Detection of spatial clusters in poor quality of diabetes control: defining hotspots as High-High and High-Low levels

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Abstract

Background: High-High district was defined as hotspot traditionally according to Moran’s I test and Local Indications of Spatial Association (LISA) statistics. This study aim is to validate the application of hotspots with High-High and High-Low levels in prevalent chronic disease.

Method: The address, care quality indicators including medication compliance, examination compliance, and complications of DM patients in the year of 2014 were extracted from the medical information system of a medical center in Tainan City, Taiwan. Patients’ addresses were transformed and grouped into 1st level dissemination area (DA1). Geographic clusters of macrovascular complications (cardiovascular, cerebrovascular and peripheral vascular disease) were identified and analyzed using Moran’s I test and LISA statistics. The association between indicators and hotspots or not were examined using Student’s t-test in two stages.

Results: 12,716 patients enrolled. There were altogether 4043 DA1s in Tainan, of which 24 belonged to High-high level and 118 belonged to High-Low level. The care quality were similar between High-high level and High-Low level. The patients in hotspots (High-high with High-Low levels) had statistically lower examination compliance (79.3% v.s. 83.3%) and higher prevalence of cardiovascular disease (88.5% v.s. 70.5%) and peripheral vascular disease (8.2% v.s. 4.8). While the medication compliance and prevalence of non-macrovascular complications were insignificant between hotspot and other areas. Conclusion: Using broader definition of hotspots for prevalent chronic disease is attainable. There was geographical difference in the outcome of DM, and the quality of care.

Keywords: prevalent chronic disease, diabetes mellitus, care quality indicator, Moran’s I test, LISA statistics, hotspots.

1 Introduction

Diabetes mellitus (DM) is a prevalent chronic disease and takes heavy medical resources (World Health Organization, 2008; Zhang, 2010; Ministry of Health and Welfare, 2017). Inappropriate DM management can cause many complications and macrovascular diseases (Sarwar, 2010). Therefore, DM management is the topmost priority in both insurance providers and institutional care (Norris, 2002; Australian Government, 2006; Ministry of Health and Welfare, 2017).

Although Taiwan government has data on DM management performed by medical institutions, it lacks the patients’ factors affecting their compliance, like traffic convenience.

Geospatial analysis is applied to find out the clusters in poor care quality areas to improve care effectiveness. Moran’s I and LISA are used for verification of spatial autocorrelation. These methods categorized the areas into High-High (HH), Low-Low (LL), Low-High (LH), and High-Low (HL) levels. The HH is traditionally defined as hotspot to identify special geographic characters (Anselin, 1995). However, for studying geographic factors affecting the care quality of prevalence chronic disease, we tried to extend the hotspot as H-H/H-L levels. In this study, we validated the samples between H-H and H-L levels and investigated the geographic clusters of DM macrovascular complications and care quality indicators between hotspot and the rest.

2 Data sources and methods

2.1 Data sources

We utilized DM patient data retrieved from data warehousing system in a medical center located in Yongkang District, Tainan City, Taiwan.

2.2 Data Collection

DM was defined as diagnosis code 250 of ICD-9-CM (International Classification of Diseases, Ninth Revision, Clinical Modification). DM patients with out-patient visits
from January 1st to December 31st, 2014 were identified. Encrypted chart numbers, birth date, of first outpatient visit date and residential address were retrieved.

Geocoding was performed on the residential addresses using the census tract from NGIS website provided by the Ministry of the Interior (Ministry of the Interior, 2017), which converted the address to its corresponding district level and 1st level dissemination area (DA1). (Figure 1)

2.3 Methods

DM care quality was assessed using four parameters:

1. Complications: with ICD-9-CM codes for nephropathy (250.4, 585), retinopathy (250.5, 362.0), neuropathy (250.6, 357.2), and macrovascular complications of cardiovascular disease (CAD) (401-5, 410-4, 428), cerebrovascular disease (CVD) (431-8), or peripheral vascular disease (PVD) (250.7, 443.8-9) in one year (Ministry of Health and Welfare, 2017; Young, 2008).

Figure 1: Geocoding of patients with type 2 DM.

- 23,588 Diabetes patients with outpatient visits during January 1st - December 31st, 2014
  - 17,570 Geocoded
  - 6,018 1st Geocoded
  - 6,012 Review medical records
  - 2,580 Geocoded
  - 3,438 2nd Geocoded
  - 3,435 Manually matched
  - 3,375 Geocoded
  - 63 Excluded
  - 10,809 Excluded
  - 12,716 Study group

2. Medication compliance:

\[
\text{Total days of out-patient prescription} = \frac{100\%}{365\text{ days}}
\]

3. Laboratory examination compliance:

\[
\frac{\text{Number of examinations performed}}{\text{Total number ordered}} = 100\%
\]

Good compliance is defined as 80% or above.

Since the parameters were estimated, the mean values of parameters for each DA1 were transformed.

2.4 Spatial analysis

Geographic clusters of macrovascular complications were analyzed using Moran’s I test and LISA statistics. The association between indicators and locations were examined using Student’s t-test in two stages. The 1st stage compared the samples between H-H and H-L levels. The 2nd stage compared the association by defining hotspot of H-H/L levels.

The softwares used were SAS 9.4, Microsoft Office Excel 2010, ArcMap 10.4.1 and GeoDa 1.12. The study was approved by the institutional review board.

3 Results

12,716 patients enrolled. More than half of the subjects were male and between 60-79 years old. 75% patients had macrovascular complications (data not shown), which was clustered (Moran’s I=0.02; z=1.72; P=0.04). There were 4043 DA1s in Tainan, including 24 H-H and 118 H-L levels. (Figure 2).

