellow triage patient (minutes) from arrival to outcome (discharge/hospitalization)</td>
</tr>
<tr>
<td>SEVERITY</td>
<td>Ratio between the number of severe accesses (yellow and red triage) and the number of not urgent accesses (green and yellow triage)</td>
</tr>
</tbody>
</table>

References: Sørup et al., 2013; Schull et al., 2011
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Description of the dataset

Registry of accesses to 19 EDs located in Liguria during 2013
Description of the dataset

Registry of accesses to the 19 EDs of Liguria (Italy) for year 2013.

- Date and time of arrival, first visit and discharging.
- Triage entrance code.
- Patient’s personal information (as gender, date of birth, residence and nationality).
- Means of transport (i.e. the arrival mode): ambulance, air ambulance, etc.
- Laboratory and non-laboratory prescriptions.
- Patient outcome.
- Discharging code.
Description of the dataset

- 19 EDs
- 633,982 accesses in 2013

- 7 BIG EDs = more than 40,000 accesses during 2013.
- 7 MIDDLE EDs = from 20,000 to 40,000 accesses during 2013.
- 5 SMALL EDs = less than 20,000 accesses during 2013.

- Difference workload:
  - One pediatric ED
  - 9 EDs have a seasonal trends in accesses
Methods: partial ordering techniques

→ Pre-processing of data
- Compute 8 indicators of ED activity
- Apply a cluster techniques to divide each indicator in a proper number of levels (Ward method using Duda–Hart stopping rule).

→ Partial Ordering techniques:
- Partially order set theory (POSET)
- Partial order scalogram analysis by coordinates (POSAC)

References: Shye 1985; Brüggemann and Patil 2011
In set theory, a totally ordered set is one in which every component \( A \) is linked to all other \( J \) components by a relation of order such that we always have either \( A > J \) or \( A < J \) or \( A = J \).

By transitivity, we can order the entire set and simplify the representation.
In a partially ordered set, the relation exists only among some couples $A$, $J$, and the others cannot be compared. A group of people ordered by height and weight can be a POSET: some elements might be both higher and heavier than some others, but occasionally one might be higher while the other is heavier.

Some subgroups of the set are totally ordered, the set is only partially ordered.
2 indicators:
\( I_1: 0 - 6 \)
\( I_2: 0 - 6 \)

<table>
<thead>
<tr>
<th>ID</th>
<th>( I_1 )</th>
<th>( I_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
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<tr>
<td>6</td>
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<td>1</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

Incomparable with 32
Better than 32 (Downset)
Worse than 32 (Upset)
Compared to composite indicators approach partial ordering techniques:

- Allow an intuitive illustration of partial orders
- Require no weighting assumptions
- Define incomparabilities
- Avoid compensations
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RESULTS POSET– All the indicators

INDICATORS USED:
- COST_Y
- VISIT_Y
- LAB_Y
- NOLAB_Y
- WAIT_Y
- WAIT20_Y
- LOS_Y
- SEVERITY

Cronbach’s alpha = 0.848
RESULTS POSAC– All the indicators

Spearman Correlation

<table>
<thead>
<tr>
<th></th>
<th>J - Axis</th>
<th>L - Axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>COST_Y</td>
<td>0.678</td>
<td>-0.333</td>
</tr>
<tr>
<td>VISIT_Y</td>
<td>0.739</td>
<td>0.492</td>
</tr>
<tr>
<td>LAB_Y</td>
<td>0.682</td>
<td>-0.112</td>
</tr>
<tr>
<td>NOLAB_Y</td>
<td>0.354</td>
<td>-0.788</td>
</tr>
<tr>
<td>WAIT_Y</td>
<td>0.424</td>
<td>-0.369</td>
</tr>
<tr>
<td>WAIT20_Y</td>
<td>0.377</td>
<td>-0.391</td>
</tr>
<tr>
<td>LOS_Y</td>
<td>0.635</td>
<td>-0.066</td>
</tr>
<tr>
<td>SEVERITY</td>
<td>0.574</td>
<td>-0.228</td>
</tr>
</tbody>
</table>

Cronbach’s alpha = 0.848
RESULTS POSET– Efficiency indicators

AVERAGE HEIGHT

Cronbach’s alpha = 0.813
RESULTS POSAC– Efficiency indicators

Spearman Correlation

<table>
<thead>
<tr>
<th></th>
<th>J-Axis</th>
<th>L-Axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>COST_Y</td>
<td>0.872</td>
<td>-0.16</td>
</tr>
<tr>
<td>VISIT_Y</td>
<td>0.681</td>
<td>0.584</td>
</tr>
<tr>
<td>LAB_Y</td>
<td>0.768</td>
<td>0.073</td>
</tr>
<tr>
<td>NOLAB_Y</td>
<td>0.654</td>
<td>-0.684</td>
</tr>
</tbody>
</table>

Cronbach’s alpha = 0.813

Average Rank

<table>
<thead>
<tr>
<th></th>
<th>ED2</th>
<th>ED11</th>
<th>ED13</th>
</tr>
</thead>
<tbody>
<tr>
<td>COST_Y</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
</tr>
<tr>
<td>VISIT_Y</td>
<td>7</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>LAB_Y</td>
<td>7</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>NOLAB_Y</td>
<td>5</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>
RESULTS POSET—Quality indicators

AVERAGE HEIGHT

Cronbach’s alpha = 0.861
RESULTS POSAC– Quality indicators

Spearman Correlation | J - Axis | L- Axis
--- | --- | ---
WAIT_Y | 0.881 | -0.063
WAIT20_Y | 0.864 | 0.04
LOS_Y | 0.771 | 0.211
SEVERITY | 0.820 | -0.559

Cronbach’s alpha = 0.861

Average Rank

<table>
<thead>
<tr>
<th></th>
<th>ED1</th>
<th>ED6</th>
<th>ED8</th>
<th>ED17</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAIT_Y</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>WAIT20_Y</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>LOS_Y</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>SEVERITY</td>
<td>6</td>
<td>3</td>
<td>8</td>
<td>6</td>
</tr>
</tbody>
</table>
- Average rank and average height are strongly correlated.
- However compensation should be avoided
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CONCLUSION AND DISCUSSION

- The ranking of EDs according to their costs and quality is propaedeutic to detect best practices or critical issues that require corrections.

- Incomparability among EDs (in particular shifts from the J-axis in POSAC) is a source of information which may suggest clear policy actions.

- Partial ordering techniques are suitable instruments to provide the decision makers with a number of different lines of actions.

- Creating very big multi-indicator systems may cause too many incomparabilities.
- Evaluation of the robustness of the procedure with additional indicators.
- Introduce indicators importance/priority in the definition of ED activity, maybe different according to the type (cluster) of AEDs.
- Try to develop effective communication for Regional Healthcare System decision makers

THANK YOU FOR YOUR ATTENTION!
REFERENCES


