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

Tain-Junn Cheng
Departments of Neurology and Occupational Medicine, Chi Mei Medical Center
No.901, Zhonghua Rd., Yongkang Dist.
Department of Hospital and Health Care Administration, College of Recreation and Health Management, Chia Nan University of Pharmacy and Science
No.60, Sec. 1, Erren Rd., Rende Dist.
Tainan City, Taiwan
tjcheng@mail.chimei.org.tw

Tsu-Yun Chiu
Department of Medical Research, Chi Mei Medical Center
No.901, Zhonghua Rd., Yongkang Dist.
Tainan City, Taiwan
jenniferchiu31@hotmail.com

Tsung-Hsueh Lu
Department of Public Health, College of Medicine, National Cheng Kung University
No.1, University Road, East Dist.
Tainan City, Taiwan
robertlu@mail.ncku.edu.tw

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 out-patient visit date and residential address were retrieved.

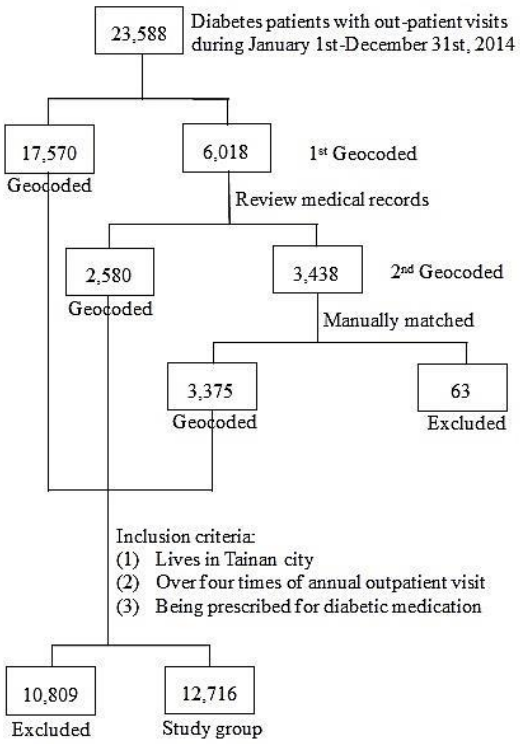
Geocoding was performed on the residential addresses using the census tract from NGIS website provided by the Ministry of the Interior (Ministry of the Interior, 2017), which converted the address to its corresponding district level and 1st level dissemination area (DA1). (Figure 1)

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.



(2) Medication compliance:

$$\frac{\text{Total days of out} - \text{patient prescription}}{365 \text{ days}} 100\%$$

(3) Laboratory examination compliance:

$$\frac{\text{Number of examinations performed}}{\text{Total number ordered}} 100\%$$

Good compliance is defined as 80% or above.

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

2.4 Spatial analysis

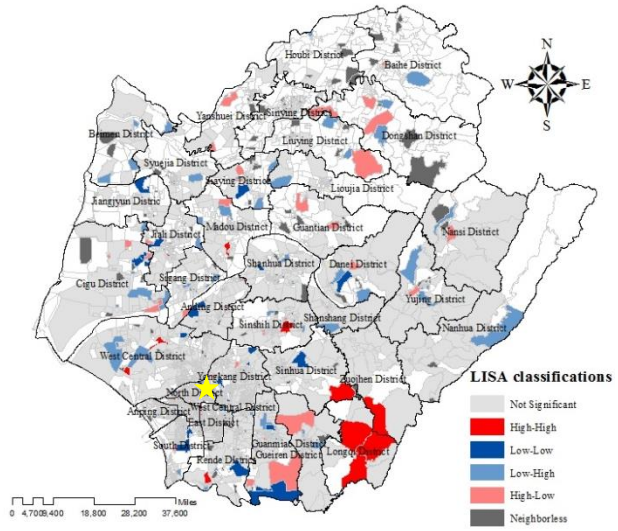
Geographic clusters of macrovascular complications were analyzed using Moran's I test and LISA statistics. The association between indicators and locations were examined using Student's t-test in two stages. The 1st stage compared the samples between H-H and H-L levels. The 2nd stage compared the association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

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

		H-H (n=24)		H-L (n=118)		
	%	Mean	SE.	Mean	SE.	p-value
Sex						
Male	50.85	0.066		53.70	0.031	0.69
Female	49.15	0.066		46.30	0.031	0.69
Age group						
<20	0.00	0.000		0.37	0.002	0.05
20-39	0.00	0.000		0.37	0.002	0.03
40-59	16.95	0.049		21.11	0.025	0.47
60-79	61.02	0.069		62.96	0.031	0.79
≧80	22.03	0.053		15.19	0.025	0.24
Good medication Compliance	72.88	0.048		68.52	0.030	0.52
Good examination Compliance						
Glucose	74.29	0.069		78.69	0.025	0.48
Lipid	76.21	0.068		81.14	0.025	0.43
Renal function	77.77	0.057		80.12	0.025	0.69
Complication						
Nephropathy	25.42	0.058		34.81	0.029	0.17
Retinopathy	1.69	0.011		5.56	0.015	0.04
Neuropathy	15.25	0.047		15.93	0.025	0.91
CAD	86.44	0.032		88.89	0.018	0.56
CVD	18.64	0.058		24.07	0.027	0.40
PVD	16.95	0.042		6.30	0.019	0.02

Notes:
SE. – standard error.