Figure 2: LISA clusters of macrovascular complications for DM patients.

Notes:

High-High – spatial clusters of similarly high proportion.
Low-Low – spatial clusters of similarly low proportion.
Low-High/High-Low – spatial outliers of dissimilar values.

*The star indicated the medical center.

The care quality between H-H and H-L levels were similar except the age distribution, retinopathy and PVD related to small sample size (Table 1). Therefore, we defined the H-H/H-L levels as hotspot for following analysis.
The care quality indicators between hotspot and the rest indicated that patients in hotspot had statistically lower examination compliance (79.29% vs. 83.30%), higher prevalence of CAD (88.45% vs. 70.46%) and PVD (8.21% vs. 4.82). The medication compliance and prevalence of non-macrovascular complications were insignificant. (Table 2)

### Table 1: Comparisons between H-H and H-L levels

<table>
<thead>
<tr>
<th></th>
<th>H-H (n=24)</th>
<th>H-L (n=118)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>50.85</td>
<td>53.70</td>
<td>0.69</td>
</tr>
<tr>
<td>Female</td>
<td>49.15</td>
<td>46.30</td>
<td>0.69</td>
</tr>
<tr>
<td>Age group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;20</td>
<td>0.00</td>
<td>0.00</td>
<td>0.05</td>
</tr>
<tr>
<td>20-39</td>
<td>0.00</td>
<td>0.37</td>
<td>0.002</td>
</tr>
<tr>
<td>40-59</td>
<td>16.95</td>
<td>21.11</td>
<td>0.025</td>
</tr>
<tr>
<td>60-79</td>
<td>61.02</td>
<td>62.96</td>
<td>0.031</td>
</tr>
<tr>
<td>≥80</td>
<td>22.03</td>
<td>15.19</td>
<td>0.24</td>
</tr>
<tr>
<td>Good medication Compliance</td>
<td>72.88</td>
<td>68.52</td>
<td>0.030</td>
</tr>
<tr>
<td>Good examination Compliance</td>
<td>74.29</td>
<td>78.69</td>
<td>0.025</td>
</tr>
<tr>
<td>Glucose</td>
<td>76.21</td>
<td>81.14</td>
<td>0.025</td>
</tr>
<tr>
<td>Lipid</td>
<td>77.77</td>
<td>80.12</td>
<td>0.69</td>
</tr>
<tr>
<td>Renal function</td>
<td>23.10</td>
<td>24.07</td>
<td>0.027</td>
</tr>
<tr>
<td>Nephropathy</td>
<td>25.42</td>
<td>34.81</td>
<td>0.029</td>
</tr>
<tr>
<td>Retinopathy</td>
<td>1.69</td>
<td>5.56</td>
<td>0.015</td>
</tr>
<tr>
<td>Neuropathy</td>
<td>15.25</td>
<td>15.93</td>
<td>0.025</td>
</tr>
<tr>
<td>CAD</td>
<td>86.44</td>
<td>88.89</td>
<td>0.018</td>
</tr>
<tr>
<td>CVD</td>
<td>18.64</td>
<td>24.07</td>
<td>0.027</td>
</tr>
<tr>
<td>PVD</td>
<td>16.95</td>
<td>6.30</td>
<td>0.019</td>
</tr>
</tbody>
</table>

**Notes:**
SE. – standard error.

### Table 2: Comparisons between hotspot and non-hotspots.

<table>
<thead>
<tr>
<th></th>
<th>Hotspot (n=142)</th>
<th>Non-hotspot (n=3901)</th>
<th>p-value</th>
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</thead>
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<tr>
<td>Sex</td>
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<td></td>
<td></td>
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<tr>
<td>Male</td>
<td>53.19</td>
<td>53.25</td>
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</tr>
<tr>
<td>Female</td>
<td>46.81</td>
<td>46.75</td>
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<tr>
<td>Age group</td>
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<td>&lt;20</td>
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<td>0.45</td>
<td>0.001</td>
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<td>20-39</td>
<td>0.30</td>
<td>3.52</td>
<td>0.002</td>
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<tr>
<td>40-59</td>
<td>20.36</td>
<td>30.96</td>
<td>0.004</td>
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<tr>
<td>60-79</td>
<td>62.61</td>
<td>53.94</td>
<td>&lt;0.01</td>
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<tr>
<td>≥80</td>
<td>16.41</td>
<td>11.12</td>
<td>0.003</td>
</tr>
<tr>
<td>Good medication Compliance</td>
<td>69.30</td>
<td>66.96</td>
<td>0.004</td>
</tr>
</tbody>
</table>

### Good examination

- **Compliance**
  - Glucose: 77.90 ± 0.024
  - Lipid: 80.26 ± 0.024
  - Renal function: 79.70 ± 0.023

- **Complication**
  - Nephropathy: 33.13 ± 0.026
  - Retinopathy: 4.86 ± 0.013
  - Neuropathy: 15.81 ± 0.022
  - CAD: 88.45 ± 0.016
  - CVD: 23.10 ± 0.025
  - PVD: 8.21 ± 0.017

**Notes:**
SE. – standard error.

### 4 Conclusion

Using broader definition of hotspot for high-prevalent chronic disease is attainable since this could consolidate the strength of association. There were clustering of macrovascular complications for DM patients. Patients in hotspot had lower examination compliance. Future works are needed to identify the contextual reasons.

### References


Macintyre S. et al. (2002) Place effects on health: how can we conceptualise operationalize and measure them? Social Science & Medicine, 55, 125-139.


