Screening for diabetic retinopathy among type 2 diabetic patients

Analytics for Population Health Management (PHM)

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Population health management (PHM): care model

- It has recently gained serious attention from mainstream healthcare organizations, and been looked as the future of healthcare.

- The emphasis is clearly shifting from volume to value, while continuing to provide person-centered quality healthcare across the population.
PHM: definition & goal

• Population is heterogeneous.

• PHM: To target right interventions to the right person at the right time.

• Goal of PHM: To keep a population as healthy as possible, minimizing the need for expensive interventions (eg emergency department visits, admissions, procedures).

*Population health management: a roadmap for Provider-Based Automation in a New Era of Healthcare*
Screening for diabetic retinopathy among type 2 diabetic patients: Developing a risk stratification tool for cost effective screening
Team and Funding

• Supported by Ministry of Health (MOH)-Competitive Research Grant (CRG) for 2 years (May 2013-Mar 2015)

• HSOR team collaborates with:
  - Dr Nikolle Tan and Dr Rajagopalan Rajesh from TTSH
  - Dr Lew Yii Jen from NHG polyclinics
Background

• The prevalence of diabetes mellitus (DM) is >10% in Singapore. Approximately 60% of type 2 diabetic patients develop diabetic retinopathy in 20 years in UKPDS study.

• According to a cross-sectional study in 2008 by SNEC, 35% of Malay diabetic patients had any DR, 9.0% had vision-threatening DR.

• Blindness due to diabetic retinopathy (DR) is the major disability among diabetic patients.
Background

- DR is often asymptomatic even in its more advanced stages. Evidences have shown that early management could prevent vision loss.

- In Singapore, annual screening for diabetic retinopathy using retinal photograph is suggested for all diagnosed DM patients managed at polyclinics regardless of their risks.

- Recent cost effectiveness studies have shown that universal annual screening for DR is not cost-effective.
Background

Universal screening
- Screening all who are not screened before
- Annual follow-up screening for all

Risk stratified screening
- Screening all who are not screened before
- Follow-up screening tailored to individual’s risk:
  - Patients with very low risk screened every 3 years;
  - High-moderate risk groups: screening frequency tailored
Objectives

- To develop and validate a **prognostic model** to stratify the **risk of developing DR** for type 2 diabetic patients
- To evaluate the **cost-effectiveness** of risk stratified screening vs. universal screening
Method

Study design

- Predictive modeling for risk stratification using retrospectively collected screening data;

Inclusion

- Type 2 DM patients who did screening in NHG polyclinics in years 2010-2013;

Exclusion

- Patients had DR or any other eye complications diagnosed at the first screening;
- Patients had no follow-up screening;
Method: data collected

- BMI and smoking status;
- Comorbid conditions;
- Duration of diabetes;
- Treatment of diabetes;
- Clinical parameters;
- Lab tests;
- Patient demographics.

Screening data
Method: outcome to be modelled

Risk status
- Event: patients with any DR diagnosed;
- Censored: patients had no DR diagnosed at last screening;

Time to status: time from 1st screening to
- Event: time of any DR first diagnosed
- Censored: time of last screening;
Modeling

Model development
- Parameter estimation: cox regression;
- Model fitting: Stepwise selection + BIC

Model validation
- Bootstrap validation

Model assessment
- Discrimination: Harrell's C concordance statistic;
- Calibration: Cox-Snell residual and the goodness of fit test.
## Final model developed by Cox model

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Bootstrap correction</th>
<th>Coefficient</th>
<th>Hazard coeff. (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg Hba1c level in last 1year</td>
<td>0.004</td>
<td>0.27</td>
<td>0.266 (0.23-0.31)</td>
</tr>
<tr>
<td>Age</td>
<td>-0.001</td>
<td>0.02</td>
<td>0.021 (0.01-0.02)</td>
</tr>
<tr>
<td>Stroke</td>
<td>0.007</td>
<td>0.45</td>
<td>0.443 (0.21-0.67)</td>
</tr>
<tr>
<td>Duration of Diabetes</td>
<td>0.002</td>
<td>0.02</td>
<td>0.018 (0.01-0.03)</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>-0.009</td>
<td>-0.30</td>
<td>-0.201 (-0.64--0.04)</td>
</tr>
<tr>
<td>Peripheral Neuropathy</td>
<td>0.03</td>
<td>0.50</td>
<td>0.470 (0.00-0.99)</td>
</tr>
</tbody>
</table>
Final model: deployment

- Algorithm: For a patient with $X$, at time $t$
  
  - $Risk = 1 - S(t, X) = 1 - S_0(t)^{\exp(X, \beta)}$
  - $S_0(t)$ is the baseline survivorship

6 months: 0.9999
1 year: 0.998
1.5 years: 0.996
2 years: 0.992
2.5 years: 0.989
3 years: 0.983
Next step: cost-effective analysis

- Markov disease progression model
- Microsimulation
Collaboration Opportunities

- Disease modeling & Microsimulation;
- Cost effectiveness analysis;
- Visual-analytics;
- Data mining;
- Geoanalytics;
- Social media;
- Modeling & simulation;
- Predictive modeling;
- Machine learning;
- Statistical modeling;
- Telemonitoring;
- Cloud computing based population management;
- Shared decision modeling.