The care quality indicators between hotspot and the rest indicated that patients in hotspot had statistically lower examination compliance (79.29% v.s. 83.30%), higher prevalence of CAD (88.45% v.s. 70.46%) and PVD (8.21% v.s. 4.82). The medication compliance and prevalence of non-macrovascular complications were insignificant. (Table 2)

Table 2: Comparisons between hotspot and non-hotspots.

		Hotspot (n=142)		Non-hotspot (n=3901)		
	%	Mean	SE.	Mean	SE.	p-value
Sex						
Male	53.19	0.028		53.25	0.005	0.98
Female	46.81	0.028		46.75	0.005	0.98
Age group						
<20	0.30	0.002		0.45	0.001	0.37
20-39	0.30	0.001		3.52	0.002	<.01
40-59	20.36	0.022		30.96	0.004	<.01
60-79	62.61	0.028		53.94	0.005	<.01
≧80	16.41	0.022		11.12	0.003	0.02
Good medication Compliance	69.30	0.026		66.96	0.004	0.38
Good examination Compliance						
Glucose	77.90	0.024		81.46	0.004	0.13
Lipid	80.26	0.024		84.51	0.004	0.06
Renal function	79.70	0.023		83.93	0.004	0.06
Complication						
Nephropathy	33.13	0.026		33.11	0.004	0.99
Retinopathy	4.86	0.013		5.50	0.002	0.62
Neuropathy	15.81	0.022		15.40	0.003	0.84
CAD	88.45	0.016		70.46	0.004	<.01
CVD	23.10	0.025		19.19	0.004	0.12
PVD	8.21	0.017		4.82	0.002	0.05

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

World Health Organization (2008) *Diabetes* [Online] Available from: http://www.who.int/mediacentre/factsheets/fs312/en/2008/en/index.html [Accessed 13 April 2017].

Zhang P. et al. (2010) Global healthcare expenditure on diabetes for 2010 and 2030. *Diabetes Research and Clinical Practice*, 87(3), 293-301.

Ministry of Health and Welfare (2017) *Open Data* [Online] Available from: http://data.hpa.gov.tw/dataset/a8edbae668c6a8293b1b92d5bc8c5a64 [Accessed 13 April 2017].

Sarwar N. et al. (2010) Diabetes mellitus, fasting blood glucose concentration, and risk of vascular disease: a collaborative meta-analysis of 102 prospective studies. *Lancet*, 375(9733), 2215-2222.

Norris S.-L. and Nichols P.-J. (2002) The effectiveness of disease and case management for people with diabetes. A systematic review. *American Journal of Medicine*, 22(4 Suppl.), 15-38.

Australian Government (2006) *The Department of Health. National service improvement framework for diabetes 2005* [Online] Available from: http://www.health.gov.au/internet/main/publishing.nsf/Content/pq-ncds-diabetes [Accessed 13 April 2017].

Anselin L. (1995) Local Indicators of Spatial Association—LISA. *Geogr Anal*, 27(2), 93-115.

Ministry of Health and Welfare, Medical Services (2017) *Assistances & Cares* [Online] Available from: http://www.nhi.gov.tw/webdata/webdata.aspx?menu=20&menu_id=836&webdata_id=3862&WD_ID=836 [Accessed 13 April 2017].

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

Walker R.-J. et al. (2014) Impact of social determinants of health on outcomes for type 2 diabetes: a systemic review. *Endocrine*, 47, 29-48.

Jiwa M. et al. (2015) Impact of geography on the control of type 2 diabetes mellitus: a review of geocoded clinical data from general practice. *BMJ Open*, 5.

Ministry of the Interior (2017) *Statistical Area Access Services* [Online] Available from: http://moisagis.moi.gov.tw/moiap/match/system_common.cfm [Accessed 13 April 2017].

Ministry of Health and Welfare (2017) *ICD & Range* [Online] Available from: http://www.nhi.gov.tw/webdata/webdata.aspx?menu=18&menu_id=703&webdata_id=1008 [accessed 13 April 2017].

Young B.-A. et al. (2008) Diabetes Complications Severity Index and Risk of Mortality, Hospitalization, and Healthcare Utilization. *The American Journal of Managed Care*, 14(1), 15-23.