Checking coding completeness by mining discharge summaries

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Undercoding of in-patient treatment episodes is a common problem in hospital information systems

- Incompleteness of disease encoding (ICD10) in hospitals
  - main diagnosis coded
  - comorbidities (secondary diseases) often not coded
  - typical: multimorbid patient admitted for surgical intervention (hip replacement, lens implant, prostatectomy…)

- Investigation: Does undercoding affect reimbursement given a DRG (diagnosis related group) - related reimbursement system?

- Setting:
  - University Hospital of Freiburg (Germany)
  - Only very severe comorbidities have impact on DRG grouping in German DRG system
Undocumented diagnoses can be detected by mining the EPR

- Hypothesis: drug (ingredient) names in the EHR for which there is no justifying ICD code point to undocumented diseases
- Most trustworthy source of drug prescriptions: Discharge summary (in many departments no structured documentation of drug administration)
- Focus on three diseases, known to be readily omitted
  1. Diabetes mellitus,
  2. Parkinson's disease,
  3. Bronchial asthma and chronic obstructive pulmonary disease (COPD).
For each of 34,865 treatment episodes:
- discharge summary
- one or more ICD codes
- 17,000 used for training, 17,865 for testing

Rule base for diabetes, Parkinson's and COPD:
- Drug indications (in ICD) manually extracted from two databases (Rote Liste, MMI) and enriched by off-label use from the training corpus
- Including brand names and ingredient names
- Each rule encoded as a triple $R = (D, P, N)$ with
  - $D =$ string characterizing a drug
  - $P =$ "positive list" of ICD codes for the diseases under scrutiny
  - $N =$ "negative list" of ICD codes for other indications

Exact string match
Filter algorithm retrieves documents (cases) for which no justification for a drug name (ICD code in the HIS) is found:

For each \( d = \{ \text{diabetes}, \text{Parkinson's}, \text{COPD} \} \)

For each document:

For each drug name specific to \( d \):

If drug name matches text token in document:

If no match between any discharge ICD code and any code in the negative or positive list for \( d \):

Return document (candidate for undercoding)
Estimation of Precision and Recall

- Precision: text samples (n = 3 * 50) of the retrieved texts were analyzed by a domain expert.

- Recall: roughly estimation by set of documents already annotated with a ICD code of interest.

For each \( d = \{\text{diabetes, Parkinson's, COPD}\} \)

For each document:

  If annotated with ICD code from positive list:
  
  For each drug name specific to \( d \):
  
  If drug name matches text token in document:
  
  If no match between any discharge ICD code and any code in the negative list for \( d \):
  
  Return document

- Recall estimator:
  
  \[ 1 - \left( \frac{\# \text{ docs returned}}{\# \text{ docs with ICD code from pos. list}} \right) \]
### Results

<table>
<thead>
<tr>
<th>Code missing? (expert rating)</th>
<th>Diabetes</th>
<th>Parkinson</th>
<th>Asthma / COPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>984</td>
<td>232</td>
<td>875</td>
</tr>
<tr>
<td>No</td>
<td>201</td>
<td>65</td>
<td>172</td>
</tr>
<tr>
<td>Precision</td>
<td>79%</td>
<td>14%</td>
<td>45%</td>
</tr>
<tr>
<td>Estimated number of undercoded episodes</td>
<td>158</td>
<td>9</td>
<td>77</td>
</tr>
</tbody>
</table>

Candidates for missing codes as returned by algorithm 1 and estimated precision after rating of 50 treatment episodes per disease.
**Diabetes drugs** | **Parkinson drugs** | **Asthma / COPD drugs**
--- | --- | ---
Multi organ failure. | Restless legs syndrome not coded | Foreign body in lung.
Hyperglycemia as side effect of severe respiratory infection | Essential tremor not coded | Pulmonary atresia combined with rhinitis and varicella.
Patient participates in a clinical trial | Huntington's chorea | Acute myeloid leukaemia and fever.
Unique insulin dose given to mitigate steroid side effects | Acute seizure | Lymph node tuberculosis. Oxis to be taken on demand.
Patient with a glucose tolerance test. | Richardson Olszewski syndrome | Pneumonia after stem cell transplantation.
Lab result for serum insulin measurement. | Paranoid schizophrenia | Salbutamol to decrease the potassium level
18 months-old infant is resuscitated | Hypokinetic rigid syndrome | Lung cancer

**Analysis of false positives**

*Background*

*Methods*

*Results*

*Conclusions*

Most false positives due to other indications not coded or not in rule base
Recall low for Diabetes and COPD

<table>
<thead>
<tr>
<th></th>
<th>Retrieved cases using filter</th>
<th></th>
<th>Total</th>
<th>Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>783</td>
<td>1031</td>
<td>1814</td>
<td>783/1814 = 43%</td>
</tr>
<tr>
<td>Parkinson</td>
<td>106</td>
<td>45</td>
<td>151</td>
<td>106/151 = 70%</td>
</tr>
<tr>
<td>Asthma / COPD</td>
<td>99</td>
<td>173</td>
<td>272</td>
<td>99/272 = 36%</td>
</tr>
</tbody>
</table>

Recall estimation based on correctly coded diagnoses (algorithm 2).
**Most false negatives due to diseases not treated by drugs**

<table>
<thead>
<tr>
<th>Disease treatment without drug administration</th>
<th>Specific drug administration not mentioned in summary</th>
<th>Diabetes</th>
<th>Parkinson</th>
<th>Asthma / COPD</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Specific drug administration mentioned in summary</td>
<td>11</td>
<td>14</td>
<td>11</td>
<td>72%</td>
</tr>
<tr>
<td>Disease treatment with drug administration</td>
<td>Drug not listed in rule base</td>
<td>5</td>
<td></td>
<td>3</td>
<td>16%</td>
</tr>
<tr>
<td></td>
<td>Drug name typing variant not matched with rule base</td>
<td>2</td>
<td></td>
<td></td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>Drug not correctly recognized</td>
<td>1</td>
<td></td>
<td>2</td>
<td>6%</td>
</tr>
</tbody>
</table>

Analysis of false negatives
<table>
<thead>
<tr>
<th>Background</th>
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</tr>
</thead>
</table>


Of all treatment episodes under scrutiny, 2% were undercoded re diabetes mellitus, Parkinson's or COPD.

Diseases deemed secondary or unrelated to the actual clinical problem tend to be omitted, given that that they have no impact for DRG grouping.

Very severe comorbidities (with relevance for DRG grouping) are normally coded; no single case of DRG-relevant undercoding.

Improvement of the method: context sensitivity, spelling correction, automation of rule base construction, searching for other text elements